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II

INFORMATION TECHNOLOGIES AND ENGINEERING EDUCATION

SATURS
CONTENTS

Information Technologies

Engineering Education

INFORMATION TECHNOLOGIES

Enhanced Participants' Registration Model on Open Public Events

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Abstract - **The Digital transformation (DT) has challenged most of the Event Management (EM) services at a time when organizers of open public events still faced a lot of manual operations upon registration of the public event's participants. This survey demonstrates a model to increase a level of digitalization and use of technology, with increased self-service level for registered participants and digital data transfer. The model is based on outcomes from the series of several case studies, practical tests and research activities in Latvia, Albania, and Germany. The paper examines different ways how organizers are able to innovate their routine activities and encourage the broader public to learn and use various digital technologies: Radio-frequency identification (RFID), Near-field Communication (NFC), Quick Response (QR) codes and Mobile apps with a purpose to link the physical and the digital world in the one coherent model. In this research the major part of event management process modelling had been done by Business process Model and Notation (BPMN2) approach. The approach proposed by authors aims to reduce the costs and workload of organizers associated with participants' registration in open public events where preliminary registration is still practically impossible or forbidden because of personal data protection issues.**

Keywords - Digital transformation, service-oriented modelling, RFID, sports event management.

I. INTRODUCTION

The first obvious conclusion in the age of digital transformation is that almost any traditional human interaction process effectively benefit from integration of digital tools and solutions in the underlying business model. Unfortunately, in real life there are specific cases and applications when human and social influence factors override eventual process digitalization possibility. As one of such specific human interaction models is open public event participants' registration process when eventual participants arrive without prior invitation, pre-approval or pre-registration. In this case, the preliminary registration online is impossible because participants appear just "on-site" before event or such type of registration is forbidden because of personal data protection issues [1]. The subject of the digital transformation and its strategic significance is understood by managers, but questions remain as to how to integrate digital solutions and how to modify business structures to transform into digital organisations [2]. From human interaction prospective registration data flow as an information structure is now the most common term for those aspects of a sentence's meaning that have to do with the way in which the hearer integrates the information into already existing information [3].

This study aims at elaborating existing open public event participants' registration models and methods of the digital transformation process determining whether they are relevant or not in the context of the digital transformation of enterprises.

Constructing the registration data flow-processing model specific number of basic modelling components has to be taken into account concerning abstraction levels and codification of activities. The proposed participants' registration model design is based on recently developed POS (participants-organizers-spectators) model framework [4] and elaborated in the next chapter.

This research paper examines outcomes from several case studies and business applications already implemented in practice or still under the development process. The approach proposed by authors aims to reduce the costs and workload of organizers associated with "on-site" participants' registration in open public events.

II. MATERIALS AND METHODS

Authors of this research used data sets and evidence from development projects administered by them individually or all together:

a) Data sets from experimental sports events series "Latgale Open" (2015-2019) [5] (Table 1):

TABLE 1 SPORTS EVENT SERIES "LATGALE OPEN" STATISTICS

Year	Registered events and participants		
	Number of events	*Number of participants*	*Number of runs*
2015	6	522	791
2016	10	765	1100
2017	9	725	1277
2018	14	840	1622
2019	9	595	1535
In total	48	3447	6325

b) Experimental participants registration datasets from Sports study program students' admission exam at the University of Shkodra "Luigj Gurakuqi", Albania, within a period of 2017-2019.

c) Knowledge transfer and innovation process modelling of SPORTident Center system- the worldwide results platform for orienteering events [6].

d) Open public event participants' mobile app for self-registration system (in development, on verification phase) [7].

Nowadays, "Industrie 4.0" modelling concept [8], [9] and complex digital transition process of enterprises [10], [11] are key aspects to increase competitiveness and effectiveness of companies. In times of digital transformation, a company's ability to survive depends upon its ability to continuously adapt its operations, its information system, and even its business model [12]. In this paper authors align theories of business modelling, enterprise modelling and service-oriented modelling in one coherent system to reach the specific aim of research with practical business outcomes.

Society today is entirely dependent on technologies. Every day new and diverse technologies are developed. To invest time and money, it is first necessary to predict the sustainability of technology [13]. Following by latest trends in the business process modelling theory authors propose public events participants' registration system model based on service-oriented business process modelling (SoBPM) approach [14]. Service-oriented Business Model Framework is one of the widely used service-dominant logic based approaches for Business Modelling in the Digital Era [15].

As basis for the development of the proposed model and understanding of necessary "building blocks" were adapted basic POS (participants-organizers-spectators) model framework [4]. The analytic modelling framework of POS formulates basic model concepts and properties (Table 2):

• Concrete concept- "Agent Type";

• Abstract concepts- "Roles", "Permissions", "Responsibilities".

TABLE 2 CONCEPTUAL TYPOLOGY AND DEFINITION OF "AGENTS"

Agents	Abstraction level		
	ROLES	*PERMISSIONS*	*RESPONSIBILITIES*
"P" Agents (parti-cipants)	Active Agent	Formal and informal rules; Minimal required level of physical and mental conditions to perform tasks	Objective self-assessment of personal physical and mental conditions; Following to orders and directions of "O" Agents; **Application to Registration protocols**
"O" Agents (event orga-nizers, trainers, teachers)	Active /Passi-ve Agent	Specific legislation and administrative orders; Acceptance of municipal and event rules	Event rules setting; Promotion and attracting of participants and spectators; **Registration of participants;** Setting up of competition environment; Safety rules; Technical equipment setting-up and certification; Recording, capture and publishing of results
"S" Agents (specta-tors, results ex-post users,	Passi-ve Agent	Passive participant, no need of specific permissions	Following to legislation and special administrative orders; Stated formal municipal, school and/or informal family rules; Stated special

Agents	Abstraction level		
	ROLES	*PERMISSIONS*	*RESPONSIBILITIES*
trainers teachers)			orders and rules of event organizers

In the next step authors made a segmentation and detailed analysis of "P" Agents and "O" Agents to identify services and protocols relevant for event registration activity. "S" Agents, as passive agents, do not take part in the formal registration process and excluded from further analysis.

A. *Setting of services and activity protocols for "P" Agents (AP) (participants) and "O" Agents (AO) (organizers).*

a) **Implementation layer (services):**

• Service 1 [S1]: Promotion, partnership agreements, contracting, advertising (online, direct);

• *Service 2 [S2]: Registration of participants into event database (online, direct, ITC system);*

• Service 3 [S3]: Activity environment and specific exercise area setting up (direct, ITC system);

• Service 4 [S4]: Configuration and setting up of ICT support system for a specific event (online, direct, ICT system);

• Service 5 [S5]: Setting up traditional event support equipment, tools, premises and service team (direct);

• *Service 6 [S6]: Basic on-site services of "Agents" during the event (direct, ITC system);*

• *Service 7 [S7]: Special timing, activity registration and results processing service of participants during the event (online, direct, ITC system);*

• *Service 8 [S8]: Final awards and prizes giving ceremony (direct);*

• Service 9 [S9]: Dismounting of event support equipment, tools, premises and cleaning up of event area (direct);

• *Service 10 [S10]: Final and overall results calculations and publishing (online, ITC system).*

Services that use participants' registration data is marked above in *italics*.

b) **Design layer (activity protocols, with identification of related services):**

• *Protocol 1 [P1]: Non-static, changing, and safe mass activity environment, with integrated advanced ITC systems [S1][S3][S9];*

• *Protocol 2 [P2]: Every "P" Agent is involved during exercise with maximum time and efforts [S2][S3][S6];*

• *Protocol 3 [P3]: Variable difficulty of exercises and courses for different ages and classes [S2][S3][S5];*

• *Protocol 4 [P4]: Limited possibility to compare ongoing performance during the race (not to loose motivation for weak participants), results only after finish [S3][S4];*

• *Protocol 5 [P5]: All individual inputs and performances are measured [S7][S10];*

• *Protocol 6 [P6]: Results are processed and published immediately after finish [S4][S7];*

• *Protocol 7 [P7]: Individual and total team results scored and processed [S4][S7][S10];*

• *Protocol 8 [P8]: Organization of separate multi-task exercises with integration into bigger serial events [S1][S7][S6][S10];*

• *Protocol 9 [P9]: All/best participants must be promoted (diplomas, medals, prizes, cups) [S8];*

• *Protocol 10 [P10]: All participants have "correct and fair results" after completing of exercise [S7][S10];*

• *Protocol 11 [P11]: Also incompletely passed courses and exercises counted and evaluated [S7][S10];*

• *Protocol 12 [P12]: Competition environment is sizeable and flexible (all ages, any physical condition, different numbers of participants) [S1][S3][S4][S6][S9];*

• *Protocol 13 [P13]: Event data are digitally recorded, stored and published [S7][S10];*

• *Protocol 14 [P14]: Integrated tools and mechanisms to simple transfer of "Agents" from "passive" to "active" [S2][S4][S6][S8].*

Activity protocols, which use participants' registration data is marked above in *italics*.

B. *Segmentation of "P" Agents (motivation layer), with identification of related activity protocol:*

• ***Participants- "children"*** (AP1): "eager to get new knowledge" [P1];

"like to explore new things" [P1][P2][P3];

• ***Participants- "youngsters"*** (AP2): "like to test new challenges" [P1][P3];

• ***Participants- "all participants"*** (APX):

"humans like to "socializes" [P1][P8][P14];

"humans all the time compete to each other" [P5][P6][P7];

"like to try "stylish" things and modern gadgets" [P1][P13];

"humans like to win" [P5][P6][P7][P9];

"nobody like to lose" [P4][P10][P11];

""team spirit" improves individual performance" [P7][P8];

"no fear or shame during performance" [P4];

"calculated and visible improvements of individual performance" [P4][P8][P13];

"full respected to "Fair play" rules, no possibility to cheat, correct results" [P10].

After summarizing modelling properties mentioned above, authors created "P" Agents (AP) (participants) event activity flow model in BPMN2 notation using ADONIS:CE modelling environment (Fig. 3) (https://www.adonis-community.com/en/) and interactive "P" Agents (AP) (participants)/ "O" Agents (AO) (*organizers*) event activity flow model in BPMN2 notation using ARIS ELEMENTS modelling environment (Fig. 3) (https://ariscloud.com/aris-elements/). The design of the both models is displayed in the next chapter.

III. RESULTS AND DISCUSSION

Statistical analysis of data sets from experimental sports events series "Latgale Open" (2015-2019) [5] (Table 1) indicates a fluctuating number of participants from year to year, but growing average number of participants per event (Fig.1) and significantly growing number of runs (Fig. 2) per Year.
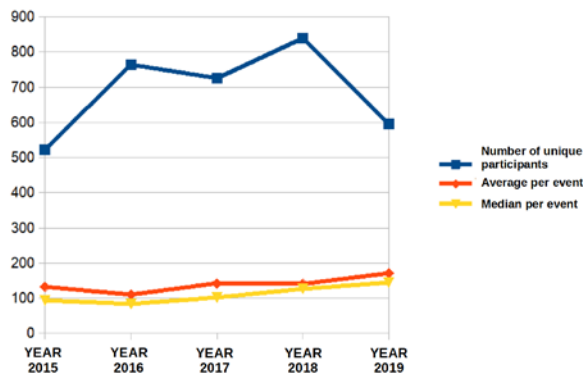
Fig. 1. Number of participants in experimental event series "Latgale Open".

In real business process activities of enterprise, it means less events with a low number of participants and more events with a high number of participants. Such progress significantly reduce fixed costs per event with relatively small growth of variable costs per participant.
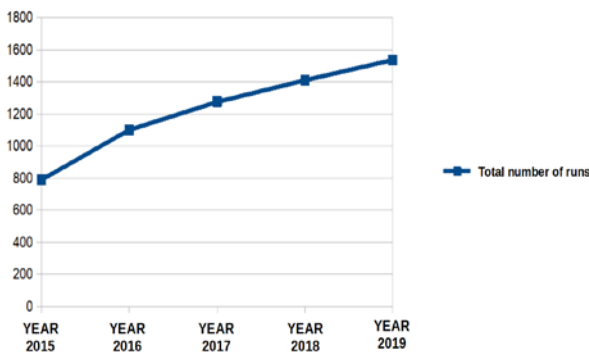
Fig. 2. Number of runs in experimental events series "Latgale Open".

From experimental data sets there were produced participants' registration timing data analysis in Year 2015. The first registration for each participant had been done manually, with assignment of unique identification number (from 1 up to 9999). After the initial registration, this unique identification number had been associated in digital database with participant's individual properties- name, surname, team/club, start group and, optionally, with personal RFID card number for further use during the next events. Participants' registration timing data statistical analysis had been validated in two different modes- 513 registration cases before start (Table 3) and 499 registration cases after finish (Table 4). Because of statistic analysis software PSPP difficulties dealing with relative time calculation data were converted into decimal form by writing of script:

```
=CONVERT(Xn, "day", "hr"
```

TABLE 3 PARTICIPANTS' REGISTRATION TIMING DATA (BEFORE START)

START_REG	Value	Time
Mean	0.010894520251245	**00:00:39**
Standard Error	0.000278081193116	
Mode	0.006111111111111	**00:00:22**
Median	0.008888888888889	**00:00:32**
First Quartile	0.007222222222222	
Third Quartile	0.010833333333333	
Standard Deviation	0.006298400902756	
Kurtosis	16.3059579171693	
Skewness	3.08518851349957	
Range	0.058611111111111	
Minimum	0.005555555555556	
Maximum	0.064166666666667	
Sum	5.58888888888889	
Count	513	

TABLE 4 PARTICIPANTS' REGISTRATION TIMING DATA (AFTER FINISH)

FIN_REG	Value	Time
Mean	0.011087731017591	**00:00:40**
Standard Error	0.000276538978528	
Mode	0.007222222222222	**00:00:26**
Median	0.008888888888889	**00:00:32**
First Quartile	0.007222222222222	
Third Quartile	0.012083333333333	
Standard Deviation	0.00617741284972	
Kurtosis	17.734126842657	
Skewness	3.18923817163189	
Range	0.058055555555556	
Minimum	0.006111111111111	
Maximum	0.064166666666667	
Sum	5.53277777777779	
Count	499	

From experimental data statistical analysis above, we can draw a conclusion that manual registration of each open

event participant takes almost equal time (39 and 40 seconds respectively) if it is done before start or after finish.

This approach allows for "O" Agents (organizers) to organize the registration process with a higher degree of flexibility to avoid long waiting lines at the start and finish

registry desks (Fig. 3). The next registration model improvement can be done by transfer of registration activity (rights and responsibility) from "O" Agents (organizers) to "P" Agents (participants) in the form of "self- registration" option.
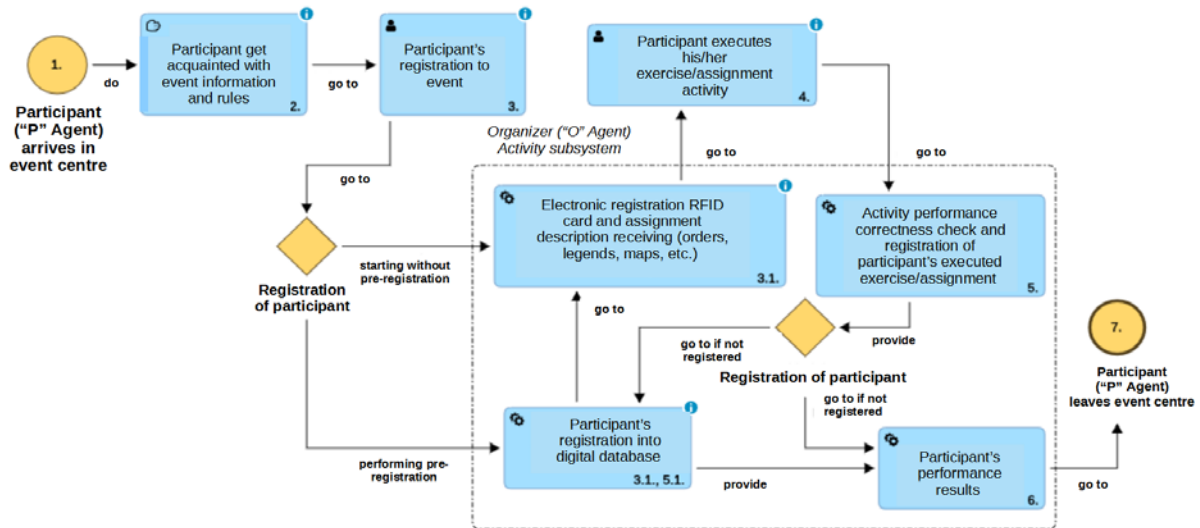
Fig. 3. "P" Agents (participants) event activity flow model in BPMN2 notation (validated in ADONIS:CE modelling environmen
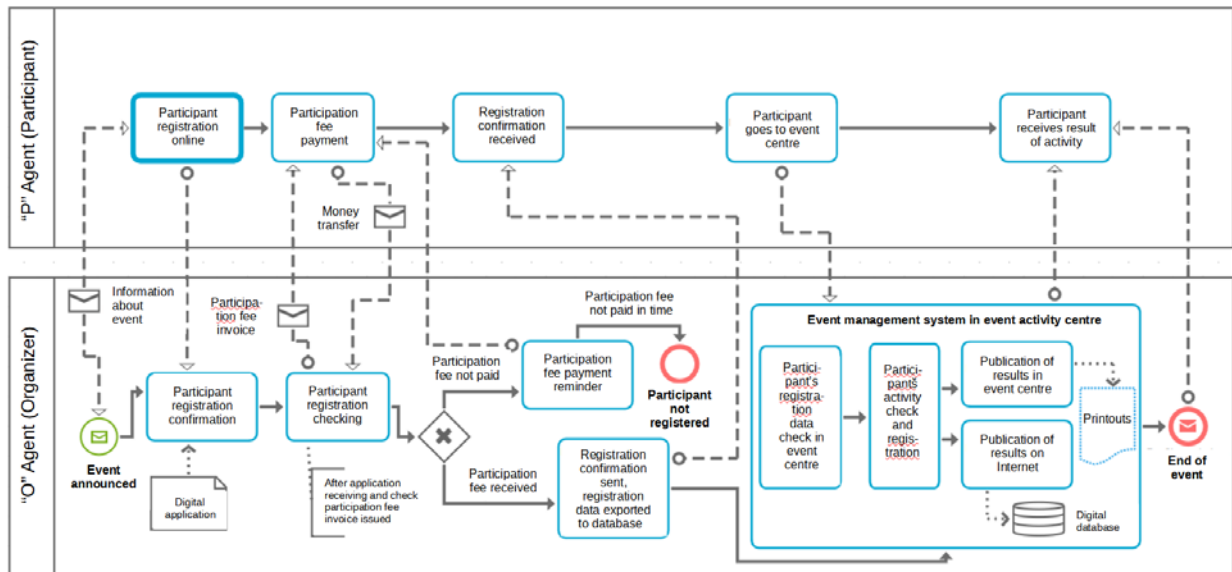
Fig. 4. Online registration activity of event flow model in BPMN2 notation (validated in ARIS Elements modelling environment)

For events with integrated possibility of preliminary registration online (Fig. 4) it can be done easily, but for open events this option does not work because new participants appear directly before or even during event. Authors of this paper proposes extensive use of smartphones for self-registration of participants in open public events. There are already existing such applications at hobby and amateur sports activity market based on technologies like QR codes (QREvents https://sites.google.com/view/azdev/home/user-manual-

qrevents-full), Internet-Bluetooth-GPS integration (MapRunners http://maprunners.weebly.com/quick-guide.html), (iOrienteering (https://www.iorienteering.com/ and others. Such apps are working well for events where timing and activity registration is done by smartphones only, but if there is a need to use external professional sports timing and activity registration equipment, for instance- RFID devices, than still connection of participant's properties (surname, name,

team, start group) and RFID tag identification must be done manually upon self-registration process.

In year 2018 SPORTident GmbH launched "SPORTident Center" results management platform (https://center.sportident.com/), integrated with Android event management system "SPORTident Orienteering App" (https://www.sportident.com/orienteering-app.html). This fully integrated system connects professional RFID timing equipment with event management software on a smartphone (Fig. 5) and "SPORTident Center" data server.

Fig. 5. Integrated SPORTident RFID data readout, event management and results printout system

However, still one major problem persists in all existing systems to make self-registration options for participants on open public events. System is always trying "to couple" two components- participant's properties and RFID tag identification number. In cases when the same tag is re-used again for other runners on mass events, it requests a manual re-registration process once again. As a solution here for open public mass events is assigning of individual participant number upon "self-registration" process which is unique and directly connected only with participant's properties nor RFID tag number. Similar principle is used, for instance, on desktop event results management program SIME (https://www.tak-soft.com/products/sport/sime/) where each participant receives his unique "participant number". The problem here occurs in case of big size participants' databases because, as usual, five or six numbers identification number is difficult to memorize for participants. Considering findings of the latest research in the sports events management area, participant satisfaction is a key factor to take part to pay for and return to well-organized competitions [16], [17], [18], [19].

As an alternative solution authors of this paper, in association with Vidzeme University of Applied Sciences students, had been developed enhanced registration app prototypes. In these prototypes a unique participants' identification is provided upon self-registration process via smartphones in easy memorable form. The identification formed with two letters and one-to-four numbers (example: AA1966- Aigars Andersons, born in 1966), duplicated with individual QR codes, as an option but not coupled with

RFID tag number [20]. Screenshots of prototypes are shown below (Fig. 6). The basic data classes provided by "O" Agents (organizers):

- D1→ Name of event (mandatory);

- D2→ Participation classes/groups of event (mandatory);

- D3→ Distances with identified length and number of controls (mandatory);

- D4→ Surname and Name of participant from database (mandatory);

- D5→ Team or club of participant (optional);

- D6→ Birth data of participant (optional);

- D7→ Running time of participant (mandatory);

- D8→ Participant's running time comparison with best running time (optional);

- D9→ Place occupied by a participant on event (mandatory).
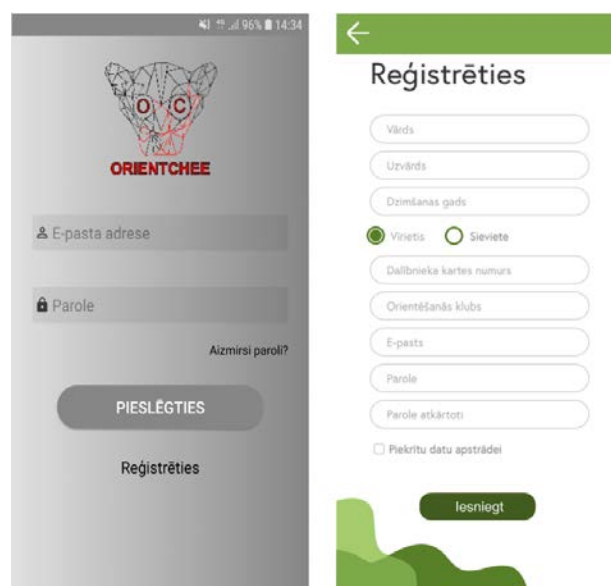
Fig. 6. Screenshots of prototypes for event participants' registration app (on the left- the first prototype of "Orientchee" app, on the right- the latest prototype of "RunReady" app)

The basic data classes input by "P" Agents (participants) upon self-registration:

- ID1→ RFID tag identification number (optional/mandatory);

- ID2→ Surname and Name of participant from manual input, database record or RFID tag data (mandatory);

- ID3→ Participant's class/group to execute (mandatory);

- ID4→ Team or club of participant from manual input, database record or RFID tag data (optional);

- ID5→ Birth data of participant from manual input or database record (optional);

- ID (x1-xn)→ Another relevant data classes of participant from manual input (optional).

IV. CONCLUSIONS

On open public events requested mandatory data input from participants, even in "self-registration mode" must be limited according to the General Data Protection Regulation (GDPR), purpose limitation is a requirement that personal data be collected for specified, explicit, and legitimate purposes, and not be processed further in a manner incompatible with those purposes (Article 5(1)(b), GDPR). Visible announcement about participant's voluntary data input must be clearly shown before registration data input.

There are existing significant barriers for participants' registration on open public events where preliminary online registration systems are non-existent or forbidden. In such cases best solution is to provide unique participants' identification upon self-registration process via smartphones in easy memorable form and duplicated with individual QR codes with optional possibility to be tied with specific RFID tag number, Bluetooth or NFC code.

Authors experimented also with computerized terminals for self-registration of participants. In reality, queues at these terminals were much longer than traditionally at the start manual data registration desks. This solution was declined as unsustainable.

For mass open public events registration system must not be limited by one registered cell phone number but the same device can be used for multiple registrations (authors of this research frequently met situations during events with one teacher or trainer and many underage kids with limited Internet data plans for their smartphones or without smartphones at all, in this case registration for all kids had been done from teacher's smartphone).

V. ACKNOWLEDGMENTS

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Indicators of Formalized Description Quality and Analysis of Production Technologies

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Abstract - **This paper discusses conceptual basis for assessment and analysis of model quality relating to formalized description of technologies. The authors give indicators used to assess formalized and textual descriptions of technologies. They raise some questions concerning the analysis of technologies that enable to make a list of indicators. The paper examines decomposition structures of specific technologies and provides the calculations of introduced coefficients.**

Keywords - coefficient, concept, decomposition structure, technology.

I. INTRODUCTION

The conceptual basis for evaluating and analyzing the quality of models is a very relevant task. The main research directions of this scientific problem are considered in this paper [1]. With regard to the issues raised on the quality assessment of formalized descriptions of production technologies (hereinafter referred to as technologies), constructed in accordance with the fundamental principles of the developed method [2, 3], and the development of technology characteristics based on their structural organization, it seems logical to talk about using the basics of structural and topological analysis [4]. Nevertheless, it worth mentioning that present structural and topological characteristics of systems obtained by analyzing traditional topological structures [5] are not suitable for obtaining the results of the above-mentioned actions. This circumstance, first of all, is caused by the impossibility of their practical application to solve the identified issues due to the existing features of the topological organization of the formed decomposition structures of technologies (DST) [6]. In this regard, we propose our own set of indicators of formalized description quality and analysis of technologies, obtained on the basis of studying the topology of the obtained ontological representations [7], which is quite consistent with the general approaches implemented in this field [8] – [10].

II. DETERMINING A SET OF INDICATORS

To assess the quality of the formalized description of technologies in comparison with their alternative textual descriptions, two indicators are introduced (when considering them, we take into account only fully formed concepts [11]):

$$A)\ K_a = \frac{k_{TD_{formalize}}}{k_{TD_{textual}}}, \tag{1}$$

where K_a – the coefficient of the content completeness of concepts, $k_{TD_{formalize}}$ and $k_{TD_{textual}}$ –the number of concepts of the formalized and textual descriptions of the technology, respectively;

$$B)\ K_b = \frac{k_{P_{formalize}} + k_{F_{formalize}}}{k_{P_{textual}} + k_{F_{textual}}}, \tag{2}$$

where K_b – the coefficient of the explicit relation of concepts, $k_{P_{formalize}}$ and $k_{F_{formalize}}$ – the number of intra-level and inter-level relations between the concepts of the formalized description of technology, respectively, $k_{P_{textual}}$ и $k_{F_{textual}}$ – the number of intra-level and inter-level relations between the concepts of the textual description of technology, correspondingly.

For K_a in formula (1), the content completeness of concepts is understood as the fact of their complete formation according to definition 2, formulated on the basis of the proposed model [2].

For K_b in formula (2), the explicit relation of concepts is understood to mean that they have both intra-level relations of immediate precedence by definition 3, in accordance with the fulfillment of the theoretical propositions 1-3, and inter-level relations («part-whole») by definition 7, in accordance with the implementation of the theoretical proposition 4 [2].

The proposed method of formalized description of technologies [2] allows us to raise and solve a number of issues related to the analysis of the technologies under consideration, related to the determination of the following list of indicators (when considering them, we consider only fully formed concepts [11]). Let`s focus on each in a more detailed way.

1) The degree of participation of all DST concepts in the formation of the main technology implementation route reflects the coefficient of non-branching technology:

$$K_1 = \frac{k_{d^*_{formalize}}}{k_{d_{formalize}}}, \qquad (3)$$

where K_1 – the coefficient of non-branching technology, $k_{d^*_{formalize}}$ and $k_{d_{formalize}}$ - the number of concepts taking part in the formation of the main technology implementation route and all DST concepts, respectively.

The non-branching of the technology is understood as the determination of the maximum depth of the DST, which is identified with obtaining the main route for the implementation of the technology.

2) The degree of participation of all DST concepts in the formation of the longest decomposition level among all unified decomposition constructions (UDC) DST shows the concentration coefficient of the technology:

$$K_2 = \frac{k_{s^*_{formalize}}}{k_{s_{formalize}}}, \qquad (4)$$

where K_2 – the concentration coefficient of the technology, $k_{s^*_{formalize}}$ and $k_{s_{formalize}}$ – the number of concepts presenting decomposition level of the most massive UDC and all the DST concepts respectively.

The concentration of the technology is understood as determining the maximum width of the decomposition level among all UDC DST, which is identified with obtaining the length of the decomposition level of the most massive UDC DST.

3) The degree of distribution of all DST concepts by the holistic UDC concepts reflects the coefficient of grouping technology:

$$K_3 = \frac{k_{t^*_{formalize}}}{k_{t_{formalize}}}, \qquad (5)$$

where K_3 – the coefficient of grouping technology, $k_{t^*_{formalize}}$ and $k_{t_{formalize}}$ – the number of concepts located in the apexes of UDC and all DST concepts correspondingly.

The grouping of the technology is understood as determining the common number of decomposition levels of all UDC DST.

4) The share of DST concepts fulfilling the implementation of the technology with the help of the equipment (machines, tools, etc.) shows the mechanization coefficient of the technology:

$$K_4 = \frac{k_{TD^W_{formalize}}}{k_{TD_{formalize}}}, \qquad (6)$$

where K_4 – the mechanization coefficient of the technology, $k_{TD^W_{formalize}}$ and $k_{TD_{formalize}}$ – the number of concepts where equipment is used and all the DST concepts respectively.

The mechanization of the technology is understood as its implementation by means of different kinds of equipment.

5) The share of DST concepts that ensure the correct implementation of the technology by introducing third-party inclusions from outside reflects the coefficient of third-party inclusions of the technology:

$$K_5 = \frac{k_{TD^X_{formalize}}}{k_{TD_{formalize}}}, \qquad (7)$$

where K_5 – the coefficient of third-party inclusions of the technology, $k_{TD^X_{formalize}}$ and $k_{TD_{formalize}}$ – the number of concepts which demand the implementation of the third-party inclusions and all the DST concepts respectively.

The third-party inclusions of the technology are understood as material components, without the use of which it is impossible to ensure the correct implementation of the technology.

III. The Range of Technologies under Consideration

According to the text of the introduction of this article, the object of research is technologies focused on material production. The implementation of modern technologies

is impossible either without specific industrial enterprises (plants, factories, etc.), each having a specific industry orientation, and production laboratories, or without the participation of qualified labor. In this paper, we consider technologies in the form of standardized textual descriptions that do not contain language contradictions and semantic omissions [12, 13]. These descriptions take into account the compatibility factor of the material components [14] involved in determining the concepts of technological actions. The most widespread in material production are those areas that are characterized by the following features, both in terms of the specifics of the description and in terms of the conditions for the implementation of specific technologies [2]:

- the representation of the possible cyclicity of individual technological actions can be considered in the form of a corresponding technological chain of concepts of technological actions;

- the output of any of the technological actions can only be input to one other technological action within the decomposition levels;
- if there is a cumulative input for a certain technological action, its formation will take place in accordance with the scheme of logical AND [15];
- numerical values of the corresponding cost characteristics of the concepts of technological actions located in the nodes of the DST have the property of additivity.

Numerous technologies fully meet these assumptions. Among them are the technologies of clothing production [16], a significant part of construction technologies [17] and mechanical engineering technologies [18]. As concrete examples, this article discusses the technological sequences of mechanical processing a part of the «Screw» type (Fig. 1, left) [19], the construction of a brick residential house (Fig. 1, right) [20], the making of men's trousers (Fig. 2), men's coat (Fig. 3) and men's jacket (Fig. 4) [21] – [24].
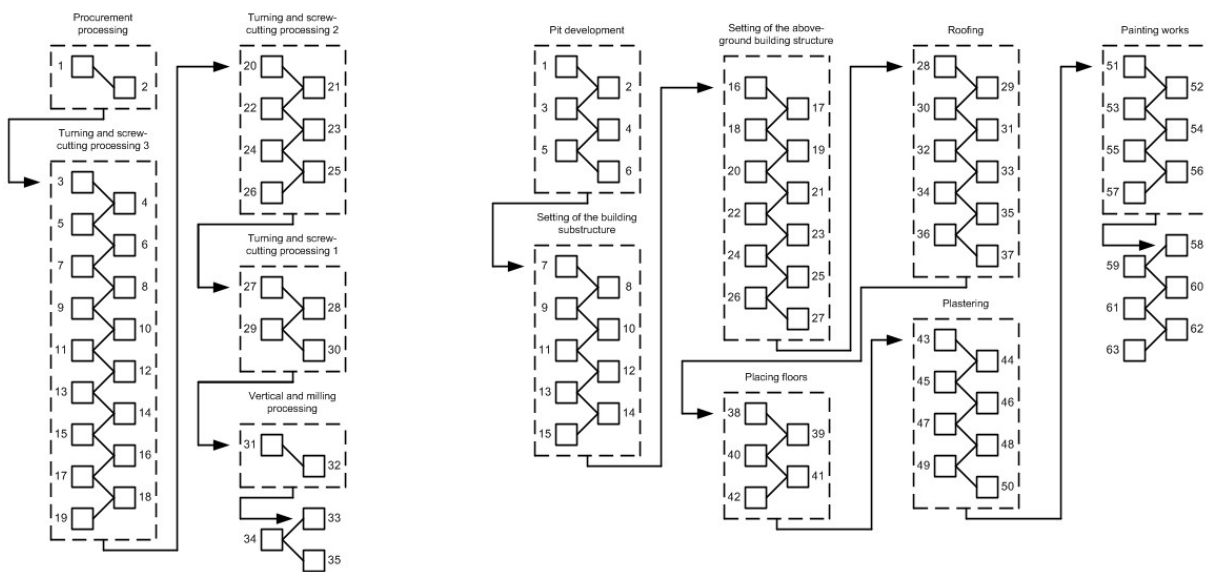
FIG. 1. TECHNOLOGICAL SEQUENCE OF MECHANICAL PROCESSING A PART OF THE «SCREW» TYPE (LEFT) AND TECHNOLOGICAL SEQUENCE OF A BRICK RESIDENTIAL HOUSE CONSTRUCTION (RIGHT).
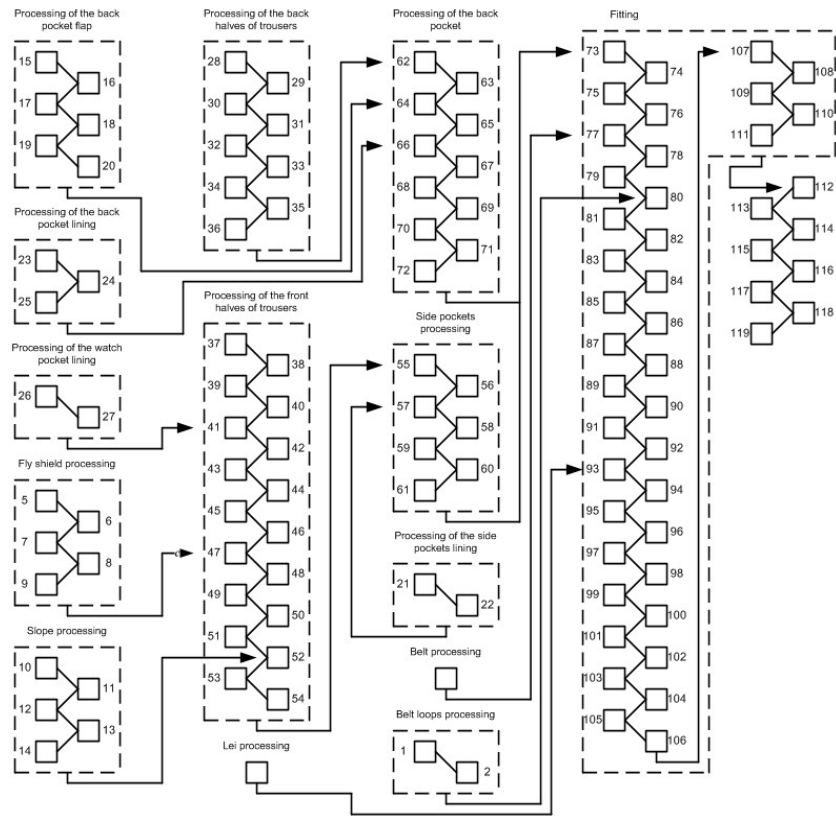
FIG. 2. TECHNOLOGICAL SEQUENCE OF MEN`S TROUSERS MAKING
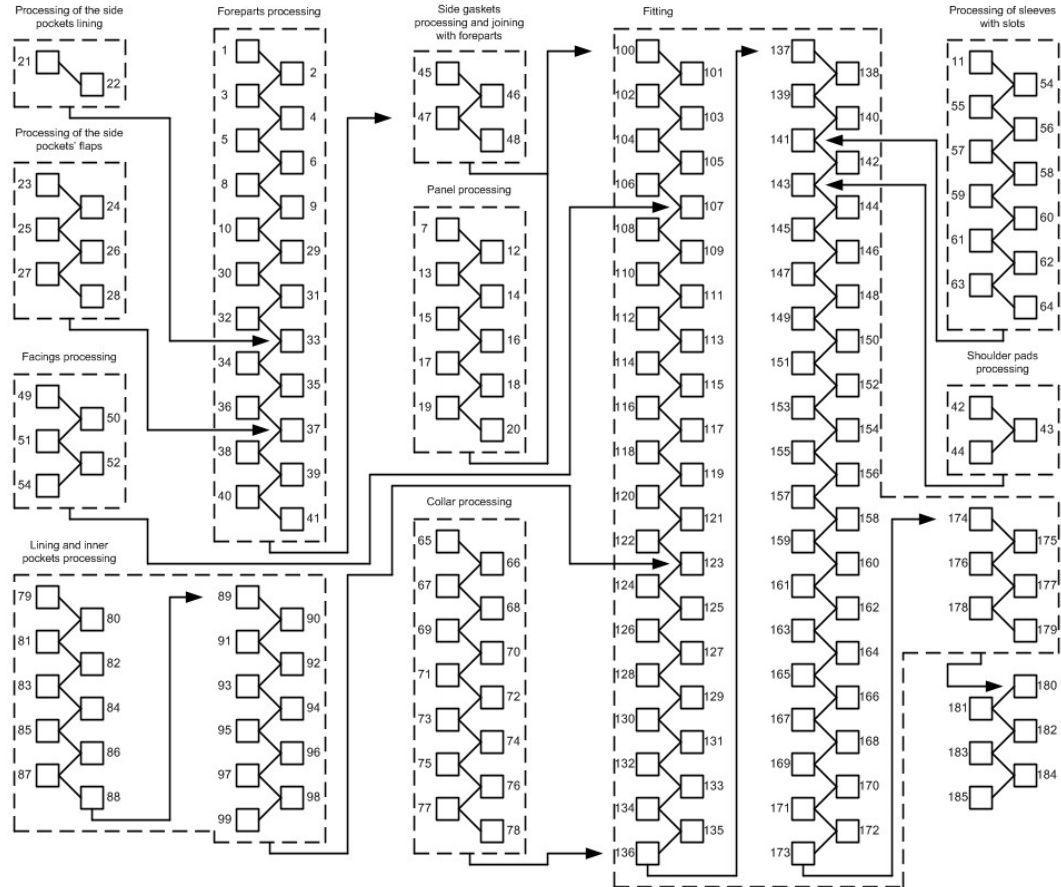
FIG. 3. TECHNOLOGICAL SEQUENCE OF MEN`S COAT MAKING
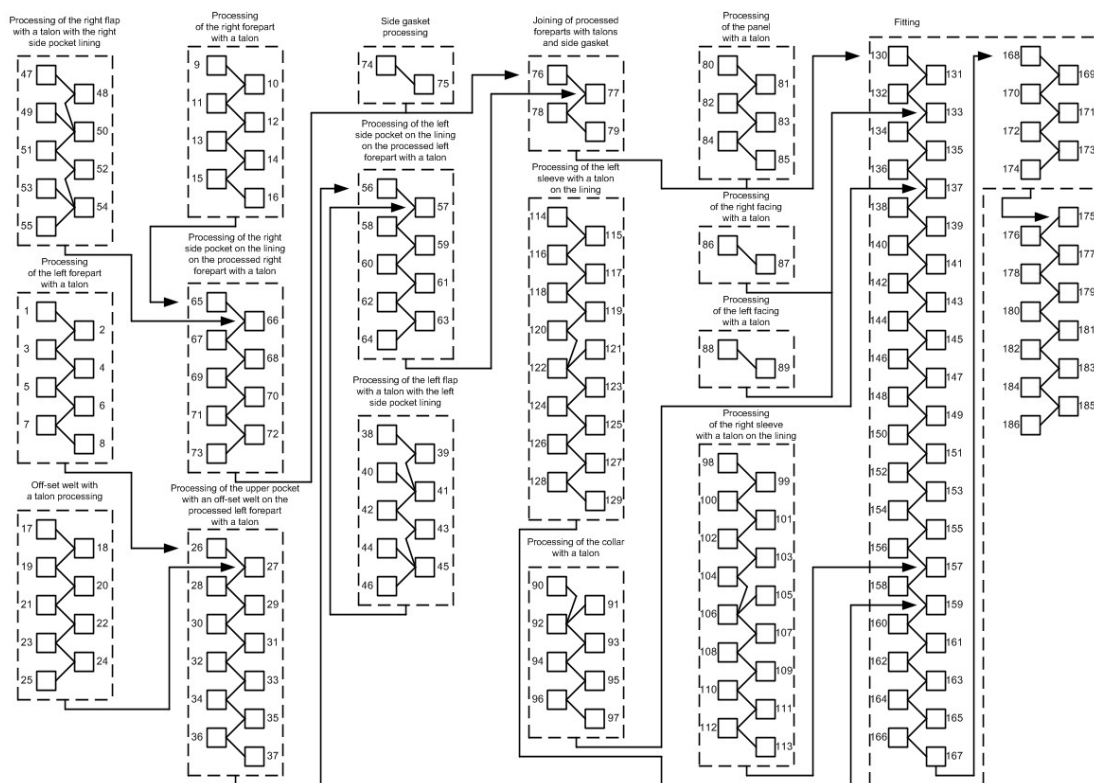
FIG. 4. TECHNOLOGICAL SEQUENCE OF MEN'S JACKET MAKING

IV. QUANTITATIVE CALCULATIONS OF THE COEFFICIENTS INTRODUCED

According to the analytical descriptions of all these indicators, which are presented in paragraph II, it is proposed to make their quantitative calculation for all the technologies under consideration. We are talking about the technology of making a men's jacket (TMM jacket), the technology of making a men's coat (TMM coat), the technology of making men's trousers (TMM trousers), the technology of construction a brick residential house (TCBR house) and the technology of mechanical processing a part of the «Screw» type (TMPP «Screw»).

First, we present the quantitative calculation results of indicators of formalized description quality of technologies.

A) Determination of the coefficient of the content completeness of concepts:

- For TMM jacket $K_a = \dfrac{204}{186} = 1,097$;

- For TMM coat $K_a = \dfrac{197}{185} = 1,065$;

- For TMM trousers $K_a = \dfrac{132}{119} = 1,109$;

- For TCBR house $K_a = \dfrac{71}{63} = 1,127$;

- For TMPP «Screw» $K_a = \dfrac{41}{35} = 1,171$.

B) Determination of the coefficient of the explicit relation of concepts

- For TMM jacket

$$K_b = \frac{184 + 203}{167 + 0} = \frac{387}{167} = 2,317;$$

- For TMM coat

$$K_b = \frac{181 + 196}{170 + 0} = \frac{377}{170} = 2,218;$$

- For TMM trousers

$$K_b = \frac{117 + 131}{105 + 0} = \frac{248}{105} = 2,362;$$

- For TCBR house

$$K_b = \frac{62 + 70}{55 + 0} = \frac{132}{55} = 2,4;$$

- For TMPP «Screw»

$$K_b = \frac{34 + 40}{29 + 0} = \frac{74}{29} = 2,552.$$

The obtained values of the coefficients K_a and K_b for the technologies under consideration also indicate the advantage of formalized descriptions of technologies over their alternative textual descriptions: in terms of the

indicator K_a – from 6.5% to 17.1%, and in terms of the indicator K_b – more than twice.

Let`s consider the results of the quantitative calculation of the technologies analysis indicators.

1) Determination of the non-branching coefficient

- For TMM jacket $K_1 = \dfrac{104}{204} = 0,51$;

- For TMM coat $K_1 = \dfrac{123}{197} = 0,624$;

- For TMM trousers $K_1 = \dfrac{84}{132} = 0,636$;

- For TCBR house $K_1 = \dfrac{71}{71} = 1$;

- For TMPP «Screw» $K_1 = \dfrac{41}{41} = 1$.

Therefore, the more DST concepts are involved in the formation of the main technology implementation route the closer indicator K_1 is to the singular.

2) Determination of the concentration coefficient;

- For TMM jacket $K_2 = \dfrac{52}{204} = 0,255$;

- For TMM coat $K_2 = \dfrac{87}{197} = 0,442$;

- For TMM trousers $K_2 = \dfrac{44}{132} = 0,333$;

- For TCBR house $K_2 = \dfrac{13}{71} = 0,183$;

- For TMPP «Screw» $K_2 = \dfrac{18}{41} = 0,439$.

Turns out that the more DST concepts are involved in the formation of the longest decomposition level among all DST UDC, the closer the indicator K_2 is to a singular.

3) Determination of the grouping coefficient:

- For TMM jacket $K_3 = \dfrac{18}{204} = 0,088$;

- For TMM coat $K_3 = \dfrac{12}{197} = 0,06$;

- For TMM trousers $K_3 = \dfrac{13}{132} = 0,098$;

- For TCBR house $K_3 = \dfrac{8}{71} = 0,113$;

- For TMPP «Screw» $K_3 = \dfrac{6}{41} = 0,146$.

Thus, the less DST concepts are distributed among the holistic concepts of the UDC DST, the closer the indicator K_3 is to 0.5.

4) Determination of the mechanization coefficient:

- For TMM jacket $K_4 = \dfrac{148}{204} = 0,725$;

- For TMM coat $K_4 = \dfrac{129}{197} = 0,655$;

- For TMM trousers $K_4 = \dfrac{96}{132} = 0,727$;

- For TCBR house $K_4 = \dfrac{27}{71} = 0,38$;

- For TMPP «Screw» $K_4 = \dfrac{41}{41} = 1$.

Turns out that the more DST concepts ensure the technology implementation via equipment, the closer indicator K_4 is to the singular.

5) Determination of third-party inclusions coefficient:

- For TMM jacket $K_5 = \dfrac{58}{204} = 0,284$;

- For TMM coat $K_5 = \dfrac{58}{197} = 0,294$;

- For TMM trousers $K_5 = \dfrac{41}{132} = 0,311$;

- For TCBR house $K_5 = \dfrac{65}{71} = 0,915$;

- For TMPP «Screw» $K_5 = \dfrac{7}{41} = 0,171$.

Therefore, the more DST concepts ensure correct implementation of the technology via third-party inclusions, the closer indicator K_5 is to a singular.

Based on the results of the calculations made, it is possible to present a summary table of all values indicators (Table I), through which the analysis of the technologies under consideration is carried out.

TABLE 1 CALCULATED VALUES OF TECHNOLOGIES ANALYSIS INDICATORS

Technology name	Calculated indicator				
	K_1	K_2	K_3	K_4	K_5
TMM jacket	0,51	0,255	0,088	0,725	0,284
TMM coat	0,624	0,442	0,06	0,655	0,294
TMM trousers	0,636	0,333	0,098	0,727	0,311
TCBR house	1	0,183	0,113	0,38	0,915
TMPP «Screw»	1	0,439	0,146	1	0,171

V. CONCLUSION

This paper considers indicators of formalized description quality and analysis of technologies with the results of the corresponding calculations, which differ

from the existing indicators by their determination and calculation, based on the topological organization features of the DST formed.

Determining the indicators of content completeness and explicit relation of concepts allows us to assess the quality of the formalized description of technologies under consideration in quantitative terms. Based on the results of other calculations, a summary table of the values of the indicators is presented, through which the analysis of the selected technologies has already been carried out.

Thus, the formalized description of technologies under consideration fully meets the proposed quality criteria in the form of content completeness and explicit relation of concepts in comparison with their alternative textual descriptions, and previously developed models and algorithms [2] contribute to the effective analysis of technologies.

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Modification of the Minimal Bergman Model of the "Insulin-Glucose" System and its Implementation in MatLab/Simulink

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Abstract - The article discusses a modification of Bergman's minimal mathematical model of the "insulin-glucose" system, which allows simulating controlled exogenous sources of glucose and insulin into the patient's blood on the model and investigating the dynamics of changes in their concentrations in normal conditions, in type I DM and type II DM. A modeling scheme is presented in graphic notations of the MatLab / Simulink computer mathematics system and a number of computational experiments on it are described to determine the type of glycemic profiles of glucose and insulin concentration in the patient's blood in the noted situations. The fundamental possibility of using model mappings in the MatLab/Simulink environment for the study and tuning of the loop for automatic regulation of the "insulin-glucose" balance in the patient's blood using a controlled insulin pump is demonstrated. It was also found that the modified minimal model can be customized for a specific patient with diabetes, which makes it possible to use it to solve the problems of individual prediction of the development of a diabetic disease in a specific patient. In addition, the described model makes it possible to recreate and virtually investigate various conditions and cases on it that affect the dynamics of insulin and glucose concentrations in the patient's blood, for example, when he performs physically stressed activities, in the presence of the effects of "aging" of insulin-producing cells in the pancreas. iron, etc.

Keywords - Diabetes mellitus, Insulin-glucose balance, Glycemic monitoring, Computer simulation, Model personalization, Computational experiment.

I. INTRODUCTION

According to the World Health Organization (WHO), diabetes mellitus (DM) is currently a global problem on a planetary scale. The number of patients with diabetes in the world over the past 10 years has more than doubled, and is currently approaching 500 million people [1]. It is known [2] that DM is dangerous, first of all, due to its complications, in particular, such as: blindness, renal failure, heart attack, stroke, amputation of the lower extremities, etc. are still practically inevitable even if all recommendations of the attending physicians are followed [3]. Until now, there is not a single effective method of treatment to get rid of DM. It is for these reasons that such tasks are important as: increasing the effectiveness of diabetes prevention, ensuring high-quality current monitoring of the condition of a patient with diabetes, performing operational prediction and managing the concentration of glucose and insulin in his blood. In this case, the formation of insulin therapy regimens for patients with DM is based on the experience

and intuition of a doctor and is more an art [4], a medico-creative process, rather than the result of deductive inferences based on objective formalized diagnostic characteristics of a diabetic disease and information about the individual characteristics of its course in specific patients. Note that in the empirical selection of the parameters of insulin therapy for diabetes, the doctor, fearing the occurrence of a hypoglycemic state in the patient, is often limited only by the weakening of hyperglycemia. At the same time, the patient's condition remains insufficiently compensated, which condemns him to subsequent late vascular complications. Here, one of the most effective ways to increase the doctor's confidence in the safety of the process of normalizing glycemia in a patient with diabetes and, accordingly, to prevent or at least significantly reduce the likelihood of developing complications from diabetes is to use computational research sites at the stage of determining the modes and parameters of insulin therapy, where the objects of study are individualized (i.e. customized for specific patients with diabetes) mathematical models of the dynamics of glucose and insulin in their blood.

The aim of this work is to construct and analyze the options for using a patient-oriented simulation computerized model for regulating the concentration of glucose and insulin in the blood of a patient with diabetes with the possibility of studying different types of this disease on it.

Note that in relation to the subject of this article, models and methods of conducting computer experiments with them are of interest, which describe the processes of ensuring the balance of "insulin-glucose" in the blood of a patient with diabetes. The need for just such models and the results of their research is due to the fact that in the treatment of DM, the primary and main task is to normalize blood glucose levels and prevent hypo- and hyper-glycemic conditions in a patient. Naturally, the presence of a correct formal description of the "insulin-glucose" balance in the blood, adapted and adjusted for a particular patient, makes it possible to solve a number of clinical problems aimed at improving the health of a patient with diabetes. This is, firstly, the organization of continuous monitoring of the glucose level before and after its correction (if necessary); secondly, the modeling of the development of controlled endocrine and physiological processes using various schemes for correcting the insulin-glucose balance. In this case, the correction of the glucose concentration in the patient's blood can be manual in nature (then the task of the model system is to predict the conditions of potentially unfavorable development of processes and to warn the patient about the need for correction), or it can be carried out semi- or completely automatically (by using devices for minimally invasive exogenous insulin delivery with a guided insulin pump). In addition, the process of external insulin delivery (bolus, basal, or combined) and the patient's body response to such an effect should also be investigated under model conditions, at least for the correct calculation of the parameters of external insulin exposure.

II. LITERATURE REVIEW

From a mathematical point of view, biological functional systems, which include systems for regulating blood glucose concentration, are stochastic nonlinear systems with multi-compartment interactions [5]. Such systems include many interacting components at the organ, tissue, cellular and subcellular levels, reflecting the dynamic processes of controlling changes in the concentration of glucose and insulin in the blood plasma. simplifiedly called the "insulin-glucose" system.

When creating mathematical model constructions and schemes that allow performing computational experiments in order to predict the dynamics of changes in glucose and insulin concentrations in the blood of a patient with diabetes and to solve problems of their control, the following approaches are used [6, 7]:

1). Empirical or "black box" models that use real physiological and other data about the patient's condition that can, to varying degrees, affect the controlled levels of glucose and insulin in the blood of a patient with diabetes - these are the previous values of glucose and insulin concentrations, physiological parameters organism (weight, temperature, blood pressure, cardiac parameters, blood composition, etc.), properties of exogenous sources of glucose and insulin intake, etc. As basic mathematical representations, analytical schemes based on linear autoregressive mappings are used [8, 9, 10] and neural network mathematical constructions [11,12].

2). Theoretical or "complete" models, based primarily on the laws of physiology, built without involving additional empirical assumptions, - they describe physiological and pathophysiological processes occurring at the organ, tissue, cellular and subcellular levels, including the distribution and dynamic changes in glucose concentration and insulin in various organs and tissues of the body, the processes of absorption of exogenous glucose, its utilization and elimination, natural (in the pancreas) and artificial (from exogenous sources) mechanisms of insulin production, etc. Formal descriptions of complete models are based on compartment mappings and the mathematical apparatus of ordinary differential equations (ODE) [13, 14, 15], including ODE with delay [16, 17], as well as the apparatus of integro-differential formal notations [18] and graph theory [19].

3). Mixed or semi-empirical models using somewhat simplified mathematical constructions of theoretical models of key physiological and pathophysiological processes occurring at the organ and tissue levels and determining the conditions and mechanisms of regulation of carbohydrate metabolism in the patient's body, supplemented by empirical formed parameters,

characteristics and functions. The empirical components introduced into the formal model schemes make it possible to reproduce in simulation conditions the functions of exogenous intake of glucose and insulin into the patient's body [20, 21], including variants with the function of controlling the concentration of glucose in the blood [22, 23], the mechanisms of the relationship between blood glucose and subcutaneous adipose tissue [24], characteristics reflecting changes in glucose concentration in the interstitial space [25], factors that take into account the effect of physical activity on the functioning of the insulin-glucose system [26], etc.

Analyzing the mentioned model concepts, it should be noted that not all the noted formal structures are applicable for individual adaptation for specific patients, for organizing guided insulin therapy, and also for setting model notations for patients with different types of diabetes.

Thus, empirical models based on autoregressive structures make it possible to effectively solve the problem of predicting changes in the level of glucose in a patient's blood, since according to the analysis of time series of real measurements of its concentration, it is possible to generate a forecast of their future values based on known data from the past. It should be noted here that such models make it possible to predict with a sufficiently high reliability the concentration of glucose in the blood only for the near future - from 30-45 minutes [8.9] to 4 hours [10]. These models have proven themselves well when customizing them for specific patients with type 1 diabetes and without diabetes, but they are not very effective in recreating type 2 diabetes. Also, autoregressive formal schemes are not sufficiently adapted to the reproduction of exogenous sources of glucose and insulin intake, to the implementation of blood glucose control regimes, to taking into account other physiological factors in the regulation of carbohydrate metabolism in the blood.

Neural network empirical models are also generally quite efficiently tuned to specific patients and make it possible to predict future glucose levels [11,12] in his blood based on several previous values and / or some currently existing factors regulating carbohydrate metabolism. At the same time, it should be borne in mind that neural network models, before using them, require a training procedure, i.e. in fact, individualized adaptation-adjustment of the model for a specific patient, and this procedure is rather complicated and time-consuming, which significantly hinders its widespread use both in solving research problems and in the medical practice of an endocrinologist. Also, neural network model structures are rather difficult to adapt to the tasks of automating insulin therapy in patients with diabetes.

Theoretical model representations use equations characterizing physiological and pathophysiological processes associated with the insulin-glucose system, written, if possible, on the basis of "first principles" ("First principles" are natural laws of nature that allow to

substantiate any phenomenon without additional empirical assumptions or special models). This approach leads to the need to use in formal schemes high-order systems of ordinary (often nonlinear) differential, integro-differential, differential-graph equations. As examples of such models, let us mention J.T. Sorensen [27] (edited by researchers Parker R.S., Doyle F.J. et al. [28,29]), C. Cobelli et al. [30,31], Archimedes [32,33]. These models contain from 7 to 30 differential equations describing the mechanisms of glucose production and absorption, insulin release and utilization, and other physiological and pathophysiological processes that affect the "insulin-glucose" balance in the patient's blood. All noted models allow their customization for specific patients with diabetes, provide the opportunity to conduct model studies of all known types of diabetes (primarily types 1 and 2), make it possible to effectively predict the dynamics of changes in the concentration of glucose in the blood of a patient with diabetes in various life situations , and also on these models it is possible to recreate exogenous sources of glucose and insulin, incl. working in an automatic mode of insulin therapy for a patient with diabetes. However, the high and often excessive complexity of the development of such models, the significant difficulties in collecting and determining the values of biological variables that must be taken into account in their formal notations, prevent the widespread introduction of these model concepts into the clinical practice of endocrinologists.

In this regard, semiempirical models of the insulin-glucose system are the most convenient for implementation in medical practice for treating patients with diabetes. As a rule, mixed models are a system of 2-3, less often 4-6 nonlinear differential and / or integro-differential equations of the first order, on the right side of which there are a number of components reflecting the mechanisms of production, exogenous intake, utilization, elimination of glucose and insulin, as well as, if necessary, recreating the influence of other physiological parameters of the body associated with carbohydrate metabolism. Among the semiempirical models of the insulin-glucose system, we note the following:

1) The minimal model (Bergman R.N. [14], which has three ODEs (equations for the dynamics of glucose, insulin and an auxiliary variable describing the dependence of the concentration of insulin in the blood on the amount of absorbed glucose).

2) Model Sturis J. [13], which includes six TACs and is based on two negative feedbacks describing the absorption of glucose by insulin and the release of insulin by the pancreas depending on the amount of glucose supplied.

3) Three-piece model Nikita K.S. [34], in the composition of three TACs - two TACs for the dynamics of insulin absorption (ultrashort and short-acting) and one TAC of changes in the concentration of glucose in the patient's blood caused by the last meal.

4) Bennett D.L. and Gourley S.A. [13,16], in which systems of two ODEs with a lagging argument are used to describe the dynamics of glucose and insulin.

These models subsequently underwent many modifications and refinements, which made them more universal and flexible to the real conditions of insulin therapy for patients with diabetes. These are the already mentioned models with exogenous sources of glucose and insulin [20,21], with components of semi-automatic control of patient's insulin therapy [22,23], which made it possible to significantly increase the level of adequacy of empirical models (especially Bergman R.N. medtli) under conditions of type 1 diabetes ... These are models that take into account the mechanisms of the relationship between the blood glucose content and subcutaneous adipose tissue [24], reflecting factors influencing the change in the glucose concentration in the interstitial space [25], etc.

Analysis of the mathematical structures of the mentioned mixed models showed that almost all of them can be used for the tasks of predicting changes in the concentration of glucose in the blood at different stages of the breakdown of diabetes disease in a patient, as well as with exogenous regular or irregular intake of glucose into the patient intravenous intake of insulin into the body of a patient with diabetes, incl. when using an insulin pump controlled by feedback from blood glucose sensors. However, among the semiempirical model representations of the carbohydrate balance system in the patient's blood, the Bergman R.N. [14] and its modifications are, perhaps, the most convenient for reconstruction by means of computer mathematics due to the moderate complexity of the mathematical representation of this model, the high flexibility of its analytical design, and the good adaptability of the formal scheme of the model to the implementation of control actions.

III. MATERIALS AND METHODS

As software tools necessary for the development and construction of a model range for carrying out computational experiments with models of the insulin-glucose system, computer mathematics software systems, such as MapleModeller or SciLabXCos, can be used. However, the Matlab software system of computer mathematics (Matrix Laboratory) [35] with the Simulink extension possesses the best tools for simulation computational modeling. This environment is equipped with a good high-level language and an interactive environment for graphical visual programming, numerical calculations and visualization of the results of computational experiments with multi-domain dynamic systems and processes.

It is known [36] that an increased blood glucose level can be initiated by the following reasons:

a) insufficient production of insulin by β-cells of the pancreas;

b) the molecular structure of insulin is changed ("defective" insulin);

c) insulin is not recognized by cell receptors.

In case of insufficient insulin production (case (a)) diabetes mellitus is called insulin-dependent, or type I diabetes, in cases (b) and (c), when enough insulin is produced, but it is not recognized or is "defective", diabetes is called non-insulin dependent, or type II diabetes.

Let us introduce a number of starting points:

1) There is a certain patient-specific "nominal (normal, acceptable) level" of glucose concentration in the blood G_0.

2) If the current glucose concentration exceeds the value G_0, i.e. when $G(t) > G_0$, insulin is produced in proportion to the difference $(G(t) - G_0)$ (often with some time delay).

3) Insulin is a conductor of glucose through the cell membrane, thus mutual utilization (elimination) of insulin and glucose occurs in proportion to the product of their concentrations in the blood.

4) When the level of glucose concentration in the blood falls below the level G_0, i.e. when $G(t) < G_0$, there is a release of glucose from the liver in proportion to the difference $(G_0 - G(t))$.

5) After exceeding the current concentration of glucose in the blood of a certain upper value G_{cr}, i.e. when $G(t) > G_{cr}$, glucose is excreted from the body through the kidneys.

6) Insulin circulating in the blood can be in two forms - in a free state and associated with proteins. Hereinafter, insulin will always be understood as free insulin.

Based on the above and modernized equations of the Bergman minimal model. system "glucose-insulin", given in [21, 37], we will form the following system of nonlinear differential equations characterizing the dynamics of changes in glucose and insulin in the blood of a patient with diabetes:

$$\begin{cases} \dfrac{dI(t)}{dt} = \alpha\left(G_0^-\right)\theta\left(G_0^-\right) - \eta G(t)I(t) + L(t) \\[2mm] \dfrac{dG(t)}{dt} = \gamma\left(G_0^+\right)\theta\left(G_0^+\right) - \nu G(t)I(t) - \mu\left(G_{cr}^-\right)\theta\left(G_{cr}^-\right) + S(t) \end{cases}, (1)$$

where $G(t), G_0, G_{cr}$ – the previously mentioned designations; $G_0^- = G(t) - G_0$, $G_0^+ = G_0 - G(t)$, $G_{cr}^- = G(t) - G_{cr}$; $I(t)$ – the concentration of insulin in the blood at a point in time t; α – coefficient of insulin production by β-cells of the pancreas at $G(t) > G_0$; η – coefficient of utilization of insulin by glucose; γ – coefficient of glucose withdrawal from the liver to maintain its normal level in the blood; ν – coefficient of glucose utilization by insulin; μ – parameter of elimination of glucose through

the kidneys at $G(t) > G_{cr}$; (note that the values $\alpha, \eta, \lambda, \nu, \mu$ are personalized values); $L(t)$ – a function that takes into account the external supply of insulin; $S(t)$ – a function that takes into account the flow of glucose into the patient's blood (for example, as a result of his nutrition); $\theta(x)$ – Heaviside function of the form:

$$\theta(x) = \begin{cases} 0, \text{ if } x \le 0 \\ 1, \text{ if } x > 0 \end{cases}, \qquad (2)$$

where one of the following values is used as an argument: $x \in \left[G_0^-, G_0^+, G_{cr}^- \right]$.

Using the graphic notations of the MatLab / Simulink environment, we will form the following model constructions of the equations of system (1) - a model of the dynamics of insulin changes (Fig. 1) and a model of the dynamics of glucose changes (Fig. 2).
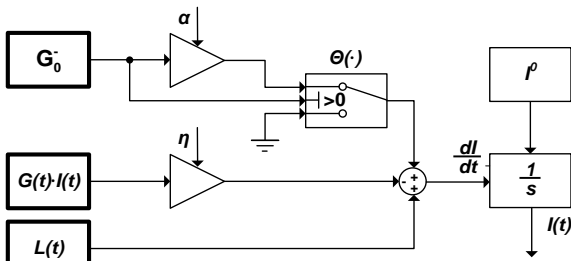
Fig. 1. Model of the dynamics of changes in insulin.
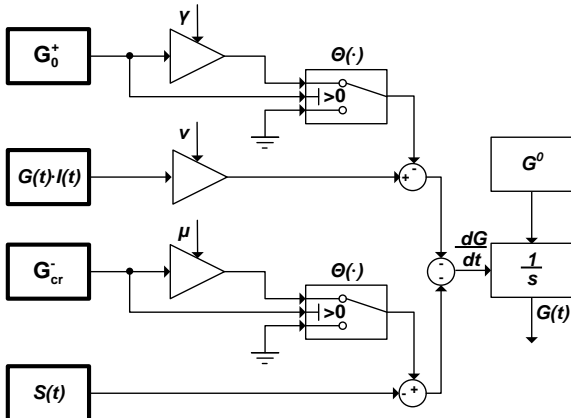
Fig. 2. Model of the dynamics of changes in glucose.

In these structures: block « $\frac{1}{s}$ » – integrator; blocks «I^0» and «G^0» – setters of the initial conditions of the integrator; block «$\triangleright$» – multiplier by the corresponding coefficient α, η, γ, ν or μ; subblocks « G_0^- », «L(t)», «G(t)·I(t)», «G_0^+», «G_{cr}^-», «S(t)» are intended to form the corresponding elements of the first equation system (1).

To determine the regularities recreated in the «S(t)» and «L(t)» subunits, simulating external sources of glucose and insulin intake, let us set out mathematical descriptions of the processes of glucose and insulin intake.

Thus, a single act of glucose intake into the patient's body from an exogenous source is modeled by a non-negative and one-extreme Gaussian function [37]:

$$S^{(0)}(t) = A_S^{(0)} \exp\left(-\frac{\left(t - T^{(0)}\right)^2}{2\sigma^2} \right), \qquad (3)$$

where $A_S^{(0)}$ – the amplitude, which determines the maximum value of the peak of the injection of glucose into the blood after a meal; $T^{(0)}$ – the interval defining the moment of the beginning of feeding (the beginning of exogenous glucose intake) relative to the beginning of the model experiment (this moment corresponds to $t = 0$); σ – variance, which controls the width of the peak, i.e. in fact, the rate of assimilation of food by the patient, the full dose of which is $A_S^{(0)}\sigma^2$ [21], while it is obvious that 95% of the food (respectively, 95% of exogenous glucose) will be assimilated by the body in an interval equal to 2σ. The value of the variable corresponding to the maximum of the function $S^{(0)}(t)$ is determined by the formula:

$$t_{max}^{(0)} = t\big|_{S^{(0)}(t) = S_{max}^{(0)}} = \left(T^{(0)} + \sqrt{\left(T^{(0)}\right)^2 + 4\sigma^2} \right) \Big/ 2. \qquad (4)$$

It is believed [21] that the food taken by the patient is completely converted into glucose on average within two hours after the beginning of the feeding process, i.e. the moment $t_{max}^{(0)}$ is 1 hour from the start of the meal $\left(t - T^{(0)}\right)$.

Three meals a day (three daily exogenous intake of glucose into the patient's body), provided that the daily meal is equivalent to two morning or evening meals, can be described as follows [37]:

$$S^c(t) = A_S^{(0)} \left(\psi\left(T^{(1)}\right) + 2\psi\left(T^{(2)}\right) + \psi\left(T^{(3)}\right) \right), \qquad (5)$$

where $\psi\left(T^{(i)}\right) = \exp\left(-\frac{\left(t - T^{(i)}\right)^2}{2\sigma^2} \right), i = 1, 2, 3$; at the same time, as a first approximation, we can assume that the rate of assimilation of food by the patient is the same in all periods of food intake.

To set a formal description of the subblock «L(t)», which simulates an exogenous source of insulin intake, let us take into account that the need to forcibly inject insulin into the patient's blood arises when the patient has diabetes mellitus and has certain difficulties with blood. There are two ways of getting insulin into a patient's blood from an external source.

The first method involves the introduction of insulin into the blood in a volume proportional to the value of the difference $\left(G(t) - G_0\right)$, moreover, only after revealing the fact of such an excess. Mathematically, this method is described by the following relationship:

$$L_1(t) = \begin{cases} k_I(G(t) - G_0), & \text{if } (G(t) - G_0) > 0 \\ 0, & \text{if } (G(t) - G_0) \leq 0 \end{cases}, \qquad (6)$$

where k_I – is the coefficient of the relationship between glucose and insulin concentrations.

The second method is based on a relay mechanism for controlling the process of insulin intake into the patient's body, which is triggered when the moment the condition is met $G(t) - G_0 > G^*$, where G^* – is some permissible excess of the minimum glucose concentration G_0. From this moment, insulin is supplied into the patient's blood at a constant concentration G_0. Mathematically, this method of injecting insulin is described by the expression:

$$L_2(t) = \begin{cases} L^*, & \text{if } (G(t) - G_0) > G^* \\ 0, & \text{if } (G(t) - G_0) \leq G^* \end{cases}. \qquad (7)$$

In both schemes of organizing the supply of exogenous insulin into the blood of a patient with diabetes, the supply is stopped as soon as the condition for the start of its administration is stopped.

IV. RESULTS

Here are some of the results of computational experiments on the simulation test site of the "insulin-glucose" system, assembled on the basis of the structural structures shown in Fig. 1 and Fig. 2. The purpose of the experiments is to determine the establishment of daily glycemic profiles of glucose and insulin in the patient's blood in the situations:

Situation 1. **The patient is healthy**. The function of insulin production by the β-cells of the pancreas is normal. Excess blood glucose is promptly neutralized by insulin produced by the body in the right amount.

Situation 2. **The patient has type I diabetes mellitus**. There is an insufficient level of insulin production by β-cells of the pancreas. Correction of the glucose-insulin balance in the patient's blood is not performed.

Situation 3. **The patient has type II diabetes mellitus**. The pancreas makes the required amount of insulin, but this insulin is "defective". Correction of the "glucose-insulin" balance in the patient's blood is not fully carried out.

Situation 4. **The patient has type I diabetes mellitus and there is a controlled system for introducing exogenous insulin into his blood**. There is an insufficient level of insulin production by the pancreas or insulin is not produced in it at all. There are means for continuous monitoring of blood glucose concentration and a system for automatic correction of it by forcibly injecting insulin into the blood from an exogenous source.

Now let us set the initial parameters necessary for organizing correct modeling (partially taking into account the data given in [21, 37]):

1) Periods of simulation: 1 day (24 hours).
2) The number of patient meals (glucose intake from an exogenous source) per day is 3 with the following time stamps: 08-00, 14-30, 19-30 hours.
3) Daily markers of the patient's blood glucose maxima: 09-00, 15-30, 20-30 hours.
4) Concentrations of glucose in the patient's blood:
   - before meals (on an empty stomach): 3,3 ... 6,1 mMol/l;
   - after each meal (after 1 hour): 8,9 mMol/l;
   - minimum allowable: 3,3 mMol/l;
   - nominal (normal): 5 mMol/l;
   - critical: 10 mMol/l.
5) The insulin concentration in the patient's blood varies from 0 to 170 mU/ml (mU – milli units of insulin).
6) Typical values of the coefficients in the equations of system (1), independent of the situations under consideration:
   - coefficient of utilization of insulin by glucose;
   - coefficient of glucose output from the liver;
   - coefficient of glucose excretion through the kidneys.
7) Coefficient of insulin production by β-cells of the pancreas: situations 1 and 3 – $\alpha = 15$; situations 2 and 4 – $\alpha = 3$.
8) Coefficient of glucose utilization by insulin: situations 1, 2 and 4 – $\nu = 6$; situation 3 – $\nu = 1$.

Here are some results from computational experiments.

Situation 1. **The patient is healthy.** The blood glucose-insulin balance is normal. The glycemic profiles of glucose and insulin concentrations have the form shown in Fig. 3, and their daily dynamics corresponds to the clinical data of a healthy organism.
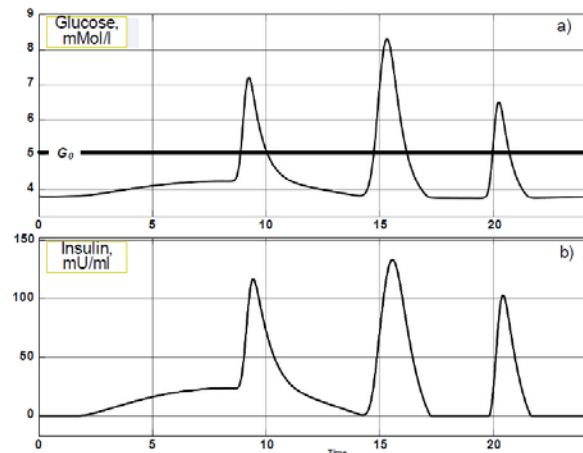
Fig. 3. Daily glycemic profiles of glucose (a) and insulin (b) concentrations in the blood of a healthy patient.

The blood glucose level does not exceed the critical value of 10 mMol/l. In the first approximation, the selected values of the coefficients in model (1) can be considered correct. Then, by manipulating the values of these coefficients, one can expect physiologically correct results from the model for certain disorders of carbohydrate metabolism. However, this does not replace the mandatory identification and adjustment procedures for the model for specific patients when using it in clinical practice.

Situation 2. **A patient has type I diabetes mellitus.** The insulin produced by the patient's body is not sufficient to eliminate glucose. In this case, the glycemic profiles of glucose and insulin concentrations in the blood take the following form - see Fig. 4. Insufficient insulin level leads to the fact
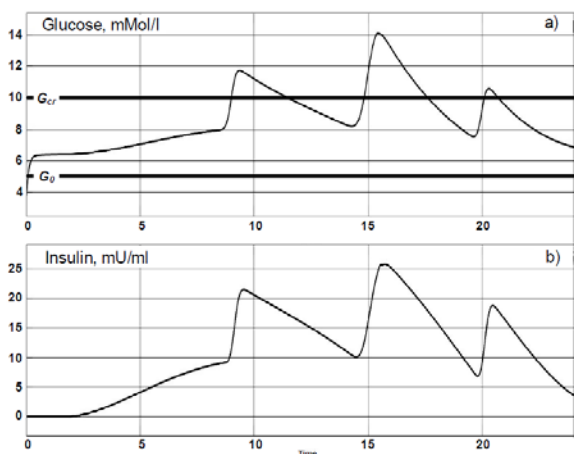
Fig. 4. Daily glycemic profiles of glucose (a) and insulin (b) concentrations in the blood of a patient with type I diabetes.

that after each meal there is a rapid increase in the concentration of glucose in the patient's blood, exceeding the critical level of 10 mMol/l. Then the glucose concentration slowly decreases, but does not reach the normal value 5 mMol/l and remains at a sufficiently high level. This effect naturally leads to the fact that excess glucose from the body's blood is excreted through the kidneys. This situation is characterized by blood effects typical of type I diabetes.

Situation 3. **The patient has type II diabetes mellitus.** The pancreas of the patient's body produces insulin in sufficient quantities, but it does not have the necessary properties for efficient utilization of glucose, i.e. is "defective". The glycemic profiles of glucose levels and moderately "defective" insulin in the blood are as follows - see fig. 5. It can be seen that, as in the case of diabetes mellitus I, after each meal there is a rapid increase in the concentration of glucose in the blood of a patient with diabetes mellitus II; however, insulin utilization requires 20-30% more insulin than in a healthy person. organism (Fig. 3). In addition, there is a slowed down, compared with the norm, process of lowering the blood glucose level and reaching its normal value only by the end of the patient's daily activity period (by 00 hours).
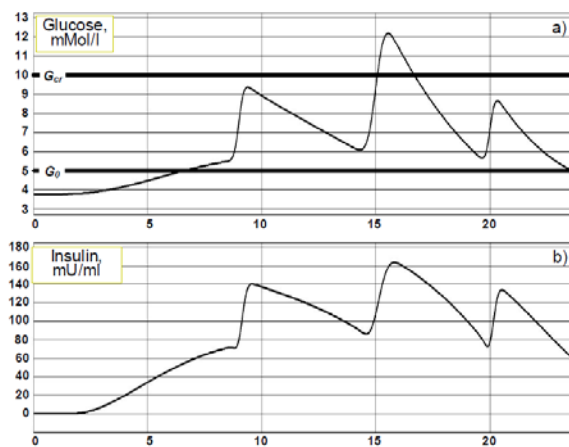
Fig. 5. Daily glycemic profiles of glucose (a) and insulin (b) concentrations in the blood of a patient with type II diabetes (a case with moderately "defective" insulin).

Situation 4. **A patient has type I diabetes mellitus and there is a controlled system for introducing exogenous insulin into his blood.** There are means of continuous monitoring of the patient's blood glucose level and a controlled system for continuous delivery of insulin into the blood from an exogenous source, which is equipped with an insulin pump [38]. Let the proportional pump control mode be selected in accordance with expression (6). The coefficient of the relationship between the concentrations of glucose and insulin is assumed to be equal $k_I = 22$, since it is generally accepted [21] that 1 Unit of insulin capable of utilizing 22 mMol glucose. Then the glycemic profiles of glucose and insulin concentration in the patient's blood take the form shown in Fig. 6. Here it is necessary to pay attention to the fact that in a patient with type I diabetes mellitus, in the absence of an automatic system for correcting the glucose-insulin balance in the blood by exogenous insulin, the maximum permissible glucose concentration level of 10 mMol/l is exceeded after each meal by the patient (see Fig. 4.a).
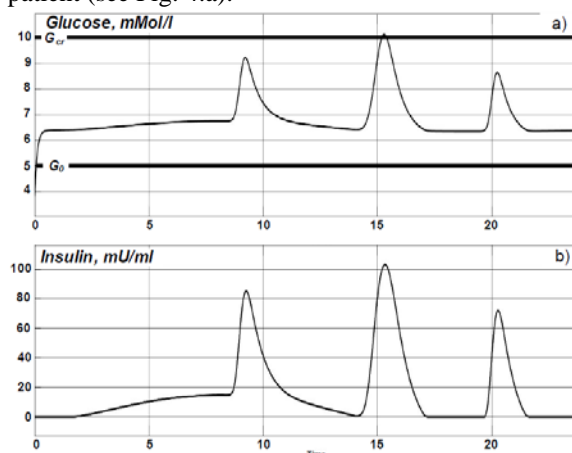
Fig. 6. Daily glycemic profiles of the concentration of glucose (a) and insulin (b) in the blood of a patient with type I diabetes mellitus, provided with a continuous supply of exogenous insulin with a proportional regulator of its consumption.

When such a patient enters the bloodstream of insulin from a controlled external source, the concentration of glucose in his blood exceeds the maximum allowable value of 10 mMol/l only once - about 15-30 in the afternoon for a relatively short time after the day (maximum) food intake by the patient, which gives the maximum injection exogenous glucose into the body (Fig. 6.a).

V. DISCUSSION

So, the considered mathematical model of the "insulin-glucose" balance (system of equations (1)), despite the undefined "roughness" of the formal description and its model representations using MatLab / Simulink, as well as the results of computational experiments carried out on this model, demonstrate the following dynamics changes in the model concentrations of glucose and insulin in the patient's blood, which fully corresponds to the real glycemic profiles of the concentrations of glucose and insulin in the blood of the human body, both for its healthy state and in the presence of type I and II diabetes mellitus. Thus, the model dynamic sections of the diurnal processes of changes in the level of glucose and insulin in the blood of a healthy patient presented in Fig. 3 adequately converge with the dynamical processes of the same name obtained in real examinations of practically healthy people (see, for example, [39]). Model glycemic profiles of glucose and insulin concentration in the blood of a patient with type I diabetes mellitus (Figs. 4 and 6) also identically reflect the dynamics of real analogous profiles obtained during glycemic control of patients with type I diabetes (see data in [39, 40]). The calculated profiles of changes in glucose and insulin levels obtained for a patient with type II diabetes (Fig. 5) also provide good agreement with the real results of daily glycemic monitoring in patients with type II diabetes (see, for example, [41]).

It should be noted that the described model of the "glucose-insulin" balance in the patient's blood has good potential for its further improvement.

So, it is of interest to model such behavior of the main organ-generator of insulin (pancreas), which reflects its dynamic "fatigue", ie. allows to recreate in model conditions a variable rate of insulin production with limitation of the upper limit of such production. To simulate this situation, it is sufficient in the first equation of system (1) to make the constant coefficient of insulin production variable, depending on the temporal characteristic or other changing factors.

Replacing the coefficients and, which determine the processes of mutual utilization of insulin and glucose in the corresponding equations of system (1) by functional operators that take into account the rate of glucose consumption under the influence of physical exertion on the patient's body, it is possible to reproduce on the considered model of carbohydrate metabolism various "insulin-glucose" consequences in the patient's blood from his hard work, physical exercise, sports and other similar physically stressful activities.

The model of insulin-glucose balance in the patient's blood described in this article can be generally recommended for implementation in clinical practice to improve the quality of insulin therapy in patients with diabetes mellitus, provided that the issues of individual identification and adjustment of the mathematical description of carbohydrate metabolism for specific patients with diabetes mellitus are resolved. The formal construction of the model description of the insulin-glucose system in the patient's blood (equations of system (1)) allows it to be adjusted for a specific patient by adjusting the values of the coefficients of insulin production by the pancreas (α), mutual utilization of insulin and glucose (η, ν), and glucose output from the liver (γ), elimination of glucose through the kidneys (μ), as well as adjusting the values of the nominal G_0 and critical G_{cr} levels of glucose concentration. This significantly increases the flexibility and scope of the considered model, makes it "patient-oriented", which is especially important in the case of its introduction into the clinical practice of an endocrinologist in order to study and predict the development of a diabetic disease in a particular patient.

Also, the methods and mechanisms of organizing glycemic monitoring of blood glucose levels with the automation of the process of exogenous insulin entering it using a controlled insulin pump also require some improvement. Here it is possible to propose a wider use of the existing developments in this area - see, for example, [38,42], which describes systemic approaches to the organization of glycemic control of the blood state of a patient with type I diabetes mellitus and systemic issues of building an insulin pump with its control circuit.

Obviously, the modified Bergman minimal model of the "insulin-glucose" system in the patient's blood considered in this article makes it possible to recreate and study under model conditions various clinical aspects of carbohydrate metabolism both for a healthy patient's body and in the presence of pathologies, including diabetes mellitus I and II types, changes in the balance of "insulin-glucose" during physical exertion, the effects of "aging" of the insulin-production capacity of β-cells of the pancreas.

VI. CONCLUSION

The authors have shown the possibility of using modern software tools - the MatLab/Simulink computer mathematics system, initially focused on solving various dynamic problems of scientific, technical, statistical, optimization focus using the mechanisms of simulation modeling and the theory of experiments, to build dynamic simulation models of carbohydrate metabolism processes in the blood a patient suffering from diabetes mellitus and conducting research on this model. The fundamental possibility of using the MatLab/Simulink software system for organizing controlled computational experiments on a model range of the insulin-glucose system, as well as for high-quality visualization of the key dynamic characteristics of the studied processes of

carbohydrate metabolism in the blood of a patient with diabetes mellitus, has been demonstrated. The obtained model results showed good agreement with real glycemic profiles of insulin and glucose concentrations in the blood of a healthy patient and in the presence of diabetes mellitus.

Thus, this article shows how an endocrinologist can effectively use the MatLab/Simulink software environment as a solid modern clinical research tool aimed at studying the dynamics of the development of signs of pathological processes associated with carbohydrate metabolism in order to ultimately improve the quality and efficiency diabetes mellitus treatment.

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Research of Approaches to the Recognition of Semantic Images of Scientific Publications Based on Neural Networks

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Abstract - **The paper is devoted to the problems of orientation and navigation in the world of verbal presentation of scientific knowledge. The solution of these problems is currently hampered by the lack of intelligent information retrieval systems that allow comparing descriptions of various scientific works at the level of coincidence of semantic situations, rather than keywords. The article discusses methods for the formation and recognition of semantic images of scientific publications belonging to specific subject areas. The method for constructing a semantic image of a scientific text developed by Iuliia Bruttan allows to form an image of the text of a scientific publication, which can be used as input data for a neural network. Training of this neural network will automate the processes of pattern recognition and classification of scientific publications according to specified criteria. The approaches to the recognition of semantic images of scientific publications based on neural networks considered in the paper can be used to organize the semantic search for scientific publications, as well as in the design of intelligent information retrieval systems.**

Keywords - semantic image, pattern recognition, semantic search, classification of scientific publications, neural network.

I. INTRODUCTION

In modern conditions, orientation in the continuously increasing volume of scientific publications without the use of automated tools is becoming more and more difficult. Scientists and specialists in different fields do not always manage to successfully track publications containing new significant results in their area of knowledge. The development of automated systems for the classification of scientific publications and the organization of semantic search for scientific information in actual areas of research will increase the efficiency of research work.

Modern approaches to the organization of automated analysis of scientific texts are mainly associated with the use of neural network technologies. The application of machine learning for the classification of scientific publications according to given features will allow creating an automated system for searching scientific publications, as well as increasing the efficiency of searching for the latest publications in a given field of knowledge.

When solving this task, a problem arises related to eliminating the contradiction between the context-dependent representation of texts in natural language and

the context-independent algorithms for their computer processing. Therefore, the authors of the article investigated and proposed approaches to the computer representation of the semantic content of texts in a context-dependent language. The application of these approaches to the construction of a semantic image of a scientific publication can be considered as a variant of the input data formation, taking into account the semantic component for a neural network, the training of which will solve the problem of classifying publications according to given features at a higher quality level and organize a semantic search for texts of scientific content in a given subject area.

It can be argued that at present the global problem of recognition of the semantics of texts has not been solved. Its full solution would lead to a genuine scientific breakthrough. But even a partial solution to this problem, proposed by the authors of the article, seems to be very relevant.

Algorithmically solvable procedures for the recognition of semantic images of texts of scientific publications allow the implementation of intelligent information retrieval systems.

II. Problems of Constructing a Machine Representation of Text in a Natural Language

The texts of scientific publications are unstructured datasets. For automated processing, these unstructured text sequences must be transformed into a structured feature space. The problem lies in developing an approach to constructing a DataSet that is suitable for processing by a neural network and at the same time provides an acceptable level of quality of the results obtained. Obviously, considering the semantics of the source text when forming the DataSet will help to improve the quality.

The existing approaches to processing the text of scientific publications to create a DataSet is described in this paper. Initially, it is required to collect a domain-specific corpus of publications for building models. At the stage of preprocessing the collected text data, it is necessary to perform a number of tasks: removing non-alphabetic characters from the text, splitting the text into a set of tokens, removing stop words, reducing words to their word stem, base or root form. Removing non-alphabetic characters and stop words is a standard procedure. It allows to delete unnecessary elements that have little effect on its general subject matter. Text preprocessing includes the removal of functional words (semantically neutral words such as conjunctions, prepositions, articles, etc.). Next, morphological analysis is performed. One of two ways is used to cast a word to the stem: stemming and lemmatization. In the first case, the ending of the word is cut off according to a certain algorithm, in the second case, the word is reduced to the base or dictionary form of a word in accordance with the applied language grammar. These measures can significantly reduce the dimension of space. As a result, all significant words that appear in the

document act as features of the document. After cleansing the data, formal feature extraction methods can be applied.

Document indexing is the construction of a certain numerical model of the text, which translates the text into a representation that is convenient for further processing. The bag-of-words model allows to represent a document as a multidimensional vector of words and their weights in the document [1]. In this case, each document is a vector in a multidimensional space, the coordinates of which correspond to the word numbers, and the values of the coordinates correspond to the values of the weights. Another common indexing model is Word2Vec [2]. It represents each word as a vector that contains information about the context (companion) words. Another indexing model is based on taking into account n-grams [1, 3, 4], that is, sequences of adjacent words.

In the works of D. A. Pospelov, V. Sh. Rubashkin, V. K. Finn, I. A. Melchuk, M. Minsky [5] – [9], classical approaches to the presentation of textual descriptions with a possible level of preservation of semantics for solving search problems and a comparative analysis of these descriptions were proposed:

- frames;
- semantic networks;
- logical models;
- model "Meaning => Text".

To identify the meaning of text-based documents, it is necessary to use semantic analysis, which is realized thanks to a linguistic analyzer. There are a number of problems that arise at the stage of semantic analysis of text-based documents:

- standardization of knowledge representation languages;
- resolution of syntactic and lexical homonymy;
- coreference of relations between units of the text;
- analysis of contexts characterized by semantic incompleteness;
- development of semantic dictionaries required to support semantic analysis algorithms.

It should be borne in mind that for a sufficiently complete understanding of the text from the linguistic analyzer, in addition to the ability to identify and formalize the semantics of the text, the ability to implement logical inference from the text is also required.

The authors' review of publications on this topic allows us to conclude that the mechanism for taking into account the semantic component in existing formalized text models does not make it possible to use even well-known methods to solve the problem of forming a context-sensitive DataSet in which the semantics of the original publication is preserved. Therefore, the authors of the article propose for discussion their approach to the formation of a semantic image of a text, based on the method of spatial representation of text descriptions.

III. METHOD OF SPATIAL REPRESENTATION OF TEXT DESCRIPTIONS

Let us consider an approach to the formation of a semantic image of a text of scientific content, based on the method of spatial representation of text descriptions, developed by the author of the article [10] – [12]. Objects that are specified by textual descriptions can be represented as an area of colored dots in the *N*-dimensional model space of a certain subject area. Thus, a graphic image of the text or a graphic model of a linguistically specified object will be obtained. Consequently, digital image processing methods can be applied to this graphic image, in particular, image recognition methods [13, 14], which are currently well studied and implemented.

Application of the method of spatial representation of text descriptions allows:

- to partially preserve the semantics of the original text, given in a natural language; when it is represented in a computer;
- to use digital image processing methods;
- to implement comparative analysis and search for texts at a higher quality level.

When implementing an approach based on the application of the method of spatial representation of text descriptions, each source text in a natural language will be associated with its graphic image. But in this graphic image of the text it is necessary to add the semantics of the original description, and then it can be called the semantic image of the text description.

One of the best options for presenting texts with preserving the semantics of description in a natural language is the predicate representation of text records in the form of *ARB* syntagmas [12]. The professional language of a scientific direction can be translated into the language of predicates. The authors of the monograph [15] have proved this fundamental possibility.

The predicate language proposed in this paper consists of a descriptor dictionary and a specific description structure, which is a set of elementary statements (syntagmas) of the standard *ARB* form, where *A* and *B* are term codes along with connection pointers, and *R* is a code of a binary relation reflecting the relationship of objects, or features of the subject area under consideration.

The following approaches to the formation of the corresponding dictionaries are proposed.

The lexical composition of the predicate language must be recorded using a descriptor dictionary. A vocabulary should be developed for each domain. Its thematic scope should be such that any texts belonging to the considered subject area are translated into the predicate language. Dictionaries are proposed to be formed on the basis of the constructed domain ontology [16, 17].

The choice of binary relations begins with finding the main types of simple natural language sentences that implement them. In such a sentence, information is recorded about two objects, an object and a feature, or two features and a relation connecting this pair. Each object or feature is most often expressed in one word, which in the sentence plays the role of a subject, addition, definition or circumstance. Attitude is also expressed most often in one word, which in the sentence plays the role of a predicate. Further, for binary relations, formal and logical properties must be established, the operations underlying the identical transformations of elementary statements must be determined. After analyzing the formal-logical properties of the selected binary relations, it becomes clear that many of them are capable of generating new relations. Therefore, it is necessary to conduct a study of the rules for transforming binary relations. Then a dictionary of binary relations is formed with the following structure [12]:

1) descriptor code;
2) head descriptor;
3) synonyms;
4) formal logical properties.

To implement a successful (and adequate) translation of a text description into the predicate language, it is necessary to carry out preprocessing of the text: translation of sentences into a simple form and replacement of pronouns with the corresponding terms.

The translation of a text description from a natural language into a predicate language takes place in two stages:

1) The translation of lexical units of the text.
2) The translation of the links that exist between them.

As a result of translation into the language of predicates of a text in a natural language, a set of syntagmas is formed, consisting of a set of *ARB* that reflect the original description. Thus, we obtain a formalized representation of the text description, which retains the meaning of the text at the level of interrelation of terms of a specific domain.

Further formalization of the text makes it possible to represent its image in the *N*-dimensional model space of the subject area. Suppose the axes of the *N*-dimensional model space are designated $X_1, X_2, ... , X_N$. Along the axes of the *N*-dimensional space, *m* identical terms of the thesaurus are located, and if necessary, you can add axes to reflect the corresponding quantitative characteristics. Let us assume that the terms in position *A* will be plotted on the odd axes, and the terms in position *B* will be plotted on the even axes. The points in the *N*-dimensional space represent multiple named relationships (*R*) between the corresponding terms of the thesaurus. Then, for example, a text description that belongs to a certain domain of knowledge will represent a separate area filled with named relations. When assigning a specific color to each type of predicate relationship, we obtain different graphic images for the interval. They can be considered models of a linguistically given object with a predicate representation of its context-dependent description (see Fig. 1).
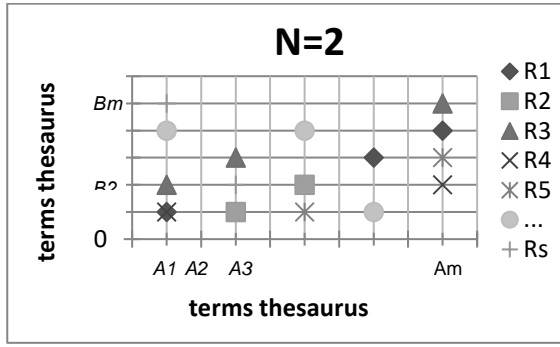
Fig. 1. Semantic image of the text.

It should be emphasized that some relationships often breed others. The order of transformation of statements is determined by the logical connections that exist for predicate relations of textual descriptions of a certain subject area. As a result, simple statements are supplemented with a set of consequences arising from them, which are new statements that were previously absent in the text. But they are necessary to preserve the semantics in the predicate representation, i.e. predicate extensions of the original description appear, containing the results of possible logical transformations of the original predicates. The predicate extensions obtained in this way, in turn, provide coloring of additional subintervals of the thesaurus space.

To build a graphical image of a text description, in most cases (with the exception of text descriptions containing quantitative data), a 2-dimensional space is sufficient (which we will call the base plane). Nevertheless, when constructing a predicate extension of the original description in the model space, a situation may arise when it is required to increase the number of its dimensions, since as a result of performing formal logical transformations, other types of relations between the existing terms may additionally come to light. The maximum number of measurements in the model space *Nmax* can be determined as in (1):

$$Nmax = 2 + 3 + k \qquad (1)$$

where 2 – is the number of measurements of the base plane,

3 – is the number of additional dimensions that may appear as a result of performing logical implications of statements containing binary relations,

k – is the number of additional dimensions that are needed to display quantitative data of the original text description.

It should be noted that texts in any natural language belonging to a certain domain will have similar semantic images in the model space of terms of this domain.

IV. METHOD OF RECOGNITION OF SEMANTIC IMAGES OF SCIENTIFIC PUBLICATIONS BASED ON A NEURAL NETWORK

Let us consider the approach to the recognition of semantic images of scientific publications, created by the authors of the article, based on the method of recognition of semantic images of scientific publications based on a neural network. The input of the neural network receives DataSets, which are semantic images of scientific publications belonging to a certain scientific field. Each semantic image is formed using the above method of spatial representation of text descriptions. This formalization of the texts of scientific publications provides a higher quality of the machine learning model, since it preserves the semantics of the original text description.

The authors propose an approach to the automated formation of a DataSet – a labeled (classified) corpus of semantic images of publications. The DataSet obtained in this way will be used at the next stage for training and testing the neural network. Classification of documents is implemented based on the application of comparison of images of individual documents with a reference image for a category for the degree of their similarity. In recognition methods based on matching, each class is represented by a vector of features of the image that is the prototype of this class. An unfamiliar image is assigned to the class whose prototype is the closest in the sense of a predetermined metric. Let us adapt the approach proposed in [13] for solving the problem of recognizing the semantic image of the text of a scientific publication.

Initially, it is necessary to form semantic images of the corpus of scientific publications belonging to specific domain. At this stage, as a result of the application of the method of spatial representation of textual descriptions, the formation of semantic images of scientific publications is carried out.

Semantic images, as shown above, are a collection of points in the *N*-dimensional model space with axes X_1, $X_2,\dots , X_N$.

Each point of each Y_g semantic image is characterized by coordinates and color (let's assume that the color is specified in the form of *RGB* model). Therefore, each semantic image of a linguistically given object – the text of a scientific publication – can be represented as a matrix of features of the following form (2):

$$Y_g = \begin{pmatrix} y_{11}^g & \cdots & y_{1N}^g & RGB_1^g \\ \vdots & \ddots & \vdots & \vdots \\ y_{M_g1}^g & \cdots & y_{M_gN}^g & RGB_{M_g}^g \end{pmatrix} \qquad (2)$$

where g = 1,2,...,W,

y_{ij}^g *– coordinates of points of the g-th semantic image in the model space (i=1, 2, …, Mg; j=1, 2, …, N),*

RGB_i^g *– colors of points of the g-th semantic image, specified in the form of RGB color model (i =1, 2, …, Mg)*

W – total number of semantic images,

41

N – the number of dimensions of the model space,

Mg – the number of points in the g-th semantic image of a text description – includes points representing the totality of ARB syntagmas of the original text description and points representing the predicate expansion of the original ARB array obtained as a result of performing formal logical transformations over it.

The set of all semantic images of the text corpus of scientific publications will be a set (3):

$$\{Y\} = \{Y_1, Y_2, \cdots, Y_W\} \qquad (3)$$

Let us assume that the points in the matrix of features of the semantic image are listed in ascending order of the coordinates of the points of the image, and if the coordinates coincide, in ascending order of the color values of the corresponding points.

At the next stage, it is required to provide the correspondence of the set of indexes of semantic images to a specific class (domain) of publications. As a result, a DataSet will be obtained from the labeled-up semantic images.

The procedure for recognizing the semantic image of a text description with such a representation of linguistically defined objects can be implemented by comparing the recognizable image of the text, given in the form of matrices of features of the model space, with the available images-standards, specified in the form of matrices of features of the same model space. That is, each matrix of the recognizable object, representing the image of this object on the plane of the model space, must be compared with a similar matrix of the reference object. In this case, the elements of each matrix of the recognizable linguistically specified object are compared with the values of the corresponding elements of each matrix of the reference object, and the number of matches is summed up. As a result of the comparison, the number of points of the semantic image of the recognizable object will be determined, which coincide with the points of the reference image.

To determine the class to which the studied linguistically specified object belongs, we introduce the set of parameters *result* (4), which shows the percentage of coincidence of the analysed text with the available reference texts (5).

$$result = \{result_1, \cdots, result_W\} \qquad (4)$$

where W – the total number of semantic images,

$$result_g = \frac{S_g}{M_0} \cdot 100\% \qquad (5)$$

where g = 1..W,

Sg – the number of points of the recognizable pattern coinciding with the points of the g-th reference pattern,

M₀ – the number of points in the recognizable pattern.

Thus, in this case, the maximum value of *result_g* means the best match of the *g*-th reference description of an object that characterizes a specific class of objects (domain) with

a recognizable publication. As a result, we can conclude that the publication in question belongs to a specific class of the domain.

As a result of this stage, a labeled corpus of semantic images will be formed, which can be used for training and testing a neural network. Let us assume:

- 95% of the corpus of semantic images will be used as a training data for the neural network;
- 5% — as a testing data.

At the next stage, it is necessary to train the neural network selected for solving the problem of classification of scientific publications [18] – [21] based on the prepared training dataset of semantic images of publications.

Then it is necessary to test the trained network on the available testing dataset. After the successful completion of this stage, the neural network is ready to recognize new publications of specific domain.

This is the essence of the method proposed by the authors for the recognition of semantic images of scientific publications based on neural networks. Using the described method, it is possible to determine the belonging of a linguistically given object (text of a scientific publication) to a specific class of objects (domain).

On the basis of this method, the authors have developed an algorithm for determining the class of the object under study, which can be used in information retrieval systems to determine the belonging of a linguistically given object (scientific publication) to one of the selected classes of objects (domain). This algorithm can be used when designing a search engine for an information retrieval system.

V. Organization of Search Engine of a New Type

The standard search engine does not consider the semantic content of natural language texts. Such text, from the point of view of the search engine, is simply strings of characters separated by spaces. It is such "words" that are preselected from the text and entered into the search index, which allows the search engine to find documents. At the same time, the query language of a good search service permits to set various restrictions on the desired combinations of words in the document, which allows, in principle, to formulate very complex queries, describing the desired meaning in the text.

However, the problem of creating good information retrieval systems based on standard search engines is that the user wants to formulate his request in the form of a simple set of words or phrases in a natural language, expecting the machine to understand these words that can be written in the text. In such a situation, if the words of the query do not match the words of the search text, it will be almost impossible to find the required document.

Therefore, on the basis of the approaches proposed by the authors of the article to the formation and recognition of semantic images of scientific publications, it is possible to design an information retrieval system of a new type. It will search not by keywords, but by coincidence of

semantic situations. Such an information retrieval system of a new type will form semantic images of documents and store them in its database (or storage). The information retrieval system should build these images using the method of spatial representation of text descriptions. And the search engine should be built on the basis of using the method of recognition of semantic image of a text description. It will compare the semantic image of the user's search query, built on the basis of the method of spatial representation of text descriptions with the semantic images available in the database of the information retrieval system of text-based documents. Then, based on a predefined successful search criterion, a list of documents relevant to the query (if any were found) is displayed. To reduce the percentage of losses when translating original sentences in natural language into the formalized representation proposed by the authors (semantic image of a text description), we formulate the requirements for the structure of queries:

- they should be written in the form of simple sentences;
- pronouns must be absent (or replaced by their corresponding concepts).

Search engines of a new type, which use the method of recognition of the semantic image of a text description, can also be used on the Internet, because they implement a semantic search for documents, which can improve the relevance of the search. But at the same time, preliminary work should be carried out to create dictionaries of descriptors and predicates for the corresponding subject areas. Semantic images of information resources of the Internet are formed on the basis of the method of spatial representation of text descriptions. These semantic images can be used to index documents on the Internet.

VI. Conclusions

The approach to the construction of semantic images of scientific publications, proposed in the article, makes it possible to theoretically substantiate the fundamental possibility of the existence of an algorithmic solution for problems of comparison, classification of these images. This approach to formalizing text for its further processing by a neural network initially has a semantic focus and potentially improves the quality of training a neural network. The algorithm developed by the authors for determining the class of a scientific publication based on neural networks can effectively solve the problem of determining whether texts of scientific content belong to one of the specified classes. This makes it possible to use the proposed approaches and algorithms in the design of new types of search engines that will carry out semantic search for documents.

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The pressure of technological innovations in meeting and event industry under the COVID-19 influence

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Abstract - **The innovation in** *technologies is one of the principal external forces that has a direct influence on the competitiveness of the meeting and the event industry. Therefore, implementation and adaptation of the new technological solutions in it has continuously followed the innovations in technological industry itself. However, the COVID-19 pandemic with the following lockdowns has pushed the industry to search for new technological alternatives to innovate their way out of the crisis in a very short time period. This was the first time when all the events from small family celebrations and weddings up to the international conferences and product launch events, have had to be cancelled or postponed or could have happened only to a very limited extent and under strict regulations excluding any larger gatherings of people. The event providers were forced to find new solutions to continue their business and not to hibernate with the minimum downtime allowance granted by the state to the employees. Technologies supporting various types of online events became the ultimate digital tool that helped event planners to execute projects from the beginning to the end after March 2020. The purpose of the research is to explore these changes in the usage of the technologies in meetings and events organized in Latvia caused by COVID-19. The quantitative analysis of the structural on-line survey data provides insights on what extent technology adoption in meetings and events businesses has been before and during COVID-19 and what are the future prospects supplemented by the in-depth interview data and qualitative analysis. Authors are investigating what is the amount of virtual and hybrid events organized in Latvia before and after COVID-19, what platforms the organizers used for their virtual events, what is the level of satisfaction and what kind of challenges the event organizers faced in the process of adoption of new technologies. The results of this research not only state the current position within the framework of the industry, but also enriches discussion about the adoption of new technologies to innovate the way out of the crisis and could help in some degree to strengthen the prod*uctivity growth in a long term perspective.**

I. INTRODUCTION

The meeting industry could be named as one of the fastest growing segments of the global economy as namely all the world's largest industries are furthered by it [1]. Despite meetings have always been there and people gathered for discussing communal interests since ancient times, the interest to attract contemporary business events to a various host destinations is argued with higher expenditures by business travellers, possibilities to utilize visitor-relevant facilities over a longer period than the traditional holiday peaks mitigating seasonality and the amenities that a city or a country can offer for that type of events co-benefit for residents and enhance attractiveness of a destination's even wider [2]. The First congress took place in Vienna in 1814-1815 to discuss the re-organization of Europe after the Napoleonic Wars [3]. The expansion of government organizations, the growth of multinational corporations, the development of professional associations, new approaches to human resource management, and the implementation of new marketing and sales techniques, stimulated the growth of meeting and event industry since 1950-ies [4], [5].

The meeting industry as a term was introduced in 2006 by a number of organizations including the International Congress and Convention Association (ICCA), Meeting Professionals International (MPI), Reed Travel Exhibitions and the United Nations World Tourism Organization [6]. This term includes business or professional meetings, conferences, congresses, fairs exhibitions [7]. The international associations such as ICCA, UIA, MPI have different categorization of meetings. The meetings could be divided into local and international with the number of

participants from five to thousands, with different number of dates and different volume of countries participating. Each association is regulating their categories depending on association and destination specification. In the academic field business tourism and meeting & events industry categorization has been examined increasingly by Arcodia and Robb [8], Swarbrooke and Horner [9] providing predominantly types of meetings, events and business travel and listing major products and developing further to the well-defined typology by Getz [10], [11] and McKercher [12]. The Evolution of technological adaptations in the sector has been comprehensively analysed by Buhalis and Law [13] and Navio-Marco et.al. [14].

As per report of the Union of International Associations (UIA) [15] the total amount of meetings in 2019 was 12 472 in 161 countries and in 1251 cities. According to the International Congress and Convention Association (ICCA) the number of international association meetings doubled every 10 years [16]. The 2019 figures confirm this raising trend, the total number of meetings is high, growing to 13 254 with 317 more events compared to the year 2018 [16]. Europe continues to have the largest share of the association meetings market, hosting 53% of all meetings held in 2019 [16]. The meeting industry became a visible actor on the tourism map of individual countries and continents [17]. Getz [10] considered events as important motivator of tourism, and highlighted its role in the development and marketing of most destinations. Getz argues that it was only a few decades ago that "event tourism" became established in both the tourism industry and in the research community, so that subsequent growth of this sector can only be described as spectacular [18].

The COVID-19 pandemic suddenly stopped the classical solutions and highlighted the new norms for meetings and events industry. The physical distancing forced the meeting organizers to show agility and resilience, in "panic creativity" conditions they have no other choice than to accept and invest into new formats of meetings and events. It is crucial to understand if the investments made will guarantee the efficiency and stability and will be paid off in future. COVID-19 vast impact on the industry dynamics has been analysed avalanching recently e.g., as researching impact on the global tourism industry, by Li et.al. [19] underlying effects on tourists' behavioural patterns, Wut et.al. [20] broadening it to the crisis management research, Kaushal and Srivastava [21] providing general managerial recommendations or as Breier et.al. [22] investigates concrete business model innovations as a way out of the crisis or MICE sector relation to the destination performance. Virtual and hybrid technologies created the paradigm of the new era of events, opened the opportunities for delegates' inclusivity, reduction of environmental impact, increase engagement and interactivity and financial accessibility, but at the same time raised up new challenges of minimizing digital exclusion, providing technical support, facilitating opportunities for networking and supporting physical wellness of the delegates [23].

The researches of several medical conferences in 2020 provides clear evidence that changes in medical meetings will have place and live activities need to consider multiple approaches that include technology [18], [24], [25], [26], [27], [28]. Medical community and event organizers already are implementing and looking for new solutions and formats supported by information and communication technologies. Margolis presented the concept of Extended Congress [24]. This concept leverages the extension of time, space and languages of scientific meeting. This concept allows to reach larger audience, increase accessibility, facilitate the networking and engagement.

Although the COVID-19 pandemic forced the event organizers to ensure significant investments and in short time to adopt their meetings, congresses, conferences, exhibitions to virtual and hybrid formats, the concept of virtual events is not new. The World Wide Web was used since 1993, one of the first scientific conferences ECCC (Electronic Conference on Computational Chemistry) was organized in 1995 and followed by other conferences and events [23]. The recent decades show that meeting industry was changing rapidly by implementing on-line registration systems, event supporting applications, virtual platforms and live streaming. The most popular meeting technologies introduced by a survey undertaken by the International Association of Conference Centres between 2012 and 2017 were conference applications, social media campaigns, audience participation applications, live event streaming, virtual participation [3] Webinars have received positive evaluations for quality, value, and relevance already since 2012 and have been used for remote training, courses and education [29]. The researches of years 2020 and 2021 show that the implementation of virtual platforms, which bring communities together in three-dimensional virtual spaces, video conferencing and media sharing tools enable participants to experience the presentations and to interact with fellow delegates [30]. The social media, online platforms and apps for meetings could be integrated into future meetings and congresses [31]. Virtual spaces and interactions can completely reform not only the events, but also education, traveling and working [32]. Therefore, the authors started structured research about challenges and opportunities and of virtual and hybrid meetings, the usage of various innovative tools implemented during the period of COVID-19 investigating dynamics of changes and looking forward for the future application of technologies in meetings and events.

II. Materials and Methods

The aim of the research is to explore the changes in the usage of technologies in the meetings and the events organized under the influence of COVID-19. The subject of this study is the usage of technologies. The object of this study are the regional and the international events which took place in Latvia in 2019 and 2020. The event is defined as the regional (with participation of delegates from Latvia, Lithuania and Estonia) or the international level conference, congress, seminar or forum with number of participants not less than 50 in Riga and not less than 25 in

the regions of Latvia. Limitations of this research is a short time period to perform questionnaires and COVID-19 restrictions which caused many service providers a complete closure of a company or a temporary closure of a business and accessibility of the respondents.

The contemporary Latvian meeting and event industry was rooted in the beginning of 1990-ies, after Latvia renewed its independence and the border opening with the West put the beginning of the international business tourism to the country re-focusing from the previous planned economy traditions to the open market economy. Unfortunately, it is limited by the destination capacity, main infrastructure (venues, international chain hotels with the meeting room capacity) and the airport being located in the capital city Riga and nearby town Jurmala, other cities have limited amount of meeting infrastructure and are not primary destinations for the regional and the international events. Most of the service providers and the event organizers are located in the capital city Riga located in the middle of the three Baltic states (Estonia, Latvia and Lithuania) and use its infrastructure.

To achieve the aim of the research, the integrated research method (i.e., the triangulation method) was used, which refers to the use of more than one method of data collection for the same objective to assure validity. A structured online survey (quantitative research method) investigates the usage of technologies in years 2019 and 2020 were developed. For all the most important players of meeting and event industry within the state were given the opportunity to respond. The primary data was collected by two questionnaires:

a) the service provider's questionnaire, where the study audience were Professional Conference Organizers (PCO), Destination Management Companies (DMC), Event Agencies, PR agencies, Hotels with conference facilities, Event Technical Equipment Providers, Congress Centres, Venues with conference facilities;

b) the event organizer questionnaire, where the study audience were Associations, other public or non-profit organizations, government or municipality organizations, education organizations, entrepreneurs.

The survey was distributed by platform visidati.lv, through the professional meeting and event industry associations, Latvian Investment and development agency, social media (Facebook, LinkedIn) and by direct mailing to various industry associations. The a) questionnaire consisted of 34 questions, answers to all the questions were mandatory, otherwise the survey could not have been proceeded. The b) questionnaire consisted of 29 questions, answers to all the questions were mandatory, otherwise the survey could not have been proceeded. Both surveys were divided in three main sections: I. A The Characteristics of the Respondents; II. The Characteristics of the Events and Delegates; III. Technology Usage. The survey was anonymous. IP restrictions were implemented; one IP address could only complete the survey once. All the data were collected within the VisiDati.lv system, and only authors could access this data, all IP addresses and responses were removed from the publicity.

Descriptive research methods were used in this study. A total of 75 responses were collected; after cleaning the data, 70 responses were found usable for the analysis purpose. The quality analysis method by using MAXQDA program was applied to both questionnaires' respondents' comments analysis. For Quantitative research analyses MS Excel was used.

The a) questionnaire was disseminated primary through the professional associations: Latvia Convention Bureau, Latvia Hotels and Restaurant Association, Association of Latvian Travel Agents and Operators, Latvian Investment and Development Agency, Latvian Event Producers Association, Latvian Event Venue Association. The b) questionnaire was sent to various Latvia represented industry professional associations for the distribution to their members, total 226 associations.

The expert interview was conducted with Neil Kalnins, the organizer of "5G TECHRITORY" conference (https://www.5gtechritory.com/). The event was investigated as a case study with the aim to look deeper into the event the technologies transformation from 2019 to 2020. The two "5G TECHRITORY" events were analysed from the following positions: event venue, number of participants, number of countries participating, number of speakers, expenses, the time spent for organization of the event, number and competence of staff, engagement and interactivity, the usage of technologies.

III. Results and Discussions

A. The Characteristics of the Respondents

The total amount of participated in the survey (n=70) was mostly represented by the event organizers (61.4%), located in Riga (60.4%). The service providers participated in the survey make 38.6%, the same as the event organizers mostly located in Riga (51.8%). Most of the respondents have long-term experience, 60% are engaged in the international events organization for more than 10 years.

B. The Characteristics of the Events and Delegates

Conferences and seminars are the main types of the events organized – 81%, forums – 36%, congresses are also placed in, but with lower intensity – 31%. Discussions, lectures, social events, visits, exhibitions, etc. were marked as other events. The average number of the events organized by associations, government and municipality organizations, education organizations and corporates vary mostly from 1 to 5 events per year – 63%, most of the service providers maintain more than 10 events per year – 89% of respondents. The number of events during COVID-19 pandemic decreased for both the event organizers by 18% and the service providers by 29%, most of the events were forced to be postponed to the year 2021 or 2022.

The number of the delegates per one event decreased in 2020. Most of the events organized before the COVID-19 varied in between 51 to 250 participants per event, the number of this type of events decreased for 10% in 2020. This could be explained by the numerous COVID-19 restrictions. However, in separate cases as "5G TECHRITORY" the number of the participants comparing

with 2019 doubled, from 700 participants in 2019 up to 2000 participants in 2020.

The country of the origin of the participants expanded in 8% of cases, in 61 % of cases the country of the origin narrowed down, and nothing changed in 31 % of cases. 52% of the event participants were from different countries in Europe, 36% from different countries all over the world and 12% - only from the Baltic States. The place of event before restrictions was 92% on site, but it decreased and 65-75% of 2020 events were online or hybrid. Despite the fact that significant number of the events were organized during COVID-19 restrictions, all the service providers mentioned the turnover decreased up to 50% or 70-90%.

C. Technology Usage

The restrictions caused by COVID-19 since March 2020 forced 69% of the meetings to be transferred into virtual or hybrid environment. The survey shows that most of the respondents already used the developed platforms, such as Zoom, Webex, MS Teams, some of the organizations implemented their own original platforms, in some cases as with "5G TECHROTORY" several platforms (Webex and specially designed local platform Attend.me) were integrated together (Fig.1).
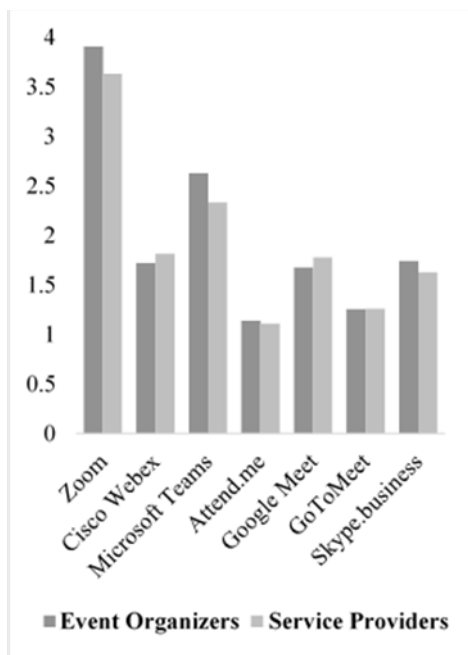
Fig. 1. Used online platforms for events (1 - not at all, 2 - a little, 3 - moderately, 4- a lot, 5 - in all events without exception).

Fig. 1. Used online platforms for events

The respondents were asked to evaluate the intensity of the usage of 16 types of technologies before COVID-19 restrictions in 2020 and their desire to operate the same technologies in the future. The results showed (Fig.2) that such technologies like the online registration, the event website, the multimedia projection, the event video filming, the social media channels are familiar to the

respondents and they used them moderately. The usage intensity of the above-mentioned types of technologies increased in 2020 and the list was added by event virtual platform, event live streaming, event online analytics, on-site data collection and webinars.

The Respondents plan to continue to operate most of the technologies they implemented and plan to do it more intensively than in 2020, specially related to the online registration, event webpage, event virtual platform, event live streaming, webinars, event online analytics, on-site data collection and social media channels. Other technology solutions named were Kahoot, Sli.do, Whatsap, Youtube, Facebook live videos, remote voting, etc. The organizer of "5G TECHRITORY", Neil Kalnins in his interview pointed out that the online analytics was one of the most valuable benefits for conference organizers, providing very precise data and delivering the detailed information about everything what has happened during the event. Another success of the event was the usage of the set of platforms. This approach ensured possibility to integrate Webex communication platform and to create three different stages of the conference and virtual expo venue. Unlike 2019, where a static website was developed for the event, 2020 technologies allowed to integrate the web page into the platform and provided the delegate engagement already from the first step. Entering the conference platform, the delegates had the choice to choose which stage they want to stay at, they could move from stage to another stage or enter the virtual expo. This brings forth the attention and interest of the participants and overcome the time difference.

The results of the survey show that the meetings and the event organizers and the suppliers in most cases positively evaluate the usage of the technologies in the organization process of the event (Fig.2). According to 81% of respondents they agree that future events will take place in hybrid format, but likewise they do not exclude the existence of fully virtual meetings and onsite meetings, which create the specific atmosphere and positive memories.

Overall, the respondents are satisfied with the new technologies, they feel safe or almost safe operating them, they consider that technologies could save time and financial resources, increase the engagement and comfort, expand the opportunity to invite and hear rare-accessible lecturers. The Service providers point out that their employees have medium or good skills in work with technologies, but only Professional Conference Organizer rates employee skills as "very good". Among the main challenges the respondents pointed out the problems connected with the Internet - 20% of the respondents mentioned lack of the Internet speed and the signal coverage. The respondents most worry about the lack of the experience and the skills, as well as uncertainty about the technical equipment they have. The following skills and knowledge they consider should be improved: digital skills, knowledge about virtual platforms, human behaviour and its prediction, as well the respondents consider as need to exchange and share experience between colleagues.
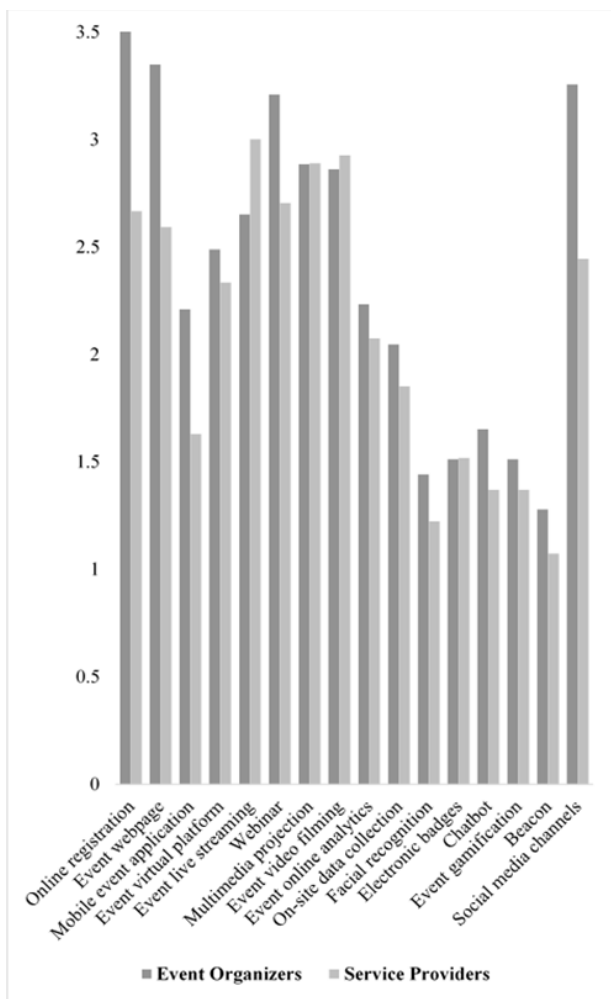
Fig. 2. Used technological solutions for events in 2020 (1 - not at all, 2 - a little, 3 - moderately, 4- a lot, 5 - in all events without exception).

Fig. 2. Used technological solutions for events

This study contributes to the Getz [11] statement about the future research direction needs regarding wider discussion on the environmental impact from the industry pointing out advantages of distant online events specific role. But it stays in the contradiction to the participant – traveller raising trend to accumulate more authentic leisure experiences combined with the business tourism. This study demonstrates adoption of various technological advances as the solution for the crisis management performed by the meetings and the event's organisers similarly as Hajibaba at al. [33] have suggested analysing the crisis management in regard to prevention and preparedness strategies facing the business travel segment, pointing to the sector which may recover sooner in the post crisis era. However, the challenge to find systematic ways out of the crisis for the entire supply chain stays open as digital solutions are not helping for many location-based services. According Wut et al. [20] there should be clear concerns about what are the effects of crisis prevention and preparedness in the future for the international tourism. This study shows clearly individual adoption of the crisis

management by various stakeholders, but there is lack of data and discussion in this research about the systematic tools to support the recovery of the whole industry. Although, what will be the financial concerns and productivity issues in a long-term of these rapid innovations caused by COVID-19.

Summarizing the main part of the results and answering the research question: what are the changes in the usage of technologies in the meetings and the events organized under the influence of COVID-19, the extremely rapid adaptability of entrepreneurs and the leap in technological development in the application of everyday developments should be highlighted within a period less than a year. Secondly, even if the initial motive was to create solutions for business continuity by replacing the current arrangements with various technological innovations, entrepreneurs are convinced that many elements from this substitution will remain, which will continue to cause changes in supply chain services.

The door for virtual and hybrid events is opened, this fact confirms CMX (Community for Online Community Professionals) the report where 80% of the respondents stated that virtual events are becoming a more critical part of the organization's business strategy [34]. We can't ignore the fact that online participation must be a part of the future face-to-face events. The Traditional format of attending scientific conferences already before COVID-19 was questioned by the communities due to the large carbon footprint associated with the international flights, low accessibility for wide set of researchers including the persons with disability and those with limited resources or having caring and family concerns [27]. The positive impact of the virtual and hybrid events on the environment, the accessibility providing the learning opportunity for a greater number of researchers, the possibility to attract leading scientists who are more likely to accept the invitations because the time commitment is significantly less [35] the lower costs makes digital formats more and more attractive. "5G TECHRITORY" organizers point out that all type of the events will continue to develop in the future but will be more segmented and rational.

IV. CONCLUCIONS

The hybrid event phenomena became a "new normal" of our everyday life, opening the new opportunities, but at the same time creating new challenges for the meeting and the event industry stakeholders.

The development of the meeting and the event industry is tightly connected with the adoption of new technologies to raise competitiveness. COVID-19 restrictions forced the industry to find new ways to organize interregional and international events and find the ways out of the sudden crisis. The majority of the industry had to make a pivot in 2020 and was forced to cover the technological adoption gap and build digital meeting solutions in their overall strategies within a very short period of time. Fast and unplanned investments in 2020 hit the financial stability of the service providers, the lasting lockdown and uncertainty aggravates the situation even more. For the events mostly already developed platforms were adopted, but for the

online activities: combinations of online registration, event webpage and multimedia projections.

Industry members contrive experiencing such a rapid digital transformation, but point out the necessity of the specific digital knowledge and skills improvement, the need of the professional specialists to operate in digitalized reality. Internet speed and coverage, access to the advanced technical equipment, professional and experienced staff are named to be the biggest challenges. Industry members predict: the events will be held mostly online or hybrid in future either, although the onsite events give more specific atmosphere and positive memories. Face-to-face events will return, but with the element of online participation. Both the organizers and the participants will assess the need for travel more carefully. Although the organisation of virtual and hybrid events in most of the cases require the same budgets as face-to-face, many of them will stay in digital or phygital environment.

This research identifies the critical factors of technology use in the meeting and event industry, clear up which technologies were the most popular in the meeting and event industry before and will stay after COVID-19, how willing and ready are the event organizers to continue the implementation of digitalization in the event organization process in Latvia. Results acquired are not state specific and are applicable to the other states of the Baltic region or elsewhere with similar industry structure and development level. However, it encourages for deeper investigations, especially implementing new digital and online (or hybrid) event organisational business models in the industry in relation to the competitiveness of the hospitality industry. After such a rapid digital transformation part of the traditional business tourism services (e.g. hotel rooms, conference halls, catering, mobility and incentive travel etc.) are not used so extensively any more – what does these changes mean for relates industries within the supply chain. Another direction for further research includes challenging the digital gap of employees and other technological advances based on the specific industry needs. What other changes will bring transformation to digital destination and what skills and knowledge should be improved to operate virtual and hybrid meetings, to investigate the behaviour of delegates, to detect the tools for deeper engagement of the participants, to explore the financial models for the successful business development in digitalized environment.

Hall quoted Dietvorst that all tourism related events have space and time attributes attached to them [34], but this is challenged with digital events, where traditional destinations turns into a virtual venue, but the flow of visitors does not follow: sharing the same time, but not place.

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Educational Model for Cross-Generational Collaboration

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Abstract - **The paper's considerations relate to an Erasmus+ project called** *Generation: Smart. Social Competences Transmedia Bridge To Cultivate A New Culture For Cross-Generational Collaboration.* **The consortium agreed that due to profound changes in the contemporary Network Societies, people of various generations have to collaborate. However, it is a complex issue due to the divergent life purposes of different aged people. Thus, the project's targeted group, i.e., educators who support adult learners, should be equipped with an educational model that constitutes a solution to this situation. The assumption was that such a model is to include social competences enabling the processes of cross-generational collaboration. Information technology transmedia blend is supposed to bridge the gap between generations. In the paper, we present an overlook of the research that focuses on developing such a framework model. The research features triangulation, which means the analysis of both quantitative and qualitative data. It is structured in three parts. The first one deals with the statistical embracement of the social environment in which the cross-generational collaboration occurs in project partner countries. It is quantitative desk research that utilizes Eurostat information. It is worth pointing out that the research is** *in statu nascendi*. **In two consecutive parts, the researchers want to acknowledge the cross-generational collaboration in working life and everyday life. Here, the survey method and the questionnaire interview technique serve as the qualitative research method. Two research groups are to be reached: entrepreneurs and the Third Age Universities' participants. The results of the above two stages will be known after the publication of this paper.**

Nonetheless, a proto-model recommendation is presented along with educational conclusions on how to use the model. The concept is based on the prior partners' analysis and design work.

Keywords - cross-generational collaboration, educational model, social competences, transmedia blend.

I. INTRODUCTION

The future depends on connectivity. Not only is it important technologically (connected devices – the Internet of Things: gathering data, e.g., to power the Artificial Intelligence algorithms), but it directly also touches people. The context of the research described in the paper focuses on the cross-generational gap that features contemporary Network Societies [1]. The term "network society" defines the stage in the development of societies in the modern world. In the network society, information is subject to a wide flow – with the use of IT and, above all, the Internet. Nowadays, due to, e.g., profound technological and demographic changes, people of different generations have to collaborate. Life and professional activities in the contemporary world demand to overcome challenges and bridge the gaps between generations. Educators who support adult learners originating from different age groups need an educational model to bridge the cross-generational gap. Such a model should be a flexible structure that can be easily updated. It can comprise a part of social competences and another part

dealing with information technology as well as innovative pedagogy. Transmedia approach – of or relating to more than one form of media[1] – can constitute a solution aiming at embracing and implementing a new culture for cross-generational collaboration [2]. It can be cultivated in two main domains: working life and everyday life. The former deals with the present and future needs of work environments. The latter one includes, among others, senior citizens, and it is strongly connected with social responsibility in the aspect of making a better world.

The model for cross-generational collaboration (the CGC Model) is supposed to be the outcome of an Erasmus+ project titled "Generation: Smart. Social Competences Transmedia Bridge To Cultivate A New Culture For Cross-Generational Collaboration" (GSmart). More information about the project can be found on the web page https://www.generationsmart.eu/ .

II. Materials and Methods

The main material connected with the research is the model itself. A model – a construction that is a simplified image of a selected fragment of reality; a formalized approach to a theory or situation in which it generates specific data. Models as descriptions are almost always partial or incomplete because they concern only selected characteristics [3]. The process of the CGC Model designing and constructing follows such a procedure of construction and verification:

1. The preliminary structure of the model (proto-model) has been designed (Fig. 1).

2. The model is subject to testing via an educational process of Transnational Training Sessions that are supposed to be conducted during the GSmart project.

3. The construction of the final design of this model is proposed.

The validity of the above procedure was confirmed by S. Libow Martinez and G. Stager [4]. They promote the term 'tinkering' in the sense of taking action to improve learning processes that arise from experience, experimentation and discovery. They also introduce the term 'constructing' to draw conclusions from experience and combine intuition – thinking and reflection – with formal aspects. It enables measurement and understanding as well as an explanation of the consequences of actions.

Following the concept of model development originally proposed by S. Libow Martinez and G. Stager, as well as by D. Leclercq and M. Poumayit [5]. It is assumed that the concept of designing and constructing an educational model consists of three stages:

1. Idea stage – refers to initial thoughts concerning a given issue. It may include phases: feedback from others, brainstorming, resource analysis, goal setting,

model outline, impact prediction, developing an action sequence diagram – a dynamic procedure of events.

2. Creation stage – the initiation of the action occurs. It may include phases of creating, experimenting, constructing and deconstructing, testing, observing the impact, documenting the process, looking for weaker elements, and reacting to them accordingly.

3. Development stage – a properly designed and constructed model should correspond to the initial assumptions of the specialists who created it. The model can be applied in educational practice. Simultaneously, the model can – and even should – be improved by considering the changing conditions of time, place, people, concept development, or needs and requirements for the education of a particular group of learners.
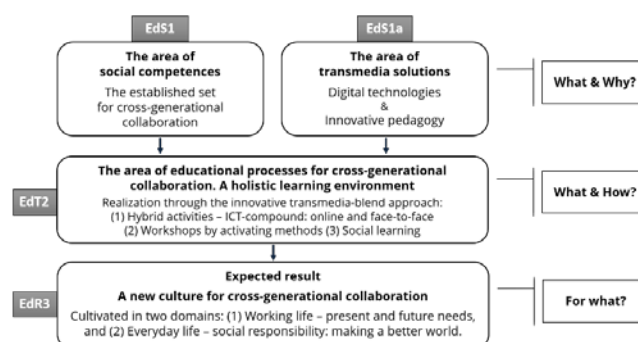
Fig. 1. Proposal of an educational model for cross-generational collaboration. The CGC Model – preliminary blueprint (proto-model)

EdS1 – the first stage of implementation of the CGC Model – the level of educational strategy. It refers to an established set of social competences.

In the project, it is assumed that to participate in the Network Societies actively, the members of such societies should be strategically educated (1) on social competences that support the development of the meta-competence (a competence that is self-referential; it is at a higher level and beyond others) – the ability for cross-generational collaboration, and (2) through digital Technology and innovative pedagogy – the transmedia-blend approach [2].

By cross-generational competence, we understand the ability of different-age people to go partners. It can be both in working life and everyday life domains. For contemporary societies, this issue is of paramount significance.

According to ESCOpedia (European Skills, Competences, Qualifications and Occupations (ESCO)), *"[…] competence means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and professional and personal development"* [6]. Whereas the term 'skill' refers mainly to methods and instruments, *"[…]*

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[1]Dictionary, https://ludwig.guru/s/transmedia [Accessed: Mar. 2, 2020]

competence is broader and refers to the ability of a person – facing new situations and unforeseen challenges – to use and apply knowledge and skills in an independent and self-directed way" [6].

Transversal knowledge, skills and competences must also be taken into account [7]. They are *"relevant to a broad range of occupations and economic sectors. They are often referred to as core skills, basic skills, or soft skills, the cornerstone for the personal development of a person"* [8]. Competences are organized in a hierarchical structure – with five headings. One of them is 'social interaction'. It underpins the GSmart project and constitutes the project's core notion regarding competences considerations.

For the sake of the GSmart project, the set of social interaction competences – the social competences – that support cross-generational collaboration has been established based on earlier research [9]. It was conducted in connection with the Erasmus+ project "Intranet: Intrapreneurship net-playbook" (Intranet) [10].

The set of social competences that support the cross-generational collaboration:

1. Adaptation,
2. Barrier-breaking,
3. Conflict resolution,
4. Creativity,
5. Critical thinking
6. Collaboration,
7. Communication,
8. Community building,
9. Cross-generational attitude swap. A competence that includes the following stages: (1) From the point of pre-existing experience, (2) Through building the cross-generational consideration, and (3) To reach the level of understanding of how to bridge the cross-generational gap.
10. Decision making,
11. Empathy – helping others,
12. Experimentation encouragement,
13. ICT – skills, and abilities of the Digital Age,
14. Inspiring,
15. Knowledge-sharing,
16. Leadership responsibility,
17. Motivation,
18. Negotiation,
19. Problem analysis,
20. Problem-solving,
21. Resilience – goal-oriented approach,
22. Social responsibility,
23. Teamwork.

The above set of social competences that bridge the cross-generational gap has been introduced to the public in the research described in the paper.

EdS1a – the first stage of implementation of the CGC Model – the level of educational strategy. It refers to the chosen transmedia solutions.

Hybrid activities – ICT-compound: online and face-to-face

Ten interactive tasks supporting the development of cross-generational collaboration through social competences. A derivative of the outcome material of the Erasmus+ Intranet project. From this perspective, the GSmart project will be a continuation of the Intranet project – yet adjusted to other social needs and contexts.

Workshops by activating methods

Five training sessions are delivered in face-to-face mode. Various proven methodologies, e.g., Design Thinking, Lego Serious Play, or gamification elements, will boost cross-generational collaboration through social competences.

Social Learning

Multiple social learning channels, such as online discussion, audio-video interactions, peer-coaching, or Slack collaborative environment, will foster a mutual understanding by cross-generational social competences [11].

Following the trend of social connectivity that features up-to-date online platforms[12], the mixture of the three foremost forms will be integrated into one holistic, consistent, and coherent framework. Multi-channel communication through the cloud-based systems Edueca (the platform by CIDET (Spain) is the place for the interactive online activities on the cross-generational collaboration through social competences), Google Workspace (the service is supposed to be a collaboration space for both the project partners and the project targeted groups, in the latter case, it will be a significant part of the project transmedia approach) and the Slack collaborative mobile environment will facilitate the integration of the GSmart's teaching and learning forms of the project. This procedure will enable us to constitute a bridge on cross-generational collaboration by education on and expansion of social competences.

EdT2 – the second stage of the implementation of the CGC Model – the level of educational tactics. It concerns the area of educational processes for cross-generational collaboration.

Tactically (operationally), it will be done by the application of the innovative transmedia-blend approach – within a holistic learning environment. It means that

the content and teaching and learning methods will combine three earlier mentioned primary forms.

EdR3 – the third stage of the implementation of the CGC Model – the level of results.

It concerns the expected objective of the model's operation. It is the cultivation – achievement, application, and development – of a new culture [2] for cross-generational collaboration in two domains: (A) Working life and (B) Everyday life – social responsibility: making a better world.

By social responsibility, we understand the ability to take the perspective of and empathize with others from different: ages – including seniors, backgrounds, and cultures – social environments, as well as to understand ethical norms for behavior. It is also a usage of creative intelligence in connection with community resources.

In the concept of competence, the term social responsibility has been specified as *"[…] the ability to act responsibly, autonomously, and considering values and standards and the effects that can be anticipated for oneself, others, and situations, and also to consciously endure the resulting consequences"* 13]. The research reveals a strong connection between social responsibility and the ability to cooperate – collaborate with others [13].

The discussed domain has a lot in common with the term "social intelligence," i.e., *"[…] the ability to connect to others deeply and directly, to sense and stimulate reactions and desired interactions"* [14] – also by the activities that can benefit senior adult learners. Socially intelligent people can quickly assess the emotions of those around them and adapt their actions accordingly. It should be a key feature for those who need to collaborate cross-generationally and build relationships of trust. It is important in cross-generational collaboration with larger groups of people and different settings. Such an approach is directed to the notions of social inclusion and the inclusion of senior adult learners.

The CGC Model's Features

At the meta-level

A framework construction

A framework means here a collection of proposed solutions with the possibility of alternation or expansion. It can be done both in the scope of content and processes related to the development of the system functionality.

It means predefining the elements of the structure, content, and procedure of the action – Dynamic Procedure of Events (DPE – described later). Such design will provide stability and, at the same time, flexibility in terms of prospective modifications and improvements of how to use the model. Such an approach ensures the possibility of a selection of social competences and transmedia

solutions, as well as alternations in the scope of educational processes – methods and the choice of the educational aim(s).

At the practical level – Learning, Teaching and Training Activities

Adjustability and validity

The GCG Model will be adjusted and validated in the training process by the project's targeted groups – during the project's training sessions. The knowledge on how to use the model will be passed to the project's targeted groups. Opinions of the project targeted groups will be used to improve the model assumptions.

Dynamic Procedure of Events

While maintaining the functional usability and flexibility of the CGC Model, it is possible to indicate the Dynamic Procedure of Events (DPE), which applies to this model. This procedure determines the proper functioning of the model. It has been assumed that the CGC Model aims to achieve a learning process that supports the development of a new culture for cross-generational collaboration.

Level of educational strategy – the definition of: who, what, and why. The stage of model implementation: 1

At the first stage of implementing the CGC Model, a strategic selection of social competences takes place (Fig. 1. EdS1). Educators can develop social competences according to a particular group of learners' needs and expectations – to boost the cross-generational collaboration. It is done by choosing relevant parts of the course implemented for the sake of the project's targeted groups. The parts' activities aim to develop different social competences and – as a result – the meta-competence of cross-generational collaboration.

The education and development of social competences using digital technologies and innovative pedagogy are strategic objectives – *sine qua non* conditions – of education in the Network Society [15]. For this reason, the first strategic level of implementation of the CGC Model also includes transmedia solutions (Fig. 1. EdS1a). The selection of specific tools has been described earlier. They serve the educational processes at the level of educational tactics –during the second stage of implementation.

The level of educational tactics – the definition of: who, what, and how. The stage of model implementation: 2

At the second stage of implementation of the CGC Model – in the area of educational processes for cross-generational collaboration – the integration of the area of social competences with the area of transmedia solutions takes place. It is done by implementing and verifying the learning environment (Fig. 1. EdT2). Learning environment – which is a key element as it determines the

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[2] Culture – here: (1) development or improvement of the minds by education or training; (2) The set of shared attitudes, values, goals, and practices that characterizes an institution or organization (Webster's definitions: https://www.merriam-webster.com/dictionary/culture [Accessed: Mar. 2, 2020]).

proper functioning of the CGC model – means here educational cooperation that consists of the following elements:

1. Educators – with whom one learns. In the GSmart project – the project's targeted groups, i.e., educators and other personnel who support adult learners;

2. Learners – who learns. In the GSmart project – adult learners educated on the cross-generational collaboration in working life and/or everyday life domains;

3. Content – what is taught, e.g., social competences to develop the meta-competence of cross-generational collaboration.

4. Methods and activities – how to learn, e.g., following innovative transmedia-blend approach – activating methods of teaching and learning;

5. Space, time, and infrastructure – learners learn where, when, and using what, e.g., digital Technology, the virtual space, and online [16].

Level of results – definition of: what is the result of the learning process that has been designed and carried out.
The stage of model implementation: 3

The third stage of the CGC Model implementation is to achieve the expected result of the educational process (Fig. 1. EdR3). This is done through teaching and learning processes as well as the analysis of the results of the verification (testing) and the use of updated information. The result is a learning environment that includes a range of processes that foster the development of a new culture for cross-generational collaboration. This new kind of culture can be cultivated in two domains: (1) Working life – present and future needs, and (2) Everyday life – social responsibility: making a better world.

In the GSmart project, this scope constitutes elements of educational processes:

Social competences factors defined at the first stage of the implementation of the CGC Model – in the area of social competences;

Digital technologies and innovative pedagogy defined at the first stage of implementation – in the area of transmedia solutions;

Activating teaching and learning methods, i.e., innovative transmedia-blend approach. It comprises three main elements:

1. Hybrid activities – ICT-compound: online and face-to-face.

2. Workshops for the project's target groups with the know-how on the cross-generational collaboration education – by activating methods.

3. Social Learning.

Integrating the components mentioned above within the CGC Model aims to achieve an innovative educational framework for cross-generational collaboration. It can constitute the theoretical and methodological basis for the a course created in the GSmart project for the sake of the project's targeted groups.

The methods that deal with the CGC Model are strongly connected with the research. It's main aim is to prepare the best educational offer for the project's targeted groups to enable them their work on cross-generational collaboration.

The primary desk research was conducted during the processes of the GSmart project proposal elaboration. It included analyzing such sources as books, articles, and reports. Thus, it was a kind of state-of-the-art analysis. We concluded that a consistent and reliable update on the cross-generational collaboration issue is highly recommended.

Therefore, the actual project's research collects and analyzes statistical information and notions of the empirical kind. It features the so-called triangulation [17]. Statistics and Social Sciences refer to the analysis of both quantitative and qualitative data to obtain more accurate research results.

As *omne trinum perfectum*, the research is divided into three parts:

Part 1: Cross-generational collaboration in the social environment. Eurostat data are used to embrace the notion of cross-generational collaboration. It is supposed to be a big picture of the issue in question in the partner countries. It is quantitative desk research that characterizes the population and labor market situation in the GSmart partner countries. It features the state and structure of the population by sex, age groups, the population aged 65+, the old-age dependency ratio and population projections to 2030, as well as the labor force participation rate by sex, age 15-64, education level, the employment rate for the 15-64 age group by sex and education level, and statistics on the unemployment rate for the 15-74 age group by sex and education level.

The statistics were obtained from Eurostat, and the available information (as of February 24, 2021) covers the periods from 2018 to 2020 (as of January 1), while the Labour Force Survey (LFS) covers the 3rd quarter of 2019 and 2020.

Part 2: Cross-generational collaboration in working life Working life indicates connections with professional activities. The GSmart research takes the perspective of entrepreneurs and managers of different ages [18]. The qualitative research assumes a selection of the research group. Participants should originate from the working life environment, i.e., entrepreneurs and managers of different ages and groups in companies, institutions, associations, and foundations. The research group should consist of not less than 30 representatives in each partner country. Here, we intend to embrace the difficulties in cross-generational

collaboration and ways of dealing with it. This part of the research is directed to managers of companies, institutions, and associations or foundations. The research is conducted by an online survey.

Part 3: Cross-generational collaboration in everyday life. Everyday life designates natural and ordinary world activities. It is experienced and treated as a foundation for all forms of standardized and targeted actions. The GSmart research takes the perspective of seniors [19]. The qualitative research is also conducted by an online survey. It aims to describe the cross-generational collaboration in everyday life from the perspective of seniors who originate from the selected Third Age Universities (TAU) in partner countries. The research assumes a selection of the research group. The research group consists of not less than 30 seniors – TAU(s) participants from each country.

III. RESULTS AND DISCUSSION

As stated in the introduction, the research team is in the process of research implementation. It started in January 2021 and is about to finish in July the same year. A complete discussion will be possible once a report with the research outcomes is published on the project's web page. However, it has already been possible to present the outset summary of the first part of the research. It is the following:

In 2020, compared to the same period in 2018, population growth was recorded in all partner countries except Poland. Populations in partner countries are predominantly male, except for Turkey where there is a higher percentage of women 50.2% (Fig. 2).
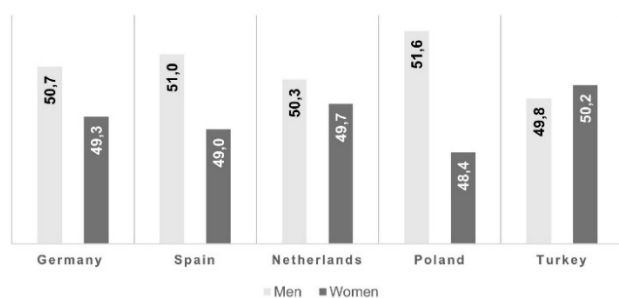
Fig. 2. January 2020 – percentage of men and women in partner countries (data in %)

In 2020, one in three people in the partner country populations were aged 25-49. In the age group 50-64, there was one in four German, one in five Spanish, Dutch and Polish citizens, and one in seven Turkish citizens. Every seventh citizen of Spain and Poland was aged 65-79, every eighth citizen of Germany and the Netherlands, and every fourteenth citizen of Turkey (7.3%). One in five citizens of Germany, Spain, the Netherlands, Poland, and one in eleven of Turkey were aged 65 or older. Every third citizen of Turkey was aged 0-24 (every sixth citizen aged 15-24), every fourth citizen of Germany, Spain, the Netherlands, and Poland (every tenth citizen aged 15-64 and every eighth citizen of the Netherlands).

In 2020, compared to the same period in 2018, populations in the partner states were experiencing an increase in the percentage of people aged 65 and older.

The old-age dependency ratio increases in all partner countries, with the highest value in 2020 in Germany at 33.7% and the lowest in Turkey at 13.4%.

In the forecast to 2030 for the European partner countries (no Eurostat data for Turkey), only Poland is projected to decrease population. The most significant population increase is projected for the Netherlands and the smallest for Germany.

In 2020, the highest labor force participation rate among partner countries was recorded in the Netherlands at 81.1% and the lowest in Turkey at 56.3%. The labor force participation rate was highest among people with tertiary education regardless of the partner country and ranged from 77.7% in Turkey to 90.4% in the Netherlands. It had the lowest values among people with less than primary, primary, and lower secondary education from 27.1% in Poland to 65.0% in the Netherlands. In 2020, compared to the same period in 2019, the labor force participation rate fell in Germany (-0.2 pp, i.e., percentage point), Spain (-1.2 pp) and Turkey (- 3.2 pp), in the Netherlands, it remained at the same level, and in Poland, it increased by 0.3 pp.

The employment rate in the partner countries in 2020 was the highest in the Netherlands, 77.6%, the lowest in Turkey, 48.8%, and the highest among people with higher education regardless of the partner country, from 66.8% Turkey to 88.2% in Poland. The lowest value of this indicator was among those with less than primary, primary, and lower secondary education, from 42.5% in Turkey to 59.8% in the Netherlands. The employment rate in 2020 compared to the same period in 2019 decreased in almost all partner countries except Poland, where an increase of 0.1 pp was recorded. Its largest decrease was observed in Spain by 2.7 pp.

According to the LFS (LSF), the unemployment rate in the third quarter of 2020 was highest in Spain and Turkey at 16.3% and 13.2%, respectively, and lowest in Poland at 3.3%. Compared to the same period in 2019, the unemployment rate decreased only in Turkey by 0.8 pp and increased in Spain by 2.4 pp.

IV. CONCLUSIONS

A new post-pandemic reality will probably shed yet new light on the processes of cross-generational collaboration. Both the CGC Model described in this paper, and the research can become a decent reference for the parties that need to embrace the issue in question.

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Automated Sensory Monitoring System Prototype for Continuous Monitoring of Material and Structure State

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Abstract **- The goal of this article is to solve problems of automated monitoring systems of industrial and aviation constructions. Based on the latest research results, the most cost-effective solutions are covered, and a practical solution is offered. This article is part of the scientific project "Development of an integrated sensor system for material and structure monitoring". The article describes the problem and suggests a practical solution for an integrated sensor system for material and structure monitoring prototype.**

Keywords - Non-destructive testing, integrated monitoring, piezoelectric sensor, impedance.

I. Introduction

Monitoring of constructions is made "all the time", that is to say - any interval deemed necessary; from the point of view of statistics - when the variable "chance the construction would crash" meets the variable "this much money can be spent on inspection". So, some faults could still occur. Manufacturing plants stop, trains break and even derail, bridges crumble and collapse, aircrafts fail and even crash. To make such occurrences less often and less severe, automated monitoring systems should be introduced. Systems that would really be able to monitor all the time - constantly and without any intervals; this would let us know when the first sign of a budding problem occurs instead of how it has to be done immediately - the best that can be done with manual maintenance at intervals - if luck allows it, to find actual problems that have already appeared or even clustered together, forming a bigger problem [1],[2],[4]-[6] Inventing and introducing such systems always come with certain limitations. Firstly - the system should be safe, secondly - the monitoring system should cost considerably less than the object it will be monitoring. This article will evaluate methods that can be used to monitor the state of constructions and the base elements, the sensory elements used for these methods, and offer a practical solution. The project objective is expected to develop a new technology which is mainly based on the reference-free principle of assessment of the monitoring results. A prerequisite for the successful solution of this problem is the results of recent original studies concerning the structure/sensor loading effects on the interaction of ultrasonic waves with structural defects.

II. Full electromechanical impedance method

A rather new method is the electromechanical impedance or full resistance (impedance) (EMI) method. The method entails scanning the sample with sound waves in a specific frequency range and the sensors then read the signature of the sample. If the state of the sample changes, so does the signature. This method is not particularly widespread. The tools to use the EMI method for now are comparatively expensive and to actually use it an extensive knowledge base is needed regarding the signature of material, as the signature is affected by various conditions, such as load, microfractures and also ambient sound; if the material can soak up humidity, the humidity level will also affect the signature. Lately, more acceptable solutions can already be found on the market both in terms of the price of the equipment and availability of databases. The databases are based on research performed with those devices and have data such as, for example,

the suggested frequency range for concrete construction depending on the depth of the scan required [8].

III. NDT Solution

The most commonly used simple EMI system is based on an impedance converter, see Fig. 1, as the AD5933 1 MSPS, a 12-Bit converter and its evaluation hardware EVAL-AD5933EBZ. The pros of this system are its comparatively low price, industrial temperature range of -40 °C to +125 °C; 2.7 V to 5.5 V power supply operation and the serial I2C interface, which allows the elements not only be linked to a computer system, but also microcontroller systems, thus making the whole system configuration and system costs more flexible [7].
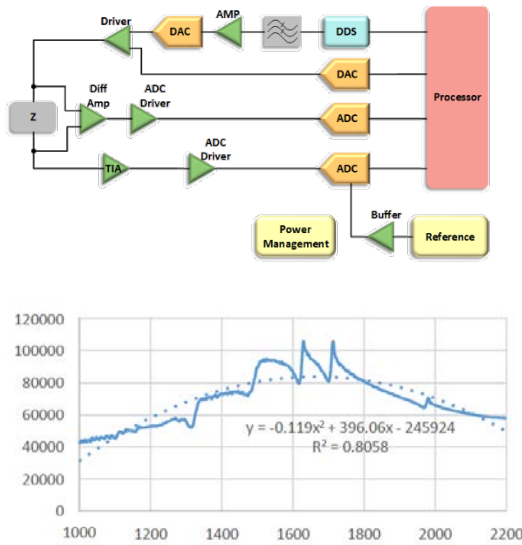
Fig. 1 Impedance Converter (upper image) and (lower image) impedance (Ω) depending on frequency (Hz) output graph.

Such microchips are mostly intended for medical or network uses, so they are not ideal for use in construction monitoring. But, if the automated monitoring systems based on this method were to become more commonplace, then the specialized systems should also become more available. During the research (Venu Gopal Madhav Annamdas, Yaowen Yang, Chee Kiong Soh,2010) [8], testing of concrete constructions was commenced using an Embedded PZT Sensor; the research confirmed that 100 kHz frequency was optimal for the tests on the concrete and the maximum measurement range was 200 mm. Since the chip can measure only the resistance, but not the capacitance or inductance, it is therefore necessary to take into account the expected circuit diagram of the PZT model. This model can be formed from resistors, capacitors and inductors using appropriate equations (1), (3), (2).

$$Z_R = R \tag{1}$$

$$Z_L = Lwj$$
$$|Z_{LMAX}| = 2\pi f_{MAX} L$$
$$|Z_{LMIN}| = 2\pi f_{MIN} L \tag{2}$$

$$Z_C = \frac{1}{Cwj}$$

$$|Z_{CMAX}| = \frac{1}{2\pi f_{MIN} C} \tag{3}$$

$$|Z_{CMIN}| = \frac{1}{2\pi f_{MAX} C}$$

To improve accuracy based on the manufacturer's recommendations, the following equations (4) can be used to obtain more accurate impedance Z measurement results.

$$Z = M \times X \times C$$
$$M = \frac{(Z_{MAX} - Z_{MIN})}{(X_{MAX} - X_{MIN})} \tag{4}$$
$$C = Z_{MIN} - (M - X_{MIN})$$

Where:
Z_{MAX} is the real maximum impedance.
Z_{MIN} is the real minimum impedance.
X_{MAX} is the maximum measured impedance.
X_{MIN} is the minimum measured impedance.

IV. Small single-board computers and prototype

Various applicable elements where revised and each had its strong and weak points. Among them, the following minicomputers where found to be the most optimal - see below.

With the creation of a popular company, the Raspberry Pi Zero W minicomputer can work with various available operating systems as well as a self-made one. They are promoted as a $5 device, although it costs $25 to acquire one. The leading advantage of this solution is its small size; it has Bluetooth 4.0 and is wireless network compatible. It consumes 100-350 mA on average, which can be considered as very efficient. Logic works with 3.3V, which allows for a wide variety of auxiliary modules and elements that can be used in conjunction. A somewhat similar creation of another company - the Orange Pi Zero Plus - an upgraded version of the Orange Pi Zero, has no power over ethernet (POE), making it a less attractive option for the prototype. The latest generation Raspberry Pi 4 is a reliable solution all-round, but its power consumption is higher than the others, as it has integrated a powerful video graphic module, which is a completely useless element in the project, just like its support of USB 3.0, as sufficient LTE can be ensured via USB 2.0. A study of LTE problems is discussed in the article [9]. As a result, for this project at this phase of research, the less known Orange Pi zero is more viable. An additional downside of this module can also be noted, which is that the components are not the latest generation and as it is not a large company, the technical support is subpar. Even though the Orange Pi zero by default can support POE (though is not preinstalled), it only provides up to 5V max. for it. It is obviously insufficient for long range communications. The majority of POE injectors have 24V or more as their operating voltage. Studying the schematic allowed one to make the conclusion that it is possible to modify the board to provide higher POE values.
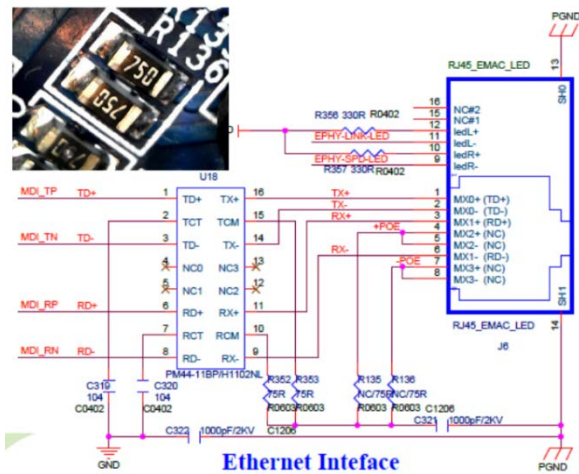
Fig. 2. Power over Ethernet (POE) of the Orange Pi zero.

Explanation of the required modifications to increase POE voltage: According to the schematic, both POE+ and POE- pins are connected to the GND through 750Ω resistors (R136 and R135 in Fig. 2). In the case that higher voltage would to be provided to this junction, it would lead to either or even all of the following: burning out of the resistors; burning of the electrical pathways of the circuit board; or power supply malfunction. Since higher voltage is a must, these resistors will need to be removed.
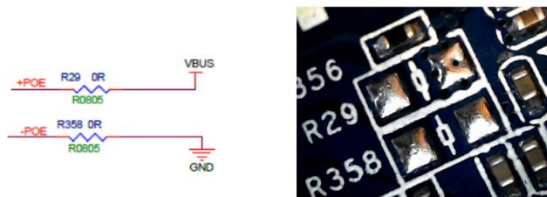
Fig. 3. Power shunt Resistors R29 and R358.

By default, the circuit board does not have resistors R29 and R358 installed, and their sockets are empty. To achieve POE with the required voltage, the R358 socket needs to be short circuited, but in the R29 socket a voltage decreasing regulator to 5V is to be installed to safely power the board itself.

Now the Orange Pi zero is primed to be linked with elements with a lot higher voltage level.

Using the modules described above, a prototype of the system was created (see Fig. 4), which consists of the following parts: **Orange Pi zero module.**

1. POE voltage decreasing regulator 6-45V to 5V 5A;
2. Power distribution bord with 5V 3.3V and I2C connectors;
3. Impedances measuring module I2C;
4. UART keyboard;
5. Temperature and humidity sensors. I2C.
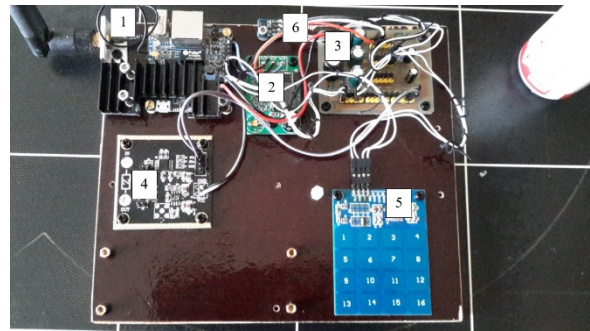
Fig. 4. Orange Pi zero with modified power supply and installed distribution connections for the measurement of impedance.

Another very promising one is a Linux based minicomputer-the "Onion Omega2+ Linux Compute Module". It is priced just over $ 10 with built-in Wi-Fi. It is offered as an independent daughter board, the power can be supplied via independent transformer/power supply connection or a separate RJ45 (POE), which is preferable for intended use. The size of the module measures 34x20x2.8mm or 42.9×26.4×9.9 mm (see Fig. 5) depending on the modification. Powered with 3.3V the minicomputer consumes 400 to 800 mA. Following, if one 3.7V Li-ion 18650 mA battery would be used, the board could work for 6-9 hours continuously.

Comparing the relevant properties, the Onion Omega family products are preferred over Orange Pi zero. Since both Onion and Orange microcomputers are Linux based, switching from one to the other is viable.

Fig. 5. Onion Omega2+ Linux Compute Module

CONCLUSION

The objective of the project is to develop a new technology that utilizes a reference-free principle of assessment of the monitoring results. Though the Orange Pi solution requires some manual modification to adjust it to the POE requirements, this modification also provides the system with flexibility not found in the default configuration of any other stock computing solution due to ability to provide higher or lower POE voltages, while the Onion Omega has RJ45 by default, allowing easier installation, though provide only default voltage values. The modified computing system has numerous applications when used in conjunction with wired, wireless and even LTE communications. The results and, as a proxy, the price, of any method used, will highly depend on how well-placed sensory elements and modules are and how effective they work together. According to the project plan, practical experiments are still scheduled for a later date. The experiments will allow to further test the method and to better optimize it for future applications, such as in the field of aviation and industrial objects and fields.

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On Integration of Evolving Infrastructure Topology Graphs and Metric Data Streams in Information Technology Infrastructure Management

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Abstract **- Modern cloud-based information technology (IT) infrastructure monitoring context and data are gathered from various systems. Typical monitoring systems provide a set of metrics characterizing the performance and health of a variety of infrastructure components. To understand the dependencies and relations among these measurements, the infrastructure topology can be analysed to provide context to the monitoring metrics. However, the metrics and the topology are updated at different time intervals and providing continuous merging and analysis of both data sets is a challenging task which is rarely addressed in the scientific literature. The paper elaborates a method for integration of infrastructure topology graph and monitoring metric data streams. The method is intended for application in the identification of anomalies in IT infrastructure.**

Keywords - infrastructure monitoring, infrastructure topology, stream processing, evolving graphs

I. Introduction

Modern information technology infrastructure is highly complex, and it consists of several subsystems such as software defined and physical network, software defined and traditional storage systems, physical servers, hypervisors, container orchestration platforms, and cloud computing platforms. Each of the infrastructure subsystems have a corresponding topology graph of infrastructure components with their corresponding metadata (e.g., allocated RAM for a certain virtual machine or characteristics of drives used in a storage system) and rapidly changing metrics of infrastructure components (e.g., input/output operations per second for a logical or physical drive). A typical large IT infrastructure generates millions of events per day at rates of about 100 events per second [1] and an averaged sized cloud has around 1000 tenants and 100,000 users) [2].

To monitor the entire IT infrastructure as a whole while taking into consideration the interrelationships of certain IT infrastructure components from different subsystems, all topology graphs and component level metrics and their corresponding time series data should be merged and analysed. Such analysis is a computationally and algorithmically complex task since massive amounts of data with different update intervals and data models need to be processed while minimizing the latency. Moreover, upon identifying a certain anomaly, the respective IT infrastructure components such as virtual machines or containers might have already been disposed and therefore removed from the infrastructure topology graph, which is why versioning of the topology graph is required for incident traceability purposes.

The objective of this article is to propose a method for providing infrastructure topology graph versioning and topology aware analysis of infrastructure component metrics.

The paper is structured as follows. Section II presents a method for providing topology aware processing of

infrastructure component time series data and topology graph versioning. Section III proves the applicability of the proposed solution by presenting a practical implementation of the method in Apache Spark, Kafka, Cassandra, and Neo4j. Section IV reviews related research and Section V concludes with final remarks.

II. METHOD OVERVIEW

This section presents a method for integrating evolving IT infrastructure topology graphs and IT infrastructure component related time series data. A high-level overview of the proposed approach is given in Fig. 1.
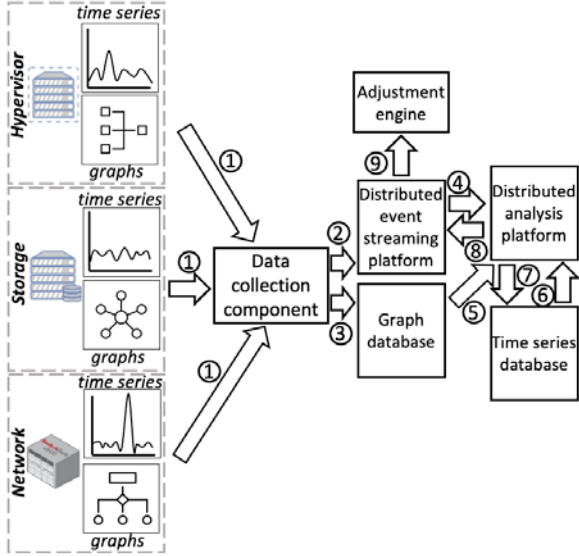
Fig. 1. Overview of the proposed method.

The given example considers three subsystems of IT infrastructure – a hypervisor, storage, and network. Each of them contains an associated topology graph which can be retrieved via API calls specific to the concrete subsystem. Such calls are computationally intensive and put a significant load on the respective subsystem, which is why their frequency needs to be limited depending on the performance characteristics of the specific subsystem. Furthermore, topology graphs can evolve in varying speeds depending on the type of subsystem. For instance, a topology graph corresponding to traditional storage equipment would experience significantly less updates compared to a graph originating from a container orchestration platform such as Kubernetes, where containers are initialized and disposed without any manual intervention. Our experience shows that the full topology graph retrieved from the respective subsystem contains a large number of vertices and edges, which are irrelevant for IT infrastructure monitoring purposes.

There are also time series data originating from the subsystems characterized by high velocity, volume and different schema. It is important that elements whose properties are constantly being measured in the time series data can be linked to certain nodes or edges in the infrastructure topology.

Topology and time series data need to be collected from the respective subsystems, what is done by the data collection component (depicted as connection #1 in Fig. 1). The following approaches can be applied for this purpose:

- Data pull – data collection component constantly queries the respective subsystem to get the time series data or topology graph. This approach is inefficient in terms of performance since subsystems are queried even if no changes have occurred. The advantage of this approach is relying on already existing APIs or log file structure and avoiding customization of infrastructure subsystem management.

- Data push – component of the subsystem or its management layer is customized to send the data to the data collection component upon receival of new data. This allows to distribute the load between the components (such as virtual machines) and achieve higher velocity of the data. It is complex to implement data push in the case of topology graph monitoring, since it would require extending the management layer of the respective subsystem.

- Reverse proxy – this strategy can be applied for continuous versioning of the topology graph without making any changes in the management layer and avoiding putting any additional computational load on the respective subsystem. This can be applied for subsystems where changes in the topology graph are made through a management web service. For instance, virtual machines are built through the web portal of the cloud computing platform, which in turn calls a management REST web service to trigger the creation of a new virtual machine, thus triggering an update in the topology graph. Putting a reverse proxy in front of the REST web service would allow to detect such events and alter the topology graph without directly querying the management layer of the subsystem. This approach can be used for detecting incremental graph updates; however, it would still be necessary to use APIs for establishing the initial state of the topology graph.

The data collection component feeds time series data into the Distributed event streaming platform (depicted as connection #2 in Fig. 1), filters out unnecessary topology graph data, and stores topology graph updates inside a graph database as a combined data centre level topology graph (depicted as connection #3 in Fig. 1). Separate topics are created in the Distributed event streaming platform for each topology component related metric (e.g., a dedicated topic for drive input/output operations per second). Component identifiers form the message key, while measurements are stored in the value section. It is advisable to use event time in the event message.

The distributed analysis platform provides processing of both topology graphs and time series data. It is done based on predefined analysis rules, which regulate:

- graph topology processing for retrieving subgraphs specific to the concrete analysis rule (e.g., all virtual machines and their corresponding hypervisors),

- time series data processing while linking certain infrastructure components based on the topology subgraph (e.g., link misbehaving virtual machine with a connected overloaded logical drive, and its physical drives).

Graph topology processing functionality of each infrastructure analysis rule includes the following:

- Graph query – a query to get the rule-related subgraphs from the graph database (depicted as connection #5 in Fig. 1)

- Graph hash calculation – a function for calculating a hash of a subgraph. This is used for detecting any structural changes in the graph.

- Get a graph ID – a function for calculating a unique identifier for each subgraph. Changed subgraph hash for a particular graph ID indicates structural changes in the specific subgraph.

- Graph serialization – a function of serializing the graph and storing it in the temporal database as a revision of the graph.

Graph topology processing is performed by the Distributed analysis platform and the serialized subgraph revisions, their corresponding hashes, IDs, and timestamps are stored in the Time series database (depicted as connection #7 in Fig. 1).

Time series data analysis functionality of each infrastructure analysis rule is concerned with the following:

- Retrieval of time series data streams from the relevant topics of the Distributed event streaming platform (depicted as connection #4 in Fig. 1).

- Retrieval of the topology subgraph from the Time series database.

- Deserialization of the time series data and topology graph, merging of both data sets according to the logic specified in the rule (e.g., calculation of average disk writes within a single logical disk as the average of all corresponding physical drives).

- Performing windowing operations and aggregations, storing intermediate stream processing results in temporal topics of the Distributed event streaming platform Experiments (depicted as connection #8 in Fig. 1).

- Archiving time series data aggregations in the Time series database for batch processing and later analysis (depicted as connection #7 in Fig. 1).

- Passing information about the detected anomalies as a data stream to a topic in the Distributed event

processing platform (depicted as connection #8 in Fig. 1).

A specific stream consumer is created for reacting upon the detected anomalies and it is deployed in the adjustment engine (depicted as connection #9 in Fig. 1).

Hierarchical rules can be created so that an infrastructure rule operating on a higher level of abstraction uses the anomaly feed provided by an infrastructure analysis rule operating on a lower level of abstraction.

III. EXPERIMENTS

To prove the applicability of the proposed approach, a prototype containing a single infrastructure analysis rule is implemented.

Neo4j is used as the graph database to store the joint topology of a storage subsystem (IBM Storwize) and virtualization subsystem (Vmware vCenter). Apache Kafka is used as the Distributed event processing platform. For experiment purposes, the time series data is accumulated in CSV files and a data simulator class is implemented in Python programming language to provide a controlled environment with expectable results and to simulate anomalies according to a predefined experiment plan. Apache Cassandra is used as the Time series database, while Apache Spark serves the purpose of Distributed analysis platform.

The sample infrastructure analysis rule considers identifying anomalies in a physical drive belonging to a common logical drive. This is based on the assumption that the storage subsystem manages to distribute load efficiency between the physical drives forming a logical drive, therefore a notable difference in physical drive performance metrics could be seen as an indication of a faulty drive or an anomaly. The list of monitored metrics, each of which are being streamed to a separate Kafka Topic are given in Table I.

TABLE I. Physical drive metrics

| # | Disk drive metrics | |
	Acronym	*Description*
1.	driveStats.mdsk.pre	Indicates the peak of read external response in milliseconds for each MDisk
2.	driveStats.mdsk.pro	Indicates the peak of read queued response in milliseconds for each drive.
3.	driveStats.mdsk.pwe	Indicates the peak of write external response in milliseconds for each drive.
4.	driveStats.mdsk.pwo	Indicates the peak of write queued response in milliseconds for each drive
5.	driveStats.mdsk.re	Indicates the cumulative read external response in milliseconds for each drive.
6.	driveStats.mdsk.rq	Indicates the cumulative read queued response in milliseconds for each drive

Fig. 2 shows the average `driveStats.mdsk.pre` value within a logical drive, anomaly margins calculated as three standard deviations away from the average value, and individual values for two included physical drives, one of which is an anomaly. It can be observed that drive with identifier `driveStats_124` behaves normally, while the drive with identifier `driveStats_26` is experiencing potentially abnormal behaviour.
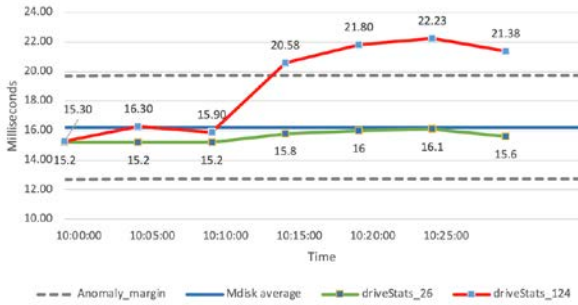
Fig. 2.   Anomaly for a physical drive.

The implementation of the graph topology processing logic for the mentioned rule is given bellow.

```
from hashlib import md5
from typing import Type
from ..abstract_rule.AbstractGraphJob import
AbstractGraphJob
from .CassandraModel import DiskAnomalies

class GraphJob(AbstractGraphJob):
 cassandra_model: = None
 ruleName = "disk_anomalies"

 def init__(self, **kwargs):
  self.cassandraModel = DiskAnomalies
  self.graphQuery = """Match (drive:
  storwize_drive)-[:RELATED]
  (mdisk:storwize_mdisk) return
  mdisk.metricTopoId,
  collect(drive.metricTopoId)"""
  AbstractGraphJob.__init__(self, **kwargs)
 def getSubgraphHash(self, subgraph):
  return md5("|". join(subgraph[1].
  encode('utf-8')).hexdigest()

 def _getSubgraphId(self, subgraph):
  return subgraph[0]

 def _getSerializedGraph(self, subgraph):
  return {'drives': subgraph[1],
  'mdisk': subgraph[0]}
```

The provided name of the rule is used to create Apache Cassandra tables for the current version of the topology subgraphs and their previous revisions. The referenced `DiskAnomalies` class further specifies the data model used for serializing the topology subgraph, while the actual serialization is performed by the function `getSerializedGraph`, which shows that the serialized graph will have two attributes – drives (an array

of the physical drives) and mdisk (the logical disk which the physical drives belong to).
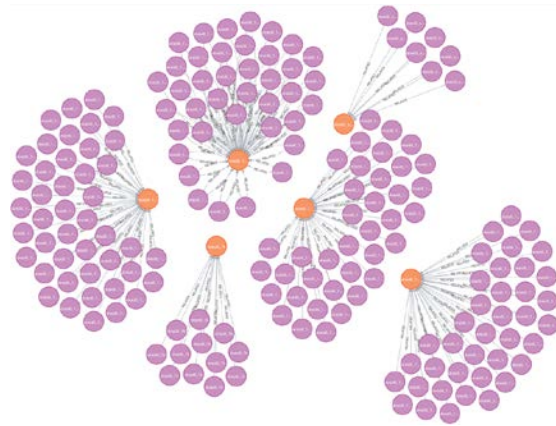
Fig. 3.   Matched topology subgraphs for disk anomaly rule.

The graph query specified in `graphQuery` attribute of the class finds all topology nodes which are tagged as "storwize drive" (physical drive) and are connected to a node tagged as "storwize mdisk" (logical disk). Tabular representations of the matched subgraphs are returned, where an identifier stored in the graph node attribute `metricTopoId` is returned for each matched node. Visualization of matching subgraphs is given in Fig. 3, while an excerpt from tabular representations of the matched subgraphs is given in Fig. 4.

Fig. 4.   Excerpt from tabular representation of topology subgraphs for disk anomaly rule.

The graph ID is equal to the ID of the corresponding mdisk (logical disk), while its hash is calculated as md5 encoded list formed by the identifiers of the included physical drives. The `AbstractGraphJob` class that the topology processing class of the disk anomaly rule extends provides built-in functionality for storing serialized subgraphs in Cassandra tables and creating new revisions upon detected changes in the graph hash. An ER diagram for two tables created to store serialized subgraphs is given in Fig. 5.
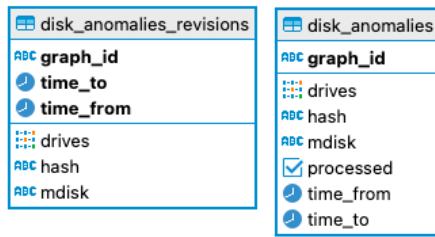
Fig. 5. ER diagram for the two created topology subraph tables.

The `disk_anomalies` table contains the current versions of the existing subgraphs and their corresponding information. Graph processing job tracks the time at which the subgraph appeared first in the `time_from` column, while the `time_to` column contains the last time the specific graph was detected. Following is the pseudocode of the algorithm for versioning of the subgraphs.

```
Update disk_anomalies set processed = False
Select all matched subgraphs from Neo4j
For each returned subgraph do
 If graph_id does not exist in table
 disk_anomalies
  Insert subgraph into disk_anomalies
   Else if graph_id exists in disk_anomalies
    If subgraph hash matches stored hash
     Update time_to to current time, set
     processed = True
    Else if subgraph hash has changed
     Copy stored subgraph to revisions table
     Update the subgraph in disk_anomalies
     table, set processed = True
Select subgraph from disk_anomalies where
unprocessed = True
 For each returned subgraph:
  Copy stored subgraph to revisions table
  Delete stored subgraph from disk_anomalies
```

The time series data analysis is implemented as an Apache Spark job and operates according to the following logic:

- Create a Spark dataframe `anomaly_margins` with drive metric corresponding anomaly margins. It will be evaluation how many standard deviations away is the average value of a drive metric from the average value of the corresponding mdisk (logical disk) metric. If the value is greater than the value specified within the anomaly margin dataframe, it will be considered an anomaly.

- Create a Spark dataframe `drive_mdisks` from Cassandra `disk_anomalies` table.

- Create drive metric Spark data stream `drive_metrics` from Kafka topics that correspond to the physical drive metrics of interest. The data stream contains unprocessed drive metrics as received from the IBM Storwize subsystem.

- Update the `drive_metrics` data stream by joining it with `drive_mdisks` dataframe so that

it now contains a corresponding mdisk ID for each drive.

- Create a new Spark data stream `drive_averages` from the `drive_metrics` stream by calculating an average value per drive per metric within a 10 second tumbling window. Save results to a new Kafka topic `da_drive_averages`.

- Create a new Spark data stream `mdisk_averages` from the `drive_metrics` stream by calculating an average value and standard deviation per logical disk, per metric within a 10 second tumbling window. Save results to a new Kafka topic `da_mdisk_averages`.

- Create two new Spark data streams based on the Kafka topics `da_mdisk_averages` and `da_drive_averages` and join them into a new data stream `joined_df` based on the time window, metric name and logical disk, so that for each average metric value of a physical drive there is a corresponding average value of the logical disk and its standard deviation.

- Join the `joined_df` with `anomaly_margins` so that for each metric there is a corresponding anomaly margin available as a new column `stdev_margin`.

- Add a new column `stdev_diff` to the `joined_df` which measures how many logical disk standard deviations away is the physical drive average metric value from logical disk's average value.

- Filter rows from `joined_df` where `stdev_diff > stdev_margin`.

- Group by drive and time window, count the number of rows per disk and collect the names of the anomaly metrics inside a new column. Output the results to a new Kafka topic `disk_anomalies`.

During the experiment, the IT infrastructure monitoring process is simulated and anomalies are induced. An extract from a Kafka console consumer connected to the `disk_anomalies` topic is given in Fig. 6. It can be seen that an anomaly is detected for the physical drive `ext-virt3-storage_driveStats_26` and a total of 6 anomalies was observed for the given drive. The names of the corresponding metrics are given in the `anomaly_metrics` array, while `window_start` and `window_end` indicate the start and end of the aggregation window.

```
{"drive_id":"ext-virt3-storage_driveStats_26","mdisk":
"ext-virt3-storage_managedDiskStats_48","graph_id":"ex
t-virt3-storage_managedDiskStats_48"}        {"window_
start":"2021-03-26T18:20:20.000+02:00","window_end":"2
021-03-26T18:20:30.000+02:00","counted_anomalies":6,"a
nomaly_metrics":["driveStats.mdsk.rq","driveStats.mdsk
.pwe","driveStats.mdsk.pre","driveStats.mdsk.re","driv
eStats.mdsk.pwo","driveStats.mdsk.pro"]}
```

Fig. 6.   Detected physical drive anomalies.

IV. RELATED WORK

Two types of data can be considered when analysing IT infrastructure for the purpose of detecting anomalies and providing predictive maintenance – evolving infrastructure graphs and time series data describing various IT infrastructure components. Existing research papers mostly concentrate on one of the aspects – either topology or time series data analysis. One of the few exceptions is the paper by Kampars et al. [3] concentrating on both data sets. The time series data are referenced as measurable properties, while aggregations are called context elements. The proposed solution lacks the ability to retrieve the topology graph from a data source and it is constructed manually. The system is based on Apache Kafka, Apache Spark and Apache Cassandra. Topology related information is stored in Cassandra and no dedicated graph database is being used.

A. Topology based infrastructure analysis

An example of topology driven anomaly detection can be found in the work by Niwa et al. [4], who present a framework for identifying anomalies in software services of OpenStack cloud computing platform. The framework is implemented in Python and Neo4J is used as the graph database for storing the topology graph.

Topology based root cause analysis of an IT infrastructure failure is also addressed by Schoenfisch et al. [5], who propose a Markov Logic Networks and abductive reasoning based solution. The proposed system was implemented in RoCA, a tool providing a graphical user interface for modelling the infrastructure and conducting the root cause analysis.

Majumdar et al. [2] perform IT infrastructure analysis for security purposes and propose a solution that is able to identify topology inconsistencies that might occur between multiple subsystems of a cloud computing platform. The proposed system gathers data from cloud management systems, cloud infrastructure system, and data centre infrastructure components. The data collection is performed in batch mode.

The security threats caused by cloud platform misconfiguration or insider attacks are addressed by Bleikertz et al. [6]. The authors establish a security system, which proactively analyses the intended cloud infrastructure configuration changes and risks associated with them and then either approves or rejects them. The graph is constantly updated whenever changes in infrastructure configuration occur [7].

A construction of a cloud-based IT infrastructure topology graph is addressed by Mensah et al. [8]. Logs from Cloud Management System and Software Defined Network controller are scanned to detect events that alter the infrastructure topology graph. The proposed system is validated by using OpenStack cloud computing platform.

B. Time series based infrastructure analysis

Harper et al. [1] propose a method for detecting failures of individual infrastructure elements based on the received operational status data and alerts. The work concentrates on detecting cascading infrastructure errors are without any knowledge of the infrastructure topology.

Mijumbi et al. [9] propose a system for analysing communication system alarms. The system is built using Apache Kafka, MongoDB, and python data science tools such as sklearn, pandas, numpy.

Anomaly detection and root cause analysis is also addressed by Lin et al. (2016). The paper proposes a method for virtualized cloud data centres and addresses the scalability challenges by using Apache Spark.

Another clustering-based anomaly detection solution is proposed by Cucinotta et al. [9] The authors perform analysis of system-level metrics, mostly related to resource consumption patterns of virtual machines by using self-organizing maps (SOM) based approach.

V. CONCLUSION

The paper presents a method for performing IT infrastructure analysis based on both metric time series data and evolving IT infrastructure topology graph. The applicability of the proposed approach is proven by implementing a prototype aimed at identifying physical drive anomalies in IT infrastructure and it is based on Apache Spark, Kafka, Cassandra, Neo4J and Python programming language.

The method allows combing topology data and time series data for comprehensive analysis of anomalies in the complex IT infrastructure. The analysis is performed in real-time and extra computational load on the infrastructure is minimized. The method also uses efficient versioning to track changes in the dynamic topology.

Identification of anomalies depends on predefined rules. These rules are derived by means of data analysis and expert knowledge. In further research, a set of rules will be derived, and the method will be evaluated to determine its computational efficiency and anomalies detection power.

VI. ACKNOWLEDGEMENT

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Special Spline Approximation for the Solution of the Non-Stationary 3-D Mass Transfer Problem

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Abstract - **In this paper we consider the conservative averaging method (CAM) with special spline approximation for solving the non-stationary 3-D mass transfer problem. The special hyperbolic type spline, which interpolates the middle integral values of piece-wise smooth function is used. With the help of these splines the initial-boundary value problem (IBVP) of mathematical physics in 3-D domain with respect to one coordinate is reduced to problems for system of equations in 2-D domain. This procedure allows reduce also the 2-D problem to a 1-D problem and thus the solution of the approximated problem can be obtained analytically. The accuracy of the approximated solution for the special 1-D IBVP is compared with the exact solution of the studied problem obtained with the Fourier series method. The numerical solution is compared with the spline solution. The above-mentioned method has extensive physical applications, related to mass and heat transfer problems in 3-D domains.**

Keywords - conservative averaging method, 3-D mass transfer problem, hyperbolic type splines, analytical solution

Introduction

The task of sufficient accuracy numerical simulation of quickly solution 3-D problems for mathematical physics is important in known areas of the applied sciences, for example, the calculation of the metal concentration in peat blocks. The metals distribution in peat layer's blocks have been modelled in [3], [4].

A.Buikis had considered the conservative averaging method (CAM) with the integral parabolic type splines for mathematical simulation of the mass transfer processes in multilayered underground systems [1].

The conservative averaging method has been applied also in a technical sphere, modelling the heat distribution in the 3-D area of the automotive fuse [5]. Cylindrical mathematical model of automotive fuse due to characterize the heat-up process in the fuse is described by partial differential equations of the transient heat conduction. CAM with integral parabolic type splines has been used to get the approximated solution of studied problem with analytical formulas [6].

In the present paper CAM using the special hyperbolic type splines is developed. With the help of these splines the IBVP in 3-D domain with respect to one coordinate is reduced to 2-D and 1-D problems. These splines in every direction of averaging contain parameters, where being based on CAM it can be chosen so that the error of the solution is decreasing.

The accuracy of the approximated solution for the special 1-D problem is compared with the exact solution of the studied problem obtained by the Fourier series method. The best values of the parameters (for minimizing the error of the solution) can be obtained with the different orientation of the averaging method, that is, applying the averaging method in the x and y directions respectively.

In the limit case when the hyperbolic type spline parameters tend to zero we get the integral parabolic spline, developed from A. Buikis [1].

MATERIALS AND METHODS

1.THE MATHEMATICAL MODEL

We will find the distribution of concentrations $c(x,y,z)$ at the point $(x,y,z) \in \Omega$ and at the time t from the following 3-D initial-boundary value mass transfer problem for partial differential equation (PDE) (1):

$$
\begin{cases}
\dfrac{\partial}{\partial x}\left(D_x \dfrac{\partial c}{\partial x}\right) + \dfrac{\partial}{\partial y}\left(D_y \dfrac{\partial c}{\partial y}\right) + \dfrac{\partial}{\partial z}\left(D_z \dfrac{\partial c}{\partial z}\right) = \dfrac{\partial c}{\partial t}, \\[2mm]
x \in (0, L_x), y \in (0, L_y), z \in (0, L_z), t \in (0, t_f), \\[2mm]
\dfrac{\partial c(0,y,z,t)}{\partial x} = \dfrac{\partial c(x,0,z,t)}{\partial y} = \dfrac{\partial c(x,y,0,t)}{\partial z} = 0, \\[2mm]
D_x \dfrac{\partial c(L_x,y,z,t)}{\partial x} + \alpha_x\big(c(L_x,y,z,t) - c_{ax}\big) = 0, \quad (1) \\[2mm]
D_y \dfrac{\partial c(x,L_y,z,t)}{\partial y} + \alpha_y\big(c(x,L_y,z,t) - c_{ay}\big) = 0, \\[2mm]
D_z \dfrac{\partial c(x,y,L_z,t)}{\partial z} + \alpha_z\big(c(x,y,L_z,t) - c_{az}\big) = 0, \\[2mm]
c(x,y,z,0) = c0(x,y,z),
\end{cases}
$$

where D_x, D_y, D_z are the constant heat diffusion coefficients, $\alpha_x, \alpha_y, \alpha_z$ are the constant mass transfer coefficients in the 3 kind boundary conditions, c_{az}, c_{ay}, c_{ax} are the given concentration on the boundaries, t_f is the final time, $c0(x,y,z)$ is the given initial concentration.

2. THE CAM WITH THE HYPERBOLIC TYPE INTEGRAL SPLINE APPROXIMATION IN Z-DIRECTION FOR THE 3-D PROBLEM

For solving IBVP (1) for every $t > 0$ using CAM we consider the following hyperbolic type spline approximation with respect to z-direction

$$c(x,y,z,t) = c_z(x,y,t) + m_z(x,y,t)f_{z1} + e_z(x,y,t)f_{z2}$$

with the following two fixed hyperbolic functions f_{z1}, f_{z2} and parameter a_z:

$$f_{z1} = \frac{0.5 L_z \sinh(a_z(z - 0.5 L_z))}{\sinh(0.5 a_z L_z)},$$

$$f_{z2} = \frac{\cosh(a_z(z - 0.5 L_z)) - A_{0z}}{8 \sinh^2(0.25 a_z L_z)},$$

where
$$A_{0z} = \frac{\sinh(0.5 a_z L_z)}{0.5 a_z L_z},$$

$c_z(x,y,t) = (L_z)^{-1}\int_0^{L_z} c(x,y,z,t)dz$ is the averaged value, $a_z > 0$ is the initial parameter (unknown). It can be seen if parameter a_z tends to zero then in the limit case we get the integral parabolic spline from A. Buikis [1].

The unknown functions m_z, e_z are determined from boundary conditions of (1) by $z = 0, z = L_z$:

$$d_z m_z - k_z e_z = 0, \quad m_z = p_z e_z, \quad p_z = k_z / d_z,$$
$$d_z = 0.5 a_z L_z \coth(0.5 a_z L_z), \quad k_z = 0.25 a_z \coth(0.25 a_z L_z)$$

,

$$D_z(d_z m_z + k_z e_z) + \alpha_z(c_z + 0.5 m_z L_z + e_z b_z - c_{az}) = 0$$

where $b_z = \dfrac{\cosh(0.5 a_z L_z) - A_{0z}}{8 \sinh^2(0.25 a_z L_z)}$.

Therefore $e_z = (c_{az} - c_z)/g_z$,

$$g_z = b_z + 0.5 p_z L_z + (2 k_z D_z)/\alpha_z.$$

Now the initial-boundary value 2-D problem is in following form (2):

$$
\begin{cases}
\dfrac{\partial}{\partial x}\left(D_x \dfrac{\partial c}{\partial x}\right) + \dfrac{\partial}{\partial y}\left(D_y \dfrac{\partial c}{\partial y}\right) + a_{0z}^2\big(c_{az} - c_z\big) = \dfrac{\partial c_z}{\partial t}, \\[2mm]
x \in (0, L_x), y \in (0, L_y), t \in (0, t_f), \\[2mm]
\dfrac{\partial c_z(0,y,t)}{\partial x} = \dfrac{\partial c_z(x,0,t)}{\partial y} = 0, \\[2mm]
D_x \dfrac{\partial c_z(L_x,y,t)}{\partial x} + \alpha_x\big(c_z(L_x,y,t) - c_{ax}\big) = 0, \\[2mm]
D_y \dfrac{\partial c_z(x,L_y,t)}{\partial y} + \alpha_y\big(c_z(x,L_y,t) - c_{ay}\big) = 0, \\[2mm]
c(x,y,0) = c0_z(x,y),
\end{cases}
$$

where $a_{0z}^2 = (2 D_z k_z)/L_z g_z$,

$$c0_z(x,y) = (L_z)^{-1}\int_0^{L_z} c0(x,y,z)dz.$$

3. THE CAM FOR CORRESPONDING SPECIAL 1-D INITIAL-BOUNDARY VALUE PROBLEM

For comparison, we consider the corresponding 1-D problem with the following parameters

$a_z = 1.79, D_x = D_y = 0, c = c(z,t), L_z = 1, \alpha_z = \infty \approx 10^7, c0 = 0,$
$D_z = 0.01, c_{az} = 1, t_f = 200$.

Then the analytical solution we can obtaine from the following Fourier series [2]:

$$U(z,t) = c_{az}\left(1 - \frac{4}{\pi}\sum_{i=0}^{\infty} \frac{(-1)^i}{2i+1}\exp(-D_z \lambda_i^2 t)\cos(\lambda_i z)\right),$$

$z \in (0, L_z), t \in (0, t_f)$, where $\lambda_i = ((2i+1)\pi)/(2 L_z)$.

For the avareged value $Uv(t) = (L_z)^{-1}\int_0^{L_z} U(z,t)dz$

we have following series:

$$Uv(t) = c_{az}\left(1 - \frac{8}{\pi^2}\sum_{i=0}^{\infty} \frac{1}{2i+1}\exp(-D_z \lambda_i^2 t)\right), t \in (0, t_f).$$

From (2) we have following initial-value problem for ODE:

$$\begin{cases} a_{0z}^2 \left(c_{az} - uz(t)\right) = \dfrac{\partial uz(t)}{\partial t}, \\ uz(0) = 0, t \in (0, t_f), \end{cases} \quad (3)$$

where $uz(t) = c_z(t)$.

The averaged spline solution is in following form

$uz(t) = c_{az}\left(1 - \exp(-a_{0z}^2 t)\right)$ and

$Us(z,t) = c_z(t) + m_z(t)f_{z1} + e_z(t)f_{z2}$.

The numerical results with Matlab are obtained by $\propto \approx 20$ in the uniform grid

$$z_m = m \cdot h_z, m = \overline{0, N_z}, h_z = L_z / N_z,$$

$$t_k = k \cdot h_t, k = \overline{0, N_t}, h_t = t_f / N_t, N_z = N_t = 20.$$

In the following figures (Fig.1.-Fig. 4.) there are represented the solutions $U(z,t), Us(z,t), Uv(z,t), uz(t)$.
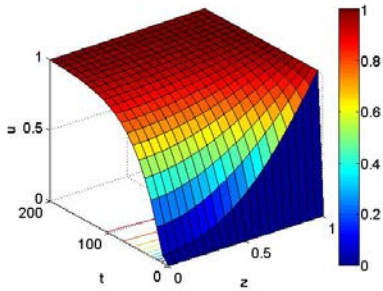
Fig. 1. Fourier series solution $U(z,t)$.
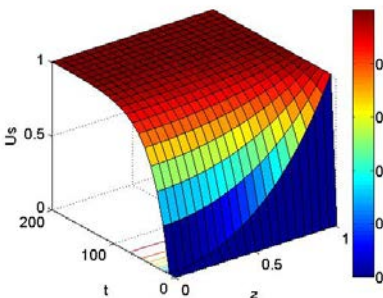
Fig. 2. Spline solution $Us(z,t)$.
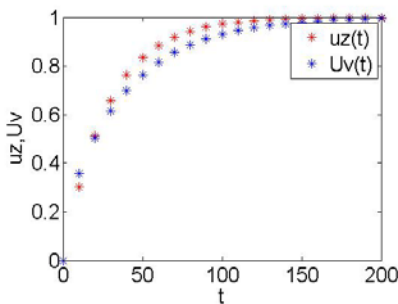
Fig. 3. Comparison the averaged solutions $uz(t)$ and $Uv(t)$.
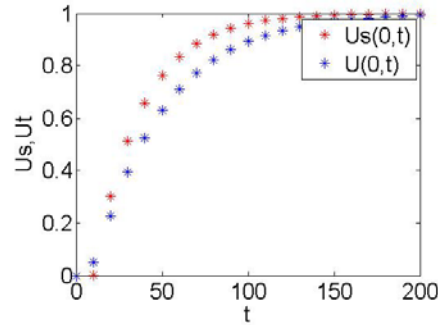
Fig. 4. Comparison the solutions $U(0,t)$ and $Us(0,t)$.

4. THE CAM IN Y-DIRECTION FOR THE 2-D PROBLEM

Using averaged method with respect to y we apply

$$c_y(x,t) = (L_y)^{-1}\int_0^{L_y} c_z(x,y,t)dy.$$

For the following hyperbolic type spline approximation

$$c_z(x,y,t) = c_y(x,t) + m_y(x,t)f_{y1} + e_y(x,t)f_{y2},$$

we have

$$f_{y1} = \frac{0.5L_y \sinh(a_y(y - 0.5L_y))}{\sinh(0.5a_yL_y)},$$

$$f_{y2} = \frac{\cosh(a_y(y - 0.5L_y)) - A_{0y}}{8\sinh^2(0.25a_yL_y)},$$

where $A_{0y} = \dfrac{\sinh(0.5a_yL_y)}{0.5a_yL_y}$ and as the parameter we

choose $a_y = a_{0z}\sqrt{1/D_y}$.

Similarly, we determine the unknown functions m_z, e_z from boundary conditions by $z = 0, z = L_z$

and $e_y = (c_{ay} - c_y)/g_y$,

$g_y = b_y + 0.5p_yL_y + (2k_yD_y)/\alpha_y$,

$m_y = p_ye_y$, $p_y = k_y/d_y$, $d_y = 0.5a_yL_y\coth(0.5a_yL_y)$,

$k_y = 0.25a_y\coth(0.25a_yL_y)$,

$$b_y = \frac{\cosh(0.5a_yL_y) - A_{0y}}{8\sinh^2(0.25a_yL_y)}.$$

The initial-boundary value 1-D problem is in the following form (4):

$$\frac{\partial}{\partial x}\left(D_x \frac{\partial c_y}{\partial x}\right) + a_{0y}^2(c_{ay} - c_y) + a_{0z}^2(c_{az} - c_y) = \frac{\partial c_y}{\partial t},$$

$$\frac{\partial c_y(0,t)}{\partial x} = 0, D_x \frac{\partial c_y(L_x,t)}{\partial x} + \alpha_x\left(c_y(L_x,t) - c_{ax}\right) = 0,$$

$$c_y(x,0) = c_0 y(x), x \in (0, L_x), t \in (0, t_f),$$

where $a_{0y}^2 = (2D_y k_y)/L_y g_y$,

$$c_{oy}(x) = (L_y)^{-1} \int_0^{L_y} c_{oz}(x,y)dy .$$

5. THE CAM IN X-DIRECTION FOR THE 1-D PROBLEM

It is possible proceed an averaging also in x - direction

$$c_x(t) = (L_x)^{-1} \int_0^{L_x} c_y(x,t)dx .$$

For the following hyperbolic type spline approximation
$c_y(x,t) = c_x(t) + m_x(t)f_{x1} + e_x(t)f_{x2}$

we have

$$f_{x1} = \frac{0.5L_x \sinh(a_x(x - 0.5L_x))}{\sinh(0.5a_x L_x)},$$

$$f_{x2} = \frac{\cosh(a_x(x - 0.5L_x)) - A_{0x}}{8\sinh^2(0.25a_x L_x)},$$

where $A_{0x} = \frac{\sinh(0.5a_x L_x)}{0.5a_x L_x}$,

and as the parameter we choose $a_x = \sqrt{(a_{0z}^2 + a_{0y}^2)/D_x}$.

Similarly, we determine the unknown functions m_x, e_x from boundary conditions by $x = 0, x = L_x$
and $e_x = (c_{ax} - c_x)/g_x$,
$g_x = b_x + 0.5p_x L_x + (2k_x D_x)/\alpha_x$, $m_x = p_x e_x$,
$p_x = k_x/d_x$, $d_x = 0.5a_x L_x \coth(0.5a_x L_x)$,
$k_x = 0.25a_x \coth(0.25a_x L_x)$, $b_x = \frac{\cosh(0.5a_x L_x) - A_{0x}}{8\sinh^2(0.25a_x L_x)}$.

From the problem (4) follows the initial problem of linear ODEs

$$\frac{\partial c_x(t)}{\partial t} = a_{0y}^2(c_{ay} - c_x(t)) + a_{0z}^2(c_{az} - c_x(t)) +$$

$$a_{0x}^2(c_{ax} - c_x(t)) = 0, c_x(0) = c_{0x}, t \in (0, t_f),$$

where $c_{0x} = (L_x)^{-1} \int_0^{L_x} c_{0x}(x)dx$.

The solution of this problem can be obtained with the classical methods.
For $c_0 = 0$ we have, $c_x(t) = (A_0/B_0)(1 - \exp(-B_0 t))$,
where $A_0 = a_{0y}^2 c_{ay} + a_{0z}^2 c_{az} + a_{0x}^2 c_{ax}$,

$B_0 = a_{0y}^2 + a_{0z}^2 + a_{0x}^2$. In the stationary case we have
$c_x = A_0/B_0$.
For fixed $t = t_f$ follows:
$c_y(x,t_f) = c_x(t_f) + m_x(t_f)f_{x1} + e_x(t_f)f_{x2}$,
$e_x(t_f) = (c_{ax} - c_x(t_f))/g_x$,
$m_x(t_f) = p_x e_x(t_f)$,
$c_z(x,y,t_f) = c_y(x,t_f) + m_y(x,t_f)f_{y1} + e_y(x,t_f)f_{y2}$
$e_y(x,t_f) = (c_{ay} - c_y(x,t_f))/g_y$,
$m_y(x,t_f) = p_y e_y(x,t_f)$,
$c(x,y,0,t_f) = c_z(x,y,t_f) + m_z(x,y,t_f)f_{z1} + e_z(x,y,t_f)f_{z2}$
$e_z(x,y,t_f) = (c_{az} - c_z(x,y,t_f))/g_z$,
$m_z(x,y,t_f) = p_z e_z(x,y,t_f)$.
Taking into account, $x = 0, y = 0, z = 0$, we get the following formulas:
$c_y(0,t) = c_x(t) + m_x(t)f_{x1} + e_x(t)f_{x2}$,
$e_x(t) = (c_{ax} - c_x(t))/g_x$, $m_x(t) = p_x e_x(t)$,
$c_z(0,0,t) = c_y(0,t) + m_y(0,t)f_{y1} + e_y(0,t)f_{y2}$,
$e_y(0,t) = (c_{ay} - c_y(0,t))/g_y$, $m_y(0,t) = p_y e_y(0,t)$,
$c(0,0,0,t) = c_z(0,0,t) + m_z(0,0,t)f_{z1} + e_z(0,0,t)f_{z2}$,
$e_z(0,0,t) = (c_{az} - c_z(0,0,t))/g_z$, $m_z(0,0,t) = p_z e_z(0,0,t)$
,

RESULTS AND DISCUSSION

We use uniform grid in the space
$((N+1)\times(M+1)\times(K+1))$:
$\{(x_j, y_i, z_k), y_i = (i-1)h_y, x_j = (j-1)h_x, z_k = (k-1)h_z\}$
$i = \overline{1, M+1}, j = \overline{1, N+1}, k = \overline{1, K+1}$,
$M \cdot h_y = L_y, N \cdot h_x = L_x, K \cdot h_z = L_z$.
For the time $t \in [0, t_f]$ we use the moments

$t_n = n\tau, n = \overline{0, N_t}$, $\tau \cdot N_t = t_f$.
The numerical results are obtained for
$D_x = D_y = 3\cdot10^{-4}, D_z = 10^{-3}, L_z = 3, L_x = L_y = 1$,
$\alpha_z = \alpha_x = \alpha_y = \propto \approx 10^7$, $M = N = K = N_t = 20$,
For determining the parameter a_z in the stationary case we do the iteration process with applying also the CAM first in y-direction and then in z-direction.
In y-direction we have
$c(x,y,z) = c_y(x,z) + m_y(x,z)f_{y1} + e_y(x,z)f_{y2}$, where
$c_y(x,z) = (L_y)^{-1} \int_0^{L_y} c(x,y,z)dy$ is the averaged value and
$a_y = a_{0z}\sqrt{1/D_y}$ is the previous value. In z-directon
$c_y(x,z) = c_z(x) + m_z(x)f_{z1} + e_z(x)f_{z2}$ where

$c_z(x) = (L_z)^{-1} \int_0^{L_z} c_y(x,z)dz$ and $a_z = a_{0y}\sqrt{1/D_z}$ is the new value for parameter a_z. We can obtain quickly conversion iteration process (with 5 iteration) for obtaining the parameters a_z, a_y, a_x with initial value $a_z = 1$. We have the stationary solution with $\tau = 1, t_f = 200$ and with the maximal error 10^{-4}. The maximal error between the 1-D exact problem and the spline solutions is 0.01334. The results of averaged solutions for $t_f = 200$ and depending on x and t we can see in (Fig. 5., Fig. 6.)
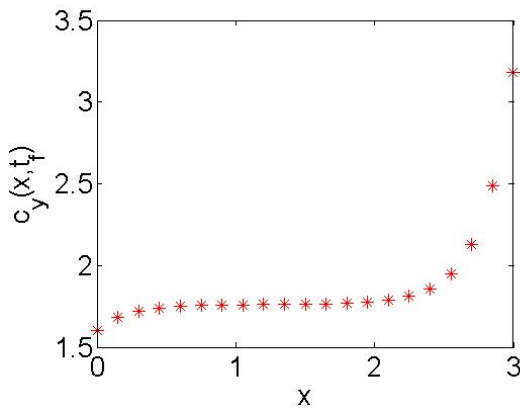
Fig. 5. The averaged solution $c_y(x, t_f)$.
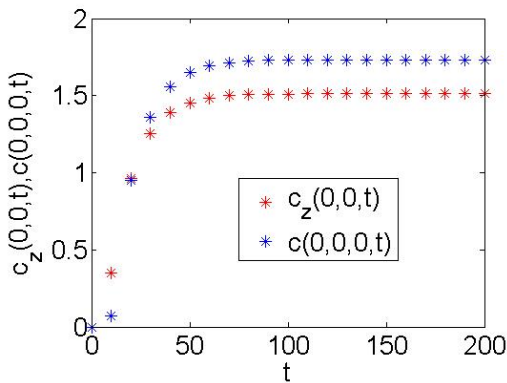
Fig. 6. The averaged solutions $c_z(0,0,t)$ and $c(0,0,0,t)$.

CONCLUSIONS

1. In the present paper the conservative averaging method with special spline approximation is applied for solving the 3-D non-stationary initial-boundary value (IBV) mass transfer problem.
2. This problem is reduced to 2-D and 1-D IBV problems using the integral hyperbolic type splines with fixed parameters.
3. Different orientation of the averaging allows you to determine the parameters of the spline function in such a way that the calculation error is minimal.
4. The solution of the special non-stationary 1-D IBV problem is obtained numerically using Fourier series method. This numerical solution is compared with the splaine function's solution and the maximal error is 10^{-4}.
5. For testing the conservative averaging method also the exact solution of the 1-D IBV problem is found and the maximal error between the mentioned problem and the splaine function's solution, in this case, is 0.01334.

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Scientific Bases for Stock Market Fiasco Forecasting Technology with Use of Information Space Entropy

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Abstract **- The article contains a theoretical study and description of general algorithm for predicting a stock market fiasco caused by non-financial and other factors. Market fiasco is considered as non-periodical, sudden and random event which can arise due to the many latent reasons. Methods of technical and fundamental analysis are useless to solve this problem, therefore, the use of systems analysis methods is proposed. The author's idea is the numerical calculation of search queries entropy as a part of global information space. Decrease in the Renyi's entropy, associated with rapid grow search queries, containing key terms from the subject area, indicates the possible stock market fiasco in the near future. This article presents an algorithm for the dynamic calculation of Renyi's entropy, allowing predict rare events which are not reflected in statistical data (or frequency of their realizations is too small). The method and algorithm can be realized in trade information systems and decision-making systems in economic sphere.**

Keywords **- Stock market, uncertainty, risk, forecasting, fiasco, collapse, Renyi entropy, information space, frequency, algorithm, technology.**

1. Introduction

The recent events, dramatic for the global economy, highlight a number of systemic problems in the area of management, forecasting, data analysis and decision making. There is an necessity to develop new effective technologies for forecasting and risk management in economic systems that can predict the emergence of "black swans" [1], i.e. rare and unpredictable events which were not reflected in historical data for past years within the foreseeable time horizon.

To mitigate the consequences of the stock market fiasco (to reduce the loss of resources) or try to avoid them we need to predict this undesirable event in advance. Development of information technology for forecasting the market fiasco (market failure, market shock) is very promising project and this allows us to reduce uncertainty [2] and be ready in the future for a sudden market collapse with change in the structure of economic relations.

II. The Problem of Market Fiasco Forecasting by Traditional Methods

There are a large number of tools [3] which allow predict economic parameters, many of them are based on time series analysis [4] and the hypothesis of the stationary time series.

On the charts of prices and returns, we can sometimes observe bursts, price jumps, which are described as random outliers (or market shocks). Stabilized period follows after such extreme change of values, then, the process of changing the values becomes stationary again.

During the market fiasco (collapse, market shock), a surge is observed on the price and yield charts - a rapid increase or decrease of the parameter (price jump), then long transition process is, and then either a process is slowly diminish, or, in most cases, the market comes back to a conditionally stable state and the time series become periodical and stationary again.

Such surge and the following stabilization period are modeled by the logistic curve (sigmoid) [5], which is given by the function:

$$f(x) = \frac{Mf(x_0)}{(M-f(x_0))e^{-rx}+f(x_0)}, \qquad (1)$$

where: e is natural logarithm (Euler's number), $f(x_0)$ is the function value at initial time ($f(x_0) \neq 0$), r is the logistic growth rate (steepness of the curve), M is maximal growth value.

We can predict changes in economic parameters during the market fiasco if parameters $f(x_0)$, M, r are correctly determined before. However, we can determine parameters of logistic curve by a posteriori analysis when the market has already collapsed and we know the peak values, amplitude and duration of the surge. For the market fiasco forecasting, such analysis is useless, because each stock market fiasco is caused by particular reasons and has individual evolution scenario. Accordingly, the values of r and M are unknown before the collapse.

For predicting of random events, such as a stock market fiasco, which realize due to the influence of unidentified latent factors in time, traditional methods, based on time series analysis, are not suitable.

Fundamental analysis [6] is also useless here, since financial and production indicators are used only while a market fiasco can realize due to many random and unpredictable events, including events of non-financial nature.

III. Entropy and Analysis of Information Search Queries Space

A complex non-trivial problem can be solved by interdisciplinary approach [7], based on the methods of system analysis, applied to large amount of initial data (BigData).

The authors' idea is to develop a technology for predicting the stock market fiasco (collapse) based on the numerical calculation of the information space entropy, and, more specifically, search queries entropy.

Information space is a set of databases, which includes publications from accredited mass media, the content of information sites, blogosphere and social networks.

Entropy is a measure of the uncertainty of a system [8].

In our interpretation, the information space entropy describes the uncertainty of the content of publications in the media and the blogosphere, and the variability of their themes.

In a stable period with low volatility, the media inform us about a variety of topics, variability and entropy are high. If large problems appear and the volatility stock market increases, media is paid more attention to these problems, therefore, the media content has similar topics, variability decreases, entropy also decreases. The increased frequency of same terms in different media sources makes the content more predictable.

The methodology for calculation the index of economic policy uncertainty EPU [9, 10, 11] is based on the frequency of certain key terms. The EPU is a set of indices that are important factor influencing on choice an investment strategy [11]. The set includes the world index, countries and regional indexes. Also, local indexes can be defined, for example, for a specific region. EPU values are also lagging in time because they are determined by a posteriori analysis of press publications, when undesirable event have realized. Since the world EPU index are calculated monthly, the delay in the value is about a month.

The information space structure can be presented, generally, as two fundamental units: information field and information flows. Information field is a set of databases (data storages) but information flows are set of inquiries and set of corresponding responses.

We can estimate the probability of a stock market fiasco a priori by analysis of search queries in the information space. In [12] authors studied the relationship between the sentiment of messages in the Internet (publications in the media and social networks) and changes in the yields of specific stocks. Data about 3238 stocks was used from 2005 to 2009. The authors observed the relationship between the number of publications (and the number of discussions) and the trading volume but stocks of different companies demonstrate different sensitivity to the tone of publications (airlines are more sensitive to the tone of the media, IT companies are less sensitive). The authors emphasize, if we apply strategies based on the analysis of publications in the media, blogs or social networks, these strategies provide the best results on short forecast horizons because the market quickly responds to news [13].

The Google Domestic Trends tool allows predict market fiasco using analysis of popular search queries [14].

Forecasting other events, leading to the market fiasco and caused by non-financial reasons (for example, the spread of a viral infection) is also possible for short horizons by analysis of popular queries using contextual data analysis [15]. For example, the Google Flu Trends service allows predict influenza epidemic in short horizons (about two weeks before the epidemic) by analyzing search queries.

These tools use a single principle for analysis the state of the subject area. For each area, a set of appropriate keywords is identified, then, a chart is plotted by the number of search queries. The chart is used for analysis of the public interest in a particular area and we can assume how the market state will change corresponding to public interest.

Nevertheless, there is some skepticism among specialists about the practical application of these tools [16].

Skepticism is caused by inaccurate predictions, which, in our opinion, are explained by the fact that the above

tools analyze frequencies of separate requests, while a rapid increase in the frequency of requests, containing keywords only, cannot indicate an impending event without a doubt.

To overcome this problem, we propose to take into account not only increasing frequency of queries, containing key terms, but also changing entropy in search queries space. There is always some nonempty set of terms, which may indicate future fiasco and have implicit context sense, but not included in set of key terms. Frequencies of such terms can also correlate with frequencies of key terms. Calculation of entropy allow us to take into account the influence of these terms and significance of secondary factors [17] that lead to the predicted event. This is important part of the information space analysis.

Search queries are a part of the information space and can be used to estimate the likely future changes in the entire space. In other words, in practice, search queries are a good proactive indicator of the system's state (both the stock market and society before a virus pandemic). The search query space also has entropy, a change in entropy can inform us about future change in the information space entropy.

We propose to predict the stock market fiasco based on the dynamic calculation of the entropy of search queries: a decrease in entropy indicates an imminent collapse of the market, an increase inform about future stable state. Note, in thermodynamics we have a similar situation: in a nonequilibrium (irreversible) process (all real physical processes are irreversible) - the closer the system's state to equilibrium (stability), the greater the entropy [18]. A stable state corresponds to maximum entropy.

Let's denote a set of search terms as Ω. Each search query is described by the presence (or absence) key terms and a region parameter.

To calculate the entropy, we introduce a finite set of key terms $ST = \{s_1, s_2, ..., s_k\}$, associated with a finite set Ψ containing negative factors with various nature. Let us denote by $Z = \{z_1, z_2, ..., z_n\}$ the set of all terms, which frequency in search queries exceeds a certain set frequency threshold w_{ad}, and $ST \subseteq Z$.

Let suppose, at time t each of the terms s_i, $i = 1, ..., k$ has a frequency of occurrence in messages ω_i, $i = 1, ..., k$. If we consider the search queries space at sequential times t_1, t_2, ..., t_m, , then at each time t_i we will get frequency vector $\{\omega_{1t1}, \omega_{2\,t1}, ..., \omega_{kt1}\}$, $\{\omega_{1t2}, \omega_{2\,t2}, ..., \omega_{kt2}\}$, ..., $\{\omega_{1tm}, \omega_{2\,tm}, ..., \omega_{ktm}\}$.

The volume of queries in time t around the world is huge, so, we can assume, frequencies ω_i, $i = 1, ..., k$, exceeding frequency threshold w_{ad}, are close to the objective values of probabilities p_i of realizations the terms s_i at time t in a set of messages. The vector of probabilities $\{p_1, p_2, ..., p_k\}$ corresponds to the vector of terms $\{s_1, s_2, ..., s_k\}$.

The random variable S takes the value s_i, $i = 1, ..., k$ from the set $\{s_1, s_2, ..., s_k\}$ with probability p_i, $i = 1, ..., k$.

To analyze the query space, we will use the generalized Renyi entropy [19, 20], which describes the quantitative diversity of the randomness of queries. The Renyi entropy is calculated by the formula:

$$H_a(S) = \frac{1}{1-a} \cdot log\left(\sum_{i=1}^n p_i^a\right),\qquad(2)$$

where $p_i = P(S = s_i)$ is the probability the discrete random variable S will be equal to the corresponding possible value of s_i; n is the total number of different possible values of the random variable S, that is, the number of given terms z_i for which $\omega_i > w_{ad}$, $i = 1, ..., n$; a - a given real number that meets the requirements $a \geq 0$, $a \neq 1$.

Theoretically, when the situation is stable and the market fiasco is not expected in the near future, we have a uniform distribution and the probabilities are so close to each other that they can be considered as equal, i.e. $p_1 = p_2 = ... = p_n = 1/n$, the Renyi entropy is $H_a(S) = log\ n$. Otherwise, the entropy starts to decrease with increasing a. Renyi entropy is used in ecology and statistics as indices of diversity, as well as in quantum information theory, where Renyi entropy is a measure of complexity.

In our problem, the Renyi entropy formula is needed for special cases:

1. $a = 0$, we obtain $H_a(S) = log\ n$, where n is the cardinality of the area of possible values of a finite random variable S, i.e. n is the number of different terms belonging to the set of possible values Z.

2. $a = 1$, in this case $H_a(S)$, according to L'Hôpital's rule, reduces to the Shannon's information entropy:

$$H_1(S) = -\sum_{i=1}^n p_i \cdot ln(p_i)\qquad(3)$$

The algorithm for dynamic analysis of the information space of queries looks like a regular sequence of following operations:

1. Define the set Ψ with all possible factors that can cause a sudden fiasco (collapse) of the market;

2. Define the set $ST = \{s_1, s_2, ..., s_k\}$, containing key terms related to the set Ψ;

3. Define the set $Z = \{z_1, z_2, ..., z_n\}$, containing a set of terms, having a high correlation with key terms, the frequency of these terms in search queries exceeds the specified threshold w_{ad} in current time t_m;

4. Determine frequencies ω_i, and probabilities p_i for the terms s_i, $i = 1, ..., k$, using the tools of semantic analysis of queries;

5. Calculate the numerical value of the entropy $H_a(S)$ by the formula (2) with the value $a = 0$, or $a = 1$, depending on the values of p_i, $i = 1, ..., k$.

If we observe a decrease in entropy in comparison with value in the previous time t_{m-1}, then this is a signal about imminent market fiasco.

IV. CONCLUSION

The proposed method has good perspectives for practical application but there are a number of problems that still need to be researched:

1. Time horizon of forecasting. There are no exact numerical estimations, only empirical data obtained from the results of using GoogleTrends tool;

2. Recommendations for the choice w_{ad} value can be formulated only after testing of the algorithm. To this moment, authors can only recommend to choose this value by the method of iterative approximation, based on the results of the preliminary semantic analysis of queries. The correct choice of the value will reduce the dimension of the task without losing the information and completeness of the set. We need more research to provide accurate recommendations.

3. We don't know whether the value of the change in entropy indicates the scale of the coming crisis. If we take into account the region parameter, then a decrease in the the search query space entropy in a particular region can predict financial problems only in this region.

4. Determination a set of key terms *ST* is a non-trivial problem. The solution will require data processing and frequency analysis for large number of queries.

Nevertheless, due to large cardinality of the set *Z*, the stated theoretical developments and the algorithm can be used in artificial intelligence systems for risk management that support the technology of processing and analyzing big data.

The proposed algorithm can be applied in complex technical systems also, if functioning processes in large industrial corporations are united into the integrated information space within the framework, offered by "Industry 4.0" concept [21]. In this case, a change in entropy of large data arrays may indicate about accumulating problems (the "snowball" effect), which will eventually find a way to be realized in the production and management system of a corporation through uncontrolled functionally weak links (the so-called "Swiss cheese holes" effect [22]) and will lead to the collapse or systemic failure in the corporation's functioning processes.

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Government communication and Internet responses: profile of Prime Minister Krišjānis Kariņš in selected digital media users' comments during the COVID-19 pandemic

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Abstract - **Perceptions play a pivotal role in assessment of efficiency of government communication. Informed by the strategic narrative conceptual framework this study looks at perception of government communication in Internet comments during three essential dates in conquering the COVID-19 pandemic in Latvia: introduction of emergency situations on March 12 and November 6, 2020, and introduction of a curfew on December 29, 2020. The study uncovers how often and how the main spokesperson in government communication – the Prime Minister of Latvia Krišjānis Kariņš – is framed in comments of three online news media in Latvia (Apollo, Delfi, Tvnet) in Latvian and Russian. Using a digital tool for online comments analysis - the Index of Internet Aggressiveness (IIA), a data set is created of 244 comments, containing a key word "Kariņš" in various cases in Latvian and Russian. Qualitative content analysis is applied to extract and to compare the frequency of appearance and the framing of Kariņš over the course of the pandemic in Latvia. The findings reveal that Kariņš appears in comments significantly more after news in Latvian than in Russian, and has been commented five times more in Delfi than in Tvnet and Apollo together. The comments in Latvian are more aggressive than in Russian, and their emotional tone increases towards the end of 2020. In majority of comments the framing is negative involving attributes of irresponsibility, superficiality, indecisiveness and danger; yet positively framed rigidity and decisiveness of Kariņš can be observed too.**

IIA is an online comment analysis tool, incorporating a machine learning program, which analyses users' comments on news on online news sites according to pre-selected keywords to grasp the commenters' verbal aggressiveness. In March 2021 the IIA data set consists of ~25.08 million comments; ~ 616.62 million word usage in written commenting and ~ 1357.40 thousand news.

I. INTRODUCTION

COVID-19 pandemic has brought to attention the importance of information and its perception, as people's behavior is directly influenced by their trust to the information sources [1], [2], [3]. During the pandemic government institutions have been among the most important ones, providing information on the virus and its containment. However, studies on the government strategic narratives have shown that not only provision of information but also its reception pays a pivotal role in efficiency of government communication [4].

This study is based on a premise that user comments after the online news articles form a useful source for exploring the inhabitants' perceptions on the government communication. Nowadays commenting is the most commonly used form for online participation; and with it the commenters not only demonstrate their own opinion, but also influence the opinions of others [5]. Therefore, in addition to traditional methods of exploring public perceptions such as surveys, focus groups and interviews, analysis of Internet comments adds an important dimension to understanding the public mood. It has been argued that anonymity of social interaction reduces the determination of individuals to adhere to certain social norms [6], liberating the individuals from the need "to behave in certain ways" as they are free to be "whoever they want to be – only to simply ―log off at the end of the day" [7, p. 6]. Thus, for researchers, Internet comments open up possibilities to explore sentiments, which people would avoid in public environment.

This study explores the perception on Latvia's Prime Minister Krišjānis Kariņš (hereinafter – Kariņš) by users of three online news media in Latvia (Delfi, Tvnet, Apollo) at three essential dates in conquering the COVID-19 pandemic in Latvia: introduction of emergency situations on March 12 and November 6, 2020, and introduction of a curfew on December 29, 2020. These dates were selected because introduction of an emergency situation and a curfew is not a business-as-usual situation in policy making. Neither politicians, nor inhabitants were experienced in living in emergency conditions, consisting of numerous restrictions and rules. Hypothesizing that unexpected situations intensify emotions and these emotions are targeted against the main perpetrators of obnoxious decisions, this study asks the following research questions:

1) Are the user comments of online news stories targeted towards Kariņš, the main spokesperson of the government communication in Latvia?

2) How is Kariņš framed in the comments?

To answer the questions, the study uses an automated tool for analysis of verbal aggressiveness in Internet comments – the Index of Internet Aggressiveness (IIA). Applying the IIA, a number of comments, a level of aggressiveness and all Kariņš related comments both in Latvian and Russian languages in the three dates of the pandemic are determined. The findings are complemented by qualitative content analysis to extract the framing of Kariņš in the selected Internet comments. The data illuminate the opportunities, provided by IIA, for audience perception studies.

II. METHODS

This study combines two research methods: for selection and analysis of comments an automated tool for online comments analysis – the IIA (http://barometrs.korpuss.lv) is applied, whereas for analysis of framing a manual content analysis is used. The IIA has been elaborated by Rīga Stradiņš University and the Institute of Mathematics and Computer Science of the University of Latvia for measuring the level of aggressiveness, trends and causes in the user comments of three news portals (Delfi, Tvnet, Apollo) with the largest audiences [8] in Latvia. The IIA can assess the level of aggression in user comments in Latvian and Russian in a given time period and dates, the most frequently used keywords in response to news content, and the relationship between news and comments. The IIA incorporates a machine learning program, which analyses user comments on online news stories according to pre-selected keywords to grasp the commenters' verbal aggressiveness [9, p. 168]. It has been estimated that the accuracy of the automatic classifier was 72.2%, having a close resemblance to the inter-annotator agreement of 78% [10]. In 2020, the IIA was updated to incorporate keywords characterising commenters' aggressiveness towards the COVID-19 pandemic. In March 2021, the IIA data set consists of ~25.08 million comments, ~ 616.62 million word usage in written commenting and ~ 1357.40 thousand news [11].

Applying the function of the IIA "Common trends" (*Kopējās tendences*, in Latvian) it was determined what was the average level of aggressiveness in the observed dates and whether the comments, containing the keyword "Kariņš", referred to the TOP 10 of the most aggressively commented articles of a particular date. After that a share of Kariņš related comments in the comments of aggressively commented articles was identified.

The function "Contexts" (*Konteksti*, in Latvian) allows to identify the objects that cause verbal aggression. For the purposes of this study, the function "Contexts" was used to identify how much and what type of aggression was facilitated by Kariņš. Overall, 263 comments from Apollo, Delfi and Tvnet in Latvian and Russian languages have been selected. All of them contained a keyword "Kariņš" in various cases in Latvian ("Kariņš", "Kariņa", "Kariņam", "Kariņu", "Kariņā", "Kariņ") and Russian ("Кариньш", "Кариньша", "Кариньшу", "Кариньше"). The use of diacritic marks in Latvian and of Latin letters instead of Cyrillic in Russian comments did not have an impact on the sample. The data-set has been reduced up to 244 comments, excluding the comments, where "Kariņš" was not used as a proper noun. Comments that contained a keyword in various cases and comments that were repeated in exactly the same form after several articles have been analysed once.

In addition to the automated IIA-driven analysis, qualitative content analysis has been applied to extract and to compare the framing of Kariņš in the selected sample of comments over the course of the pandemic in Latvia. Framing refers to "selecting and highlighting some facets of events or issues, and making connections among them so as to promote a particular interpretation, evaluation, and/or solution" [12, p. 417]. Analysis of framing provides an insight into the emotional variations of comments, which altogether are categorized as aggressive. Framing of Kariņš was analysed following a codebook consisting of 9 code groups. Comments, related to news stories about COVID-19, were separated from other comments. 20 categories, revealing particular human characteristics, both positive and negative, were invented. The categories are derived from the six basic emotions - happiness, sadness, anger, fear, disgust, and surprise, as classified by discrete emotion theorists [13]. Except the latter, these emotions are considered to be relevant for this study, and are expanded to diversify the emotional framing. As a result, anger is manifested in comments that frame Kariņš as irresponsible, superficial, detached/unreliable, unfair and guilty. Disgust is revealed in comments that frame Kariņš as a stooge or as being omniscient, arrogant/annoying, meaningless/dumb, incompetent, crafty and hypocritical. Sadness is expressed in comments that frame Kariņš as weak/indecisive, uninformed/ naïve and confused. Fear appears in comments which frame Kariņš as dangerous and authoritarian. Happiness is manifested in comments framing Kariņš as responsible, decisive and having done maximum possible

in a positive sense. Comments without a particular emotional framing are included in the category "neutral".

III. RESULTS AND DISCUSSION

This study demonstrates that Kariņš has been commented five times more in Delfi than in Tvnet and Apollo together (Table 1). He has been mentioned in comments more, when the first emergency situation on March 12, 2020, was introduced. The amount of comments decreases and is almost the same at the moment of announcement of the second state of emergency on November 6 and introduction of a curfew on December 29, 2020.

TABLE 1. FREQUENCY OF KARIŅŠ RELATED COMMENTS ACROSS DATES AND NEWS PORTALS

	12.03.	06.11.	29.12.	Number of comments
Apollo	2	0	10	12
Delfi	85	73	44	202
Tvnet	8	0	22	30
Total	*95*	*73*	*76*	*244*

Kariņš appears in comments significantly more after news in Latvian than in Russian (Table 2). In the Latvian versions of Apollo, Delfi and Tvnet there are 211 comments, yet the Russian versions of the same news portals have only 33 comments. Arguably, it resonates with the finding that for the Russian-speaking journalists it was more difficult to gain an up-to-date information from the Latvian government in Russian [9, pp. pp. 46-48], which resulted in less news on COVID-19 in the Russian-speaking portals.

TABLE 2. FREQUENCY OF COMMENTS ACROSS LATVIAN AND RUSSIAN NEWS PORTALS

	12.03.		06.11.		29.12.	
	LV	*RU*	*LV*	*RU*	*LV*	*RU*
Apollo	2	0	0	0	10	0
Delfi	78	7	69	4	25	19
Tvnet	7	1	0	0	20	2
Total	*87*	*8*	*69*	*4*	*55*	*21*

Delfi is the most popular news portal both among the Latvian and the Russian audiences, collecting 172 comments in Latvian and 30 comments in Russian. The data uncover a decreasing trend of Kariņš related comments towards the end of 2020 in Latvian. Whereas on March 12 Kariņš appeared in 87 comments, on December 29 he was mentioned in 55 comments. In Russian, a sharply increasing trend at the very end of 2020 can be observed. Namely, Kariņš appears in 8 and 4 comments on March 12 and November 6 respectively, and in 21 comments on December 29.

The observed trend resembles a reverse situation if compared to the general level of aggressiveness in comments (Table 3). In comments of the news in Latvian the average level of aggressiveness increases towards the end of 2020, yet in the comments, reacting to news in Russian, it decreases. So, in Latvian comments, Kariņš is mentioned less when the level of aggressiveness is high, but in Russian it is the opposite – he appears in comments more, when the overall aggression is lower.

TABLE 3. LEVEL OF AGGRESSIVENESS IN LATVIAN AND RUSSIAN NEWS PORTALS ACROSS DATES

	12.03.	06.11.	29.12.
LV	3.17	3.37	3.54
RU	1.97	1.63	1.61

As regards the thematic framework, majority of Kariņš related comments follow the news about the COVID-19 pandemic. Out of 244 comments, 226 react to the COVID-19 news and only 18 comment other news (Table 4).

TABLE 4. THEMATIC FRAMEWORK OF COMMENTS' RELATED NEWS

	Apollo	Delfi	Tvnet	Total
COVID-19 news	12	184	28	226
Other news	0	16	2	18

It suggests that in audience perception in the observed dates Kariņš is primarily associated with tackling the COVID-19 crisis, not other issues.

Content-wise, the news receiving five or more Kariņš related comments refer to the following topics. On March 12, it is the news about calling an emergency meeting of the government and the Crisis Management Council (29 comments), declaring an emergency situation (24 comments), introduction of essential safety measures, including the closure of borders (6 comments) and address of Kariņš to the parliament (5 comments). On November 6, the news depict re-launching of an emergency situation (27 comments), impact of COVID-19 on economy (9 comments), political parties' suggestions on restraining the COVID-19 (8 comments) and COVID-19 infection and death rates in Latvia (7 comments). On December 29, majority of comments are directed towards the news on introduction of the curfew (40 comments) and involvement of police and army in control of the curfew (10 comments).

The above-mentioned news is partly represented in the articles that are the most aggressively commented ones of a particular day (Table 5). For instance, on March 12, the TOP 10 of the aggressively commented articles in Latvian contains six articles, after which comments on Kariņš are made. A share is lower in the TOP 10 in Russian. For instance, on March 12 the top of the most aggressively commented articles contains only one article with Kariņš related comments.

TABLE 5. SHARE OF ARTICLES WITH KARIŅŠ RELATED COMMENTS IN THE TOP 10 OF THE MOST AGGRESSIVELY COMMENTED ARTICLES

	12.03.	06.11.	29.12.
LV	6	5	5
RU	1	3	3

Overall, comments containing Kariņš form only a minor part of all comments that are devoted to a certain aggressively commented article (Table 6).

TABLE 6. SHARE OF KARIŅŠ RELATED COMMENTS IN THE COMMENTS OF TOP 10 AGGRESSIVELY COMMENTED ARTICLES

	12.03.		06.11.		29.12.	
	Kariņš	*Total*	*Kariņš*	*Total*	*Kariņš*	*Total*
LV	47	1578	44	1710	25	1610
%		*3*		*2.6*		*1.6*
RU	2	328	3	705	16	1049
%		*0.6*		*0.4*		*1.5*

It can be observed that the Kariņš related comments form from 0.4% to 3% of all comments that are devoted to those TOP 10 aggressively commented articles, which contain the comments on Kariņš. The proportion decreases towards the end of the year in the comments in Latvian, and increases in the comments in Russian. It resonates with the trend on frequency of Kariņš related comments in Latvian and Russian news portals.

As regards framing, in majority of COVID-19 related news comments Kariņš is framed negatively (Table 7).

TABLE 7. FRAMING OF KARIŅŠ IN NEWS COMMENTS

Category	Number of comments
Irresponsible	25
Weak, indecisive	21
Stooge (by the US, Soros)	20
Superficial	20
Neutral	16
Omniscient (with irony)	15
Dangerous, authoritarian	15
Arrogant, annoying	13
Responsible	12
Detached, unreliable	11
Meaningless, dumb	10
Incompetent	9
Unfair	8
Did maximum possible (positively)	7
Crafty, cheater	5
Uninformed, naive	5

Category	Number of comments
Guilty	4
Decisive	4
Hypocritical	3
Confused	3

In equal numbers he has been framed as irresponsible (25 comments), weak and indecisive (21 comments), and superficial (20 comments). Some commenters regard talking or action of Kariņš as representing omniscience (15 comments). At the beginning of the pandemic these comments reveal confusion about delays in imposing restrictions or too-weak restrictions, while towards the end of the year concerns emerge about economy, state allowances and family supply due to restrictions on shopping. Such concerns pave way for comments about detachment of Kariņš from needs of people (11 comments) and his incompetence as a head of the government (9 comments).

A part of comments at all observed dates refers to Kariņš origin as the citizen of the United States (US) (20 comments). For this, in his activity (or inactivity) in conquering the COVID-19 pandemic Kariņš has been framed as guided by the US or George Soros, the American financier and philanthropist.

One commenter states: "If Kariņš gets an order from the US, he will announce a state of emergency in Latvia; if not, then everyone will have to suffer or die" [14]. Links of Kariņš with the US proportionally have been more emphasized in comments in Russian than in Latvian. In Russian, Kariņš has been depicted as a stooge of Americans in 8 comments out of 32 total COVID-19 related news' comments in Russian, while in Latvian – in 12 comments out of 194 COVID-19 related news' comments in Latvian.

Towards the end of 2020, a more aggressive tone appears in the comments. In autumn, more than in spring, Kariņš has been framed as dangerous and authoritarian (15 comments), arrogant and annoying (13 comments), and unfair (8 comments). Such representation is directed towards inadequate preparations for the second stage of the pandemic, inconsistent restrictions and unclear support to the victims of the crisis in November, and especially towards introduction of a curfew and plans to involve police and army in control of the curfew in December. As one commenter expresses: "[K]ariņš conducts a coup d'état? [T]he last time in peacetime the curfew has been introduced during the coup d'état of [U]lmanis" [15]. [1] Towards the end of 2020, also more anger and fatigue from the restrictions is represented in comments. One comment states: "Mr Kariņš, please be a real statesman and don't say a speech at the turn of the years!!! Please, be quiet at least

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[1] On 15 May 1934 the then Prime Minister of Latvia Karlis Ulmanis with the help of the army conducted a coup d'état as a result of which the system of parliamentary democracy ceased to exist in Latvia.

in the last minute of this year!!! Please, very much. All this is ENOUGH!" [16]. It produces comments, where Kariņš is depicted as a cheater (5 comments), guilty for the losses (4 comments), hypocritical (3 comments) and confused (3 comments).

On the positive side, there are 23 comments that emphasize rigidity and decisiveness of Kariņš. His ability to make unpopular decisions is underlined too, especially in autumn when the government has long been hesitating to invent stricter safety measures. Reacting to the announcement of the second state of emergency one commenter writes: "It was a long time ago needed. A badge to Kariņš who does not fear making unpopular but necessary decisions" [17]. Overall, these comments affirm that Kariņš has done everything possible yet the results would depend on inhabitants' determination to stop the pandemic.

The disproportion between the positive and the negative framing of Kariņš suggests that majority of the internet users employ the commenting opportunity to express their dissatisfaction with his work. Internet anonymity might have been a powerful factor fostering such framing. At the same time, the proportion of Kariņš related comments is low in the total number of comments after the most aggressively commented articles. It implies that Kariņš provokes a relatively small share of audience interest and aggressiveness, and by and large is not an object, which would dominate the audience discussions on COVID-19 pandemic.

IV. CONCLUSIONS

This study demonstrates the possibility to extract a perception of a particular public figure in user comments of largest Latvian online news media by combining an automated, machine-learning based tool – the IIA – and a manual content analysis. With the help of the IIA all Kariņš related comments in three dates of the COVID-19 pandemic (March 12, November 6 and December 29) were identified and analysed, including the level of aggressiveness in these dates, a share of articles with Kariņš related comments in the TOP 10 of the most aggressively commented articles and a number of Kariņš related comments in them. The data confirmed that Kariņš was commented significantly more after news in Latvian than in Russian, and has been commented five times more in Delfi than in Tvnet and Apollo together.
However, in general user comments of online news stories targeted Kariņš relatively rarely. Kariņš received a minor part (0.4% to 3%) of all comments that were devoted to those TOP 10 aggressively commented articles of a particular day, where he was mentioned in comments. A share of such comments decreased towards the end of 2020 in the comments in Latvian and increased in the comments in Russian.

Thematically, COVID-19 pandemic was the main topic in news, after which Kariņš related comments were made. Framing analysis revealed that in audience comments

Kariņš has been framed mostly negatively, displaying such features as irresponsibility, indecisiveness, superficiality and danger. However, around 10% of comments made a positive evaluation, emphasizing decisiveness and rigidity of Kariņš. Internet anonymity might have contributed to dominance of negativity; yet such an assumption would require more detailed qualitative studies.

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Simulation of a School Canteen to Understand Meal Duration Impact on Food Waste

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Abstract - **A system simulation is a one of the approaches to understand business processes or to explain them to other people. It is an excellent decision making solution to provide data-driven conclusions based on system modelling and experiments. This paper proposes simulation results of a school canteen. The aim of the research was to investigate the relation between a food waste amount and meal time duration. The proposed simulation was based on business process analysis, business process modelling, a Monte Carlo method and expert knowledge. The frequency distributions were constructed based on children meal duration observation completed by their mothers. It is a magnificent citizen science solution to involve mothers in the research because they can additionally better understand their children meal preferences and habits. Therefore, a questionnaire for citizens was developed, which can be applied to collect statistical data for model accuracy improvement and extension.**

Keywords - food waste; modelling; school; simulation.

INTRODUCTION

Food waste has increasingly gained attention over the last years both at global and at European level. In the period of time 2011-2016, zero food waste became a more often topic of discussion at all political levels.

In 2011, the European Commission identified food as one of the key sectors where resource efficiency should be improved [1].

In 2015, the G20 stated that "the reduction of food loss and waste is a good objective for G20 collective action", but the United Nations indicated in its agenda for sustainable development that, by 2030, it aimed to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" [2-3].

In 2016, the Council of the European Union supported efforts of all actors to reduce food waste, which would contribute to achieving SDG 12.3, which aimed at halving per capita global food waste at the retail and consumer level and reducing food losses along production and supply chains, including post-harvest losses by 2030 [2].

Situations which generate food waste can be very different, but they occur at every stage of the food supply chain from farms to processing and manufacturing to shops, restaurants and at home.

There is an sufficiently small number of researches related to food waste, which were completed in Latvia. Meanwhile, the published data are not precise enough. Previously, the researches about zero food waste in schools are not mentioned too. However, foreign researchers completed many investigations related to food waste amount, their sources and cause factors.

Martins et al. (2020) completed a sophisticated review of factors influencing food waste during lunch of school

children. The main factors identified as positively influencing the reduction of plate waste during lunch in primary schools were as follows: the presence of teachers during mealtimes, the possibility of children leaving the canteen whenever they want and the level of satisfaction with the sensory characteristics of meals [4]. Meantime, sensory characteristics and satisfaction with food is investigated by Ervina et al. (2020) [5].

The topic of our research is the development of a school e-mentor system, which is possible to forecast food waste and provide recommendations to reduce its amount. However, due to the lack of open data, which depicts time-series of food waste amount and considering the restricted access to collect data in schools due to the prevailing Covid-19 situation, we decided to construct a Monte Carlo model to generate synthetic data for neural network pre-training using a transfer-learning strategy and to better understand influencing factors. Additionally, the simulation model can be directly applied as a module in the proposed e-mentor system. The current research proposes our pilot study, which investigates two factors: meal duration and food dislike. However, it is important to identify required statistical data to develop an appropriate questionnaire for crowdsourcing.

MATERIAL AND METHODS

The requested time to eat a dish (T) is generated by the Monte Carlo model. The food waste (w) depends on eaten amount (e), and a part left behind (d), if a child dislikes a dish:

$$w - d = (1.0 - d) - e(t) , \quad (1)$$

where $t \in T$ is the length of lunch.

To simplify the model for simulation, all dishes were summarized in three groups: 1) an easily chewing main dish; 2) a hardly chewing main dish; 3) a soup together with a hardly chewing main course. Food like fruits or deserts, as well as drinks like juice or milk were ignored because they can be eaten/ drunk fast or taken to the classroom.

According to the mothers who have participated in the interview, the part left behind (d) can be less than 20%. Meanwhile, the velocity of eating is different for each type of meal. It is similar and constant in the cases of a soup or an easily chewing main course. In the case of a hardly chewing main course, the velocity of eating is different for the first and the second parts. It is double smaller for the second part simultaneously being constant.

Thus, the eaten part soup or an easily chewing food e_s can be calculated by Eq. 2:

$$e_s(t) = t/T , 0 \le t \le (1 - d)T . \quad (2)$$

If the linear velocity decrease is considered for the hardly chewing food e_m (see Fig.1), the time moment of the second part can be calculated using the next system:

$$\begin{cases} \frac{3}{4} v_0 t = 0.5 \\ \frac{v_0}{2}(T - t) = 0.5 \end{cases} \quad (3)$$

$$t = \frac{2}{5}T . \ (4)$$

Thus, the initial velocity of eating can be calculated by Eq. 5:

$$v_0 = \frac{5}{3T} . \ (5)$$

At the same time, the eaten part $e_m(t)$ can be calculated by next Eq. 6-8:

$$e_m(t) = \int v(t)dt . \ (6)$$

$$e(t) = \begin{cases} \int \left(v_0 - \frac{5v_0 t}{4T}\right)dt, \ 0 \le t < \frac{2}{5}T \\ \int \frac{v_0}{2}dt, \ \frac{2}{5}T \le t \le T - \frac{2d}{v_0} \end{cases} . \ (7)$$

$$e(t) = \begin{cases} v_0 t - \frac{5v_0}{8T}t^2, \ 0 \le t < \frac{2}{5}T \\ \frac{v_0}{2}t, \ \frac{2}{5}T \le t \le T - \frac{2d}{v_0} \end{cases} . \ (8)$$

A soup together with a hardly chewing main course (e_t) must be calculated using Eq. 2 and Eq. 8 simultaneously:

$$e_t(t) = \{ e_s(t_1) + e_m(t_2) \,|\, t = t_1 + t_2 \}. \quad (9)$$

The probability distributions of meal duration are based on an expert evolution of three voluntary mothers who observed the meal process of their children. The children were not restricted with time. The summary of the evaluation is provided in Table 1.

The observations were based on traditional family dishes. Therefore, dislike probability (p) is unknown – it will be simulated to depict situations when schools monitor or ignore children preferences in the menu. Other, the main variable of experiment, is lunch duration. The variables of experiments are described in Table 2.
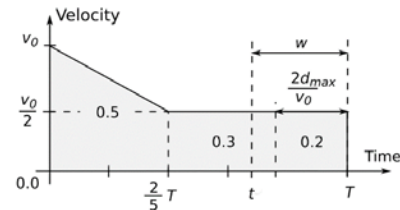
Fig. 1. Simulation scenario of the Monte Carlo model.

Table 1 Parameters Defined by Experts

Meal Type	Parameter	Units	Distribution type	Mean (μ)	Std. dev. (σ)
Soup	Required time (T)	seconds	normal	225	30
Soup	Left behind (d)	%	normal	15%	2.5%
Easily Chewing Main Dish	Required time (T)	seconds	normal	285	30
Easily Chewing Main Dish	Left behind (d)	%	normal	15%	2.5%
Hardly Chewing Main Dish	Required time (T)	seconds	normal	660	120
Hardly Chewing Main Dish	Left behind (d)	%	normal	15%	2.5%

Table 2 Variables of Experiment

Parameter	Units	Min	Max	Step
Lunch time (t_{max})	minutes	5	20	1
Dislike probability (p)	%	0%	25%	1%
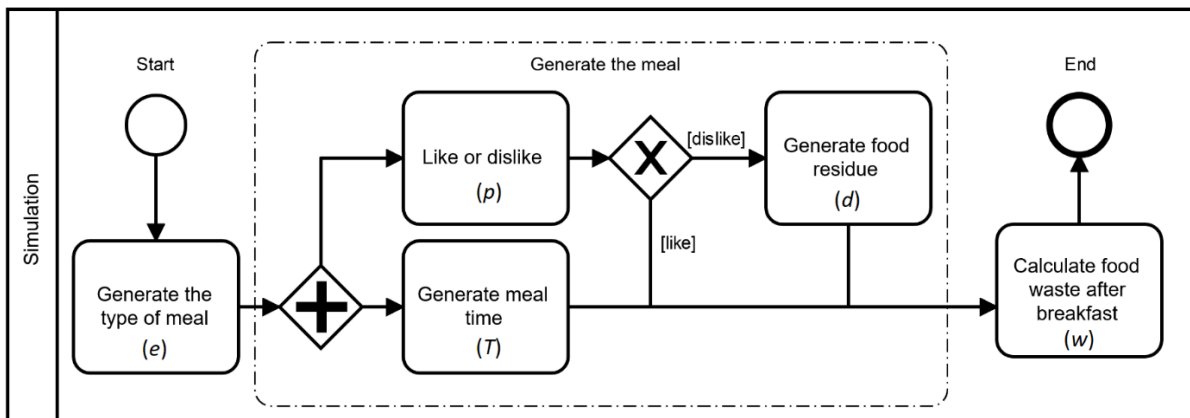
Fig. 2.   Simulation scenario of Monte Carlo model.

RESULTS AND DISCUSSION

The simulation was based on the observations made by three voluntary mothers. Of course, it is not a sufficient number to simulate a realistic situation. However, this is a sufficient amount of data to complete the pilot study. The objectives of this study was to select technologies, to provide the concept of a mathematical model and to obtain some statistical data, which depict relations among parameters to develop a crowdsourcing questionnaire.

The results of simulations are depicted in Fig. 3, which depicts food waste dependence on lunch duration and dislike probability. To simplify the investigation of the results obtained, the tomograms of the minimums and maximums are provided too (see Fig. 4).
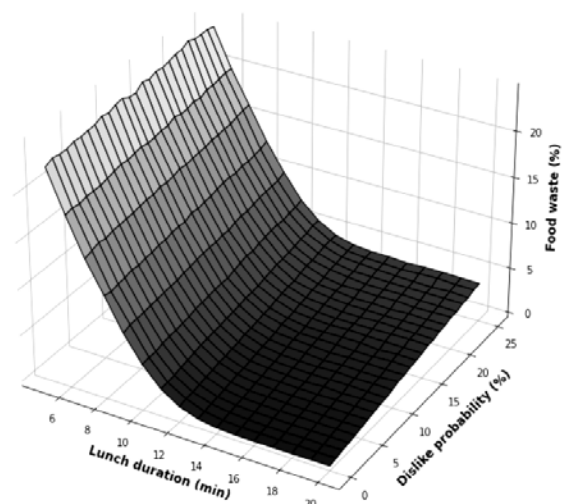
Fig. 3.   Simulation results: food waste dependence on lunch duration and dislike probability.
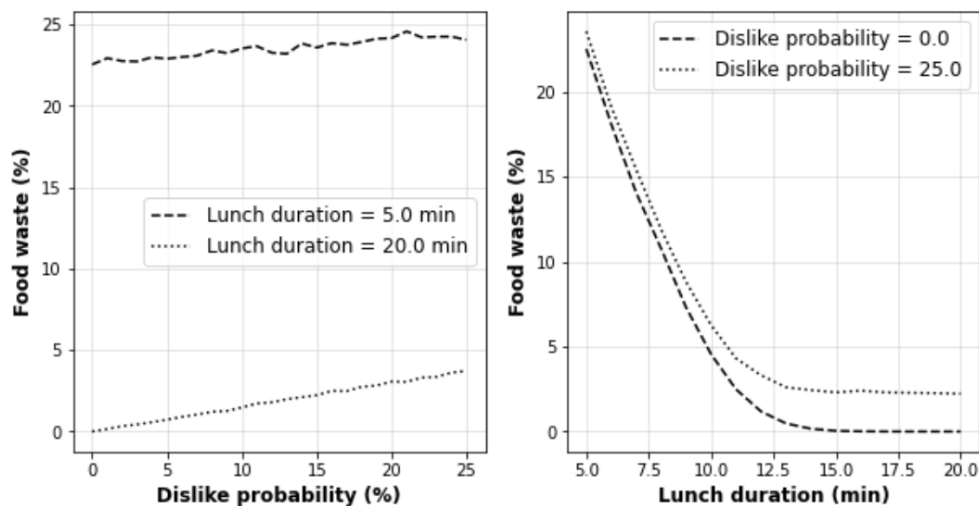
Fig. 4.   Surface tomograms.

It is possible to see that incorrect lunch duration can provide the large amount of food waste, because it has exponential form. According to our pilot data, the minimal duration is 15 minutes, which do not include arrival time. Considering the satisfaction with food, it provides smaller amount, because it has linear dependence. Thus, lunch duration must be set before the school starts to optimize their menu considering children preferences.

Comparing the results with other investigations reveals that Zandian et al. [6] identified the average meal duration 8.8 min for boys and 10.7 min for girls, providing references to similar observations, which is close to expert data applied in the simulation. Meanwhile, Cohen et al. [7] provided another important finding that students ate significantly less of their entrée, milk, and vegetable when they had less than 20 minutes, suggesting that they likely did not have enough time to fully consume their meal. It means that average lunch duration can be increased in some cases. For example, Hamdi et al. mention average lengths 17 and 18 minutes [8].

Speaking about the questionnaire, next data must be collected to improve the model: children age, arrival time, part of a disliked dish left behind, eating duration for easily and hardly chewing food.

CONCLUSIONS

The Monte Carlo model was developed, which can be directly or indirectly applied to forecast food waste depending on meal duration. The obtained results are comparable with the investigations of other researchers.

ACKNOWLEDGEMENT

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Challenges of Advanced Analytics Maturity Model Development

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Abstract - **Significance to understand the advanced analytics ecosystem maturity is increasing caused by constantly growing data volumes and demand for advanced analytics including automated decision making based on data or process automation. The analytics maturity assessment helps to identify strengths and weaknesses of the organization's analytics ecosystem and can provide detailed action plan to move to the next level. The focus of the paper is to review and analyse analytics maturity models to assess their application as frame to build a new analytics maturity model or replicate with time adjustment any of reviewed models. The literature review and publicly available assessment models provided by analytics sector were used to review and analyse analytics maturity models. Fifteen models were reviewed and four of them analysed by twelve characteristics. Summary of four models includes analytics maturity levels, domains, accessibility of questionnaire, discloser of maturity level detection and authors assessment of several characteristics. Comprehensive descriptions of analytics maturity levels were available for many models. Solid recommendation sets for each maturity level provided for the most disclosed models. One of the most important components, approach to detect specific maturity level, was not transparent or disclosed with limitations. However, it is possible to develop a new model or replicate in some extent based on models reviewed in this paper, but it requires extensive professional experience in advanced analytics and related functions.**

Keywords - advanced analytics, analytics maturity, maturity models, maturity assessment.

I. INTRODUCTION

Every minute of every day a huge amount of data created – social media, email communication, any device connected to the internet, google search. The future of digitization and internet of things promise a further generation of new data volumes. New advanced analytical approaches demanded to deal with and make sense out of large volumes of unstructured and structured data.

Data-driven business environment is competitive advantage for any organization. To ensure faster and smarter decision-making, organizations are forced to use advanced analytics to analyse the past, understand the present behaviour and predict and influence the future events, actions, decisions and behaviour. The potential value of data is uncovered only when data-driven decision making becomes a culture of organizations like a blood circulation. Several studies argue that in order to establish data driven decision making, - organizations need to introduce maximally automated processes to manage and use all different kind and fast-moving data from internal and external sources to turn that information into deep and colourful insights [1]. New approaches, algorithms, tools and platforms help to make sense out of large volumes of unstructured and structured data, and methods which ensure so called advanced analytics [2].

The competition between organizations is very tough and usually requests many decisions on organization's side before launching the product or communication with potential customers. The one of differentiators of success is an ability to make decisions which support customers' values and preferences. To ensure faster and smarter decision-making, organizations are forced to use advanced analytics to analyse the past, understand the present behaviour and predict and influence the future events, actions, decisions and behaviour. By implementing advanced analytics into operations, organizations significantly increase a control over daily decisions that ensures a higher potential to meet their business goals [3].

Assessment of the advanced analytics ecosystem is crucial for further development, competitions in the market and to reach the strategic goals of the organization. The assessment and understanding of the investments needed and next steps is critical to make digitization process productive [4].

Considering the increasing demand for advanced analytics including automated decision making based on data or process automation the significance to understand the advanced analytics ecosystem maturity level in any country, industry or organization is topical. The analytics maturity assessment or detection of the analytics development level by several factors which are crucial to ensure proper analytics performance helps to identify strengths and weaknesses of the organization's analytics ecosystem and can provide detailed action plan step by step to move existing analytics ecosystem to the next level or level what is relevant to the organization to meet its strategic goals. However, we can find the models for advanced analytics maturity assessment, there is a limited disclosure of the specific methodology how to develop such models. The assessment process, specific factors and their weight to put organization in the specific level of analytics maturity, are more 'know-how' of analytics sector than transparently disclosed full methodology to ensure reproducibility or validation of the models. Another issue is a time, data volumes and rapid development of technologies what requires regular adjustment of the model.

The paper aims to enhance previous reviews of the models with insights of the methodology and overall process to build or replicate such assessment models. Various organizations' analytics maturity models are publicly available with, in some level, disclosed methodology to find out domains or spheres of influence, factors, questions, answers, behaviour and drivers what allows to build such assessment model. 15 models reviewed and 4 analysed in this paper.

II. Materials and methods

The review and analysis of the analytics maturity models is based on the literature review - scientific publications, reports of the researches, books published by experts and opinion leaders, online published materials and practical assessment of the publicly available analytics maturity assessment tools provided by analytics, technical or IT consulting companies. The literature review process was performed in 2 stages - identified, collected and reviewed materials to point out analytics maturity models with the most extensive information about methodology behind the development of models, the most trustable, the most known and widely used. The second stage was practical experiment taking the online tests to assess the organizations' analytics maturity level to complement existing description of the models from the first stage of literature review. As a result, summary of the characteristics was created for the 4 models who can serve as a base to replicate, adjust or build the own model for specific region, country, industry or segment.

III. Results and discussion

A. Analytics maturity models

Many maturity models for Analytics, Business Analytics, Business Intelligence, Big data, Information Systems have been developed with several domains and stages of analytics. One of the first is Watson's model for data warehousing maturity which covers such domains like people, processes and technologies [5]. Comuzzi & Patel provides an explicit summary of domains and subdomains used in different maturity assessment models. There are such domains as Analytics, Organization, Governance, Technologies, Data, Sponsorship, Culture, Strategy, People and others that have been used and proposed by several authors [6]. Davenport & Harris's Analytics maturity assessment model proposed in 2007 is one of the very often cited ones and used as a base. They indicate 3 domains: 1) Organization with subdomains Analytical objectives, Analytical processes; 2) Human with subdomains Skills, Sponsorship, Culture, and 3) Technology [4]. In 2010, the base model was enhanced with DELTA framework [8] and in 2017 the new release followed with DELTA Plus model containing 7 domains: Data, Enterprise, Leadership, Targets, Analysts, Technology, Analytics techniques and 5 maturity stages from Analytically Impaired to Analytical Competitors [9]. Krol & Zdonek disclose a rich summary of analytics maturity models with stages and domains [7]. Cosic et al. proposes 4 domains with 4 subdomains for each: "Governance (Decision Rights, Strategic Alignment, Dynamic BA Capabilities, Change Management), Culture (Evidence-based Management, Embeddedness, Executive Leadership and Support, Flexibility and Agility), Technology (Data Management, Systems Integration, Reporting and Visualisation BA Technology, Discovery BA Technology), People (Technology Skills and Knowledge, Business Skills and Knowledge, Management Skills and Knowledge, Entrepreneurship and Innovation)" [10].

Traditionally 5 levels of maturity are used widely, sometimes the Zero level is created to sort those who haven't done/ implemented/ developed anything in specific area. Becker at al. [11] identified and worked out 5 levels of maturity. All the above-mentioned authors use a 5-level maturity assessment. In case of Comuzzi & Patel [6], in addition, the Zero level had been created because of organizations that required sorting them as the Zero level in a specific domain or subdomain.

Summarizing the authors above, the 5 levels of maturity can be interpreted: level 1 – beginners with weak analytical capability, only spreadsheet based and issues with data gathering and quality; level 2 – intermediate silos analytical activities, better data accessibility; level 3 – wide operational usage with some coordination between analytical community, existing data warehouses/ repositories/data lakes; level 4 – analytical organization with high quality data, integrated analytics in the many processes and decision-making, analytics as competitive advantage; level 5 – visionary advanced organizations with analytics culture and mindset, testing/adopting cutting edge tools/techniques/solutions, high competitive advantage.

Exploring analytics maturity models to gather and analyse the methodology behind to build or replicate such model, the 15 analytics maturity models were reviewed: 1. Watson's data warehousing maturity [5], 2. Comuzzi & Patel model [6], 3. Early DELTA model [4], 4. Cosic et al BACMM model [10], 5. Analytic Processes Maturity Model (APMM) [12], 6. Analytics Maturity Quotient Framework (AMQ) [13], 7. Blast Analytics Maturity Assessment Framework [14], 8. Data Analytics Maturity

Model for Associations (DAMM) [15], 9. DELTA Plus Model [16], 10. Logi Analytics Maturity Model [17], 11. Online Analytics Maturity Model (OAMM) [18], 12. SAS Analytics Maturity Scorecard [19], 13. TDWI Analytics Maturity Model [20], 14. Web Analytics Maturity Model – WAMM [21], 15. Defining analytics maturity indicators (DAMI) [22].

After the review of literature, reports, publications and the test of publicly available assessment tools, 4 models were selected for deeper analysis. They were selected by such factors like discloser of the survey questions, described methodology, provided guidelines to replicate or adopt such model.

B. Methodology behind Analytics maturity models

The detailed methodology is necessary to replicate or adjust the model for the specific industry, country, segment or organization. Therefore, 4 models who disclose more explicit approach chosen for detailed analysis. Models were described by domains, factors, interpretation of the results (maturity level) and recommendations, any other supportive information what increases the ability to replicate or build the model. The summary of characteristics for the 4 models provided in Table 1. In addition, authors own ranking of the following characteristics: Maturity level description, Recommendations, Reproducibility, Interpretation were used to indicate how helpful model could be for replication or development of analytics maturity model. 5-point ranking was used, where 1 – slightly helpful, with minimal description and 5 – very helpful with very detailed description. These are Analytics Maturity Quotient Framework (AMQ) [13], DELTA Plus Model [16], Defining analytics maturity indicators (DAMI) [22] and TDWI Analytics maturity model [20]

Analytics Maturity Quotient Framework (AMQ)

Analytics Maturity Quotient (AMQ) Framework is based on 4 domains: Data Maturity, Leadership, Analytics Talent, Decision making process. Domains contain 2-4 factors with 10-point scale. Final result as a Score between 0-10. Publicly available simple DYI survey [13] to assess AMQ and comprehensive AMQ assessment available for organizations. Model developed based on detailed stake-holder interviews, auditing and surveys. In case of comprehensive approach, the detailed and the prioritized recommendation set for increasing analytics maturity provided. The analytics maturity assessment model constantly is developed and updated.

DELTA Plus Model

DELTA Plus Model Adapted from [8],[4],[9] and is a tool developed by the International Institute for Analytics (IIA). DELTA Plus Model is based on 7 domains: Data – breadth, integration, quality; Enterprise – approach to managing analytics; Leadership – passion and commitment; Targets – first deep then broad; Analysts – professionals and amateurs; Technology – approach, orientation, velocity; Analytics techniques - sophistication, diversity. Publicly available version [24] provides 1 factor with 5 statements for each domain. Analytics maturity stage is provided between 1-5. 1 - Analytically Impaired, 2 - Localized Analytics, 3 - Analytical Aspirations, 4 - Analytical Companies, 5 - Analytical Competitors. The comparison to the industry and digital native is provided complementary. The algorithm of the maturity level detection is not disclosed, but for those who make an assessment the explanation of each maturity stage is sent, the action list to move from one stage to another is shared. The model is developed on many years of researches, interviews, surveys.

Defining analytics maturity indicators (DAMI)

Defining analytics maturity indicators: A survey approach paper model is based on 5 domains: Data, Organization, Leadership, Techniques and applications and Analysts. 4 stages of the analytics maturity were found out with clustering based on 28 factors. 1 – No analytics, 2 – analytics bootstrappers, 3 – sustainable analytics adopters, 4 – disruptive analytics innovators. The research provides key characteristics of each stage and key recommendations to improve analytics. Model developed based on interviews as a pre-test for the survey in 2 rounds with interval 1 year, results validation by experts. Full questionnaire is available with 67 questions.

TDWI Analytics Maturity Model

TDWI Analytics maturity model is based on 5 domains: Organization, Resource, Data Infrastructure, Analytics, Governance. Maturity consists of 5 stages plus 1 stage (chasm) between third and fourth stages. Maturity stages are 1 – Nascent, 2 – Early, 3 – Established, 4 – Mature, 5 – Advanced/ Visionary and the Chasm – the most difficult stage to overcome to reach the next level. The research provides wide set of characteristics of each stage and solid outlook of recommendations to improve analytics. Model developed based on extensive researches, surveys and interviews for many years. Full questionnaire is available with 52 questions as online assessment tool. It is required to apply for the assessment to get full questionnaire [23].

All 4 models disclose domains and factors. Only AMQ model does not disclose specific maturity levels.

TABLE 1 ANALYTICS MATURITY MODELS - SUMMARY OF CHARACTERISTICS

Characteristics	AMQ	DELTA Plus	DAMI	TDWI
Maturity levels	Not disclosed	5	4	5+1
Number of Domains	4	7	5	5
Number of factors	11	7	28	22
Assessment	10-point scale	Statements	Scale, Statements	Scale, Statements
Maturity level describer	AMQ score 0-10	DELTA Score 1-5	Cluster 1-4	Score 1-20
Maturity level detection	Not disclosed	Not disclosed	Clustering	Weighted score by domains and average total score
Model development	Interviews, auditing and survey	Researches, surveys, interviews	Interviews, survey, validation by experts	Researches, surveys, interviews
Survey questionnaire disclosed	Short DIY version only, 11 questions	Only 7 statements and domains	67 questions, full survey	52 questions, full survey
Maturity level description	1	5	5	5
Recommendations	1	5	3	1
Reproducibility	3	4	5	5
Interpretation	1	2	4	4

Maturity level detection is not disclosed fully by any of models, however the algorithm behind is the most important to be able to build the model what is able to detect maturity level of specific organization. The most transparent is DAMI model. On the one hand, questionnaire is disclosed by all models, on another hand, publicly available versions for 2 models has very short questionnaires what could help to get some first estimation where organization stands overall, but would not be very helpful for new model development.

Author recognizes DAMI and TDWI models as the most appropriate to use as base for the new model development. These models could be the most helpful if person who aims to build own model does not have very extensive experience in wide range of analytics. These models provide full questionnaires and provides hints to make an analysis on the survey data which ensure some reproducibility of these models to use them in another countries or industries and afterwards allows to compare results.

IV. CONCLUSIONS

Data, analytics, related tools and overall analytics ecosystem becomes more and more crucial topic in any organization taking into account high digitization demand. Therefore, organization's analytics maturity assessment becomes critical to continue successful business and many analytics service providers or analytics consulting companies develop analytics maturity assessment as part of their commercial services. There are much more analytics maturity assessment models available than mentioned in this paper, but very often publicly available versions are with limited options – fewer questions, not disclosed

maturity level detection methodology, outcome as a high-level assessment of maturity level what does not answers - how, when, what, how much resources needed to make the next step in analytics maturity development.

Ability to build or replicate the own analytics maturity assessment model could be attractive to large organizations, organizations with existing analytical teams and drive to encourage analytical culture organization-wide, analytical teams, researchers, consultants and experts in analytics sector. Another reason is a rapid development of technologies, analytical platforms, increase of data volumes, data accessibility for wider audience what leads to risk – publicly available (not commercial) analytics maturity assessment models are outdated or partly outdated. However, models available in the market can provide comparison with industry, with similar segment, with overall level.

All 15 reviewed models give some skeleton for the independent development of the analytics maturity model. However, the person or group of persons who are going to build or replicate the model should be from the analytics or related industry – experts and/or practitioners, to be able not only replicate or build such model, but create relevant questionnaires, run audits, make interviews, understand, use and interpret outcome giving precise assessment of overall maturity level and by domains, develop a set of recommendations to improve existing level or move to the next. All reviewed models disclose domains, in some extent sub-domains or factors, at least high-level description of analytics maturity levels, but without discloser of methodology how to detect specific maturity level. In some cases, more information was provided what sits behind the model and how it was developed – like

surveys, interviews with experts, audits, back test after some time on the same pool. From the 4 models analysed, 2 models disclose the full survey questionnaire, 1 give insight in analyses of the data and indication of the maturity levels, 2 gives some explanation on detection of maturity level.

It is possible to develop a new model or replicate in some extent analytics maturity assessment model based on models reviewed in this paper. The challenging part is methodology how to detect the level of maturity. Another challenge is to interpret results to provide explanation of detected analytics maturity level and recommendation for the next steps to improve overall analytics maturity level. One more challenge is to monetize the move to the higher maturity level. In addition, time and rapid development of technologies plays significant role because the model should include the newest trends of analytics ecosystem to not become outdated as soon it is created. It should be able to assess the maturity level properly today and in the mid-term future to give the right recommendations to the organizations to develop the analytics ecosystem according to the newest and most applicable solutions. Thus, drives the need for the new and new analytics maturity assessment models.

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Improving Adaptive Learning in a Smart Learning Environment

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Abstract **- It has been broadly argued that, in the near future, the demand for skilled labor will increase whilst that for routine activities will decrease. In this regard, the need for making greater investments in education to re-skill workers and support continuous learning has been invoked as an essential requirement for preserving people's employability.**

Digital technology is deemed increasingly necessary to sustain the educational endeavor, for the possibilities it offers to make more accessible and low-cost educational interventions. It allows for the creation of personalized learning paths and customized digital learning solutions, for courses to be available to a large attendance of learners, and for teaching-learning activities to be offered at significantly reduced cost.

In this article, a learning unit structure designed to improve adaptive learning is proposed, and mechanisms for adaptive learning in a smart learning environment are discussed.

The implemented teaching-learning solution is also illustrated. This is a preliminary application based on an approach that combines the teacher experience with learning analytics.

Keywords - Learning Adaptivity, Learning Analytics, Learning Unit Structure, Smart Learning Environment.

I. INTRODUCTION

Nowadays, an increasing amount of research in the educational scope focuses on technology that can be used to increase teaching-learning productivity and efficiency.

In 2020, the COVID-19 pandemic severely impacted on educational systems worldwide, forcing a transition from face-to-face teaching to remote teaching-learning and e-learning. Data from surveys conducted during the resulting shut down of educational institutions reveals a broad consensus regarding the positive attributes of the so-called emergency remote teaching, even if the organization of remote classes, virtual exams, and the various bureaucratic activities proved extremely challenging at the time [1], [2], [3], [4], [5]. The massive and unprecedented use of technology in training activities as a result of the outbreak made the question of how to enhance personalized learning experiences in a digital environment more topical.

Creating personalized learning paths and customizing digital learning can allow educators to reach very large audiences of learners, whilst also reducing the cost of teaching-learning activities.

Oppermann and Rasher distinguished between learning adaptivity and learning adaptability [6] referring to adaptivity to a system that adapts itself according to the user rather than forcing the users to change its behavior (adaptability). According to the authors, in learning systems, the application of adaptivity finds more suitability than adaptability. Currently, many adaptive learning platforms are available that promise the application of adaptive learning for personalizing the learning process, whilst numerous investigations are being carried out on the use of adaptive learning in various scopes [7], [8].

Adaptive learning solutions are often based on learning analytics [9]. The last few years have seen an increased interest in learning analytics and adaptive learning, since online and mobile technologies have facilitated access to a huge wealth of data that can be used to customize the learning process. The use of analytics in education can enhance many aspects of the teaching-learning experience. Data produced by students during training activities can be used to improve their achievements and proficiency.

The personalization of learning content and modality is crucial for disadvantaged groups since, usually, teachers aim their activities to match the needs of the average student whilst, in reality, a great number of students do not correspond to this profile. Furthermore, learning analytics can improve remote teaching-learning, helping teachers to

identify learners who are insufficiently challenged, bored, confused, or who are failing to attend [10].

This paper presents an application based on SALM (Smart Adaptive Learning Model) that results from research carried out within the scope of two international projects, DocTDLL (Implementation of Transformative Digital Learning in Doctoral Program of Pedagogical Science in Latvia), whose aim is the application of Transformative Digital Learning to Ph.D. study programs, and ASL (Adult self-learning: supporting learning autonomy in a technology-mediated environment), which is aimed at improving and extending the supply of high-quality learning opportunities tailored to the needs of individual low-skilled or low-qualified adults.

II. RESEARCH OBJECTIVE AND METHODOLOGY

The main research objective lay in defining and implementing a smart learning environment able to support adaptive learning processes. According to Huang, Yang, & Hu (2012) [11], a smart learning environment is based on technical components that provide learners with appropriate support (such as guidance, feedback, hints, or tools) in the right place and at the right time. It should meet individual learners' characteristics and needs, which might be determined by analyzing their learning behavior, performance, and the online and real-world contexts in which they are situated.

This research foresees three phases:

1. Analysis of experience in adaptive learning and learning analytics in order to define the smart learning environment's functional structure.
2. Implementation of a preliminary solution based on structured learning units and the automatic creation of personalized learning paths

combining teacher expertise and learner behavior.
3. Integration of e-learning and remote learning with virtual agents, and creation of learner profiles based on a weighted analysis of their preferences and achievements.

The methodology adopted was to analyze experiences gathered in structuring learning units and the SCORM (Shareable Content Object Reference Model) [12]. Although SCORM presents limitations in ensuring security, sequencing, and interoperability in the learning content [13], it is a conceptual reference model in the creation of learning objects.

At this time, phase 1 and phase 2 have both been concluded.

A smart learning environment has been defined that integrates solutions for context-sensitive and customized learning in order to accelerate and enhance learner proficiency. Following this, an experimental application has been implemented to provide learners with individual learning paths automatically, based on their own knowledge level and supported with specific options at different learning stages, e.g. providing low-qualified learners with additional didactic materials to fill their knowledge gaps.

III. SALM FUNCTIONAL STRUCTURE

SALM is inspired by the principles of adaptive learning [14], namely the delivery of custom training through just-in-time feedback, pathways, and resources.

Fig. 1 shows the functional structure of SALM [15].
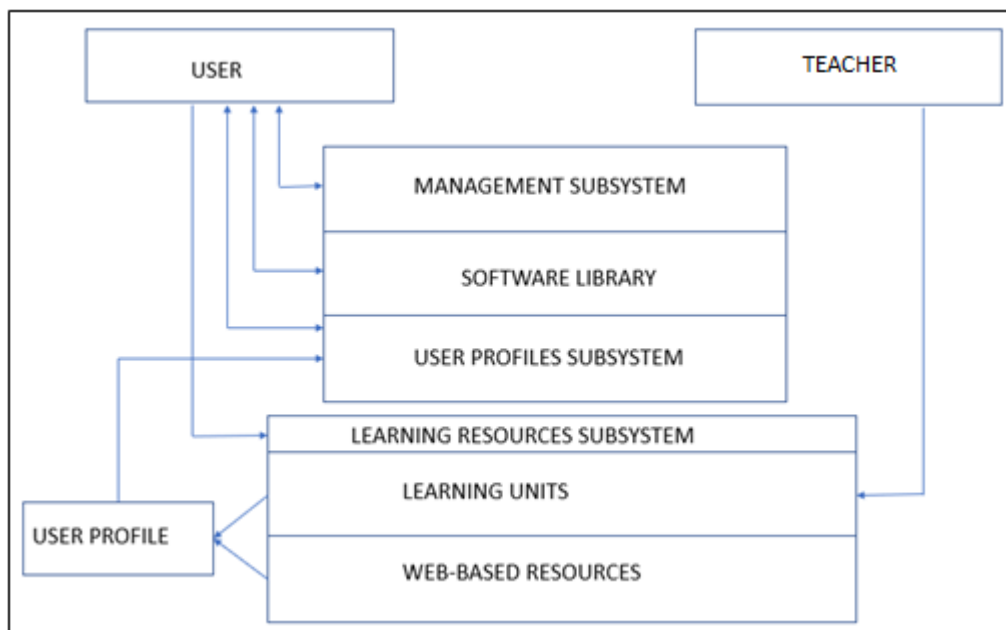
Fig. 1. SALM functional structure (own source)

The main components of SALM are:

1. Management subsystem that encompasses functions to support:
   o interaction between learners and teachers;
   o interaction among learners;
   o building of user profiles;
   o building of learning units;
   o organization of customized learning path;
   o filtering of resources according to learner profiles;
   o evaluation of learning retention;
   o analysis of learning resources to create ontologies.
2. Software library, which includes programs and algorithms to:
   o perform intelligent searches on the web according to learner profiles;
   o make inferences to select learning resources according to user profiles;
   o calculate the learning rate;
   o evaluate the learner status.
3. Profile subsystem, which contains the profiles of users, recorded as the result of an analysis of their activity.
4. Resources subsystem, which is divided into integrative learning materials and web-based learning resources. The former includes lectures and didactic materials such as course notes, slideware, study guides, self-assessment questionnaires, etc. The latter includes web searches, such as links to didactic objects, websites, articles, audio/video objects, etc.

Trainers prepare learning units, but learners have the possibility to add new learning resources gathered from their own activity on the web. These resources are listed under the see also section of a learning unit.

In the SALM model, the structure of learning units plays a crucial role, since a significant degree of adaptive learning performance depends on how learning units have been created [16].

IV. SALM STRUCTURED LEARNING UNITS

Learning units are objects comprising various multimedia components (Fig. 2):

- Learning objects;
- Questions;
- Chat;
- Forum;
- Integrative materials;
- Final test.

Each learning unit contains a header with the following data:

- Name of the author (s);
- Organization (name of the author's organization);
- Date of creation (derived automatically);
- Date of the last update (derived automatically);
- Title;
- Summary;
- Keywords;
- Expected achievement;
- Prerequisites (knowledge that a learner should possess).

Learning objects are the basic learning items/resources of a learning unit, and can be figured as the bricks in a Lego construction.
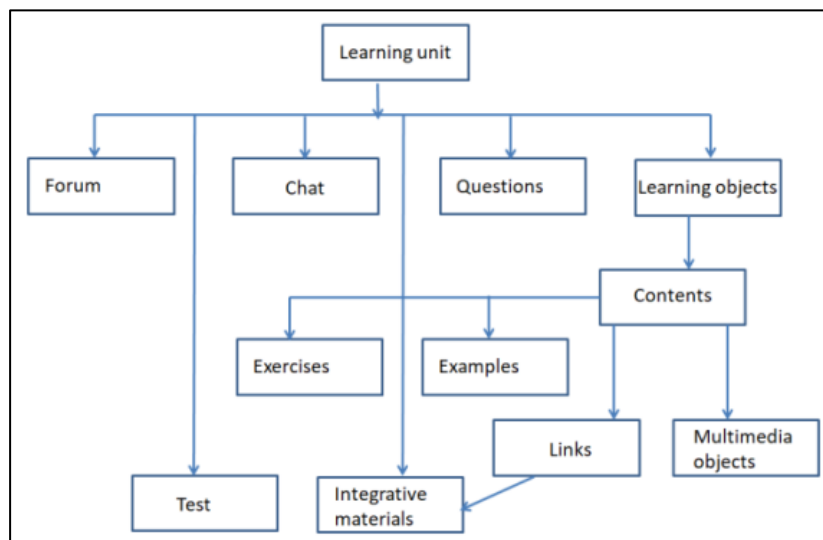
Fig. 2. A learning unit structure (own source)

Learning objects have been described in literature in many different ways, depending on the background of the author and their application context [17]. They are addressed variously as learning objects, information objects, instructional objects, educational objects, content objects, media objects, knowledge objects, and so on. However they are defined, the key element that is emphasized is their reusability:

- A digital resource that can be reused to support learning [18].
- Any entity, digital or non-digital, that may be used for learning, education, or training [19].
- A small piece of learning material (e.g. visualization, video clip, animation, interactive simulation, interactive exercises) that is a reusable, compact, and unitary entity [20].

In SALM learning objects are:

1. Contents (multimedia objects and links)
2. Examples
3. Exercises

Contents can include:

- links to integrative materials, namely learning objects that a teacher creates for or associates to a learning unit;
- embedded multimedia objects, such as video, schemes, pools, etc.

Integrative learning materials play a crucial role in the SALM adaptive teaching-learning solution. They correspond to the learning materials that the teacher didn't include in a learning unit but deem essential to understanding it. Usually, these materials refer to definitions, general principles, theories, etc., that a skilled learner should know or should be able to find by consulting a dictionary, an encyclopedia, or the web.

Integrative learning materials include:

- pre-knowledge needed for the learning unit contents;
- supplementary readings, examples, and exercises.

Due to its nature, the same integrative material can be associated to more than one learning unit.

V. THE TEACHING LEARNING SOLUTION

A pre-determined but flexible teaching strategy has been adopted. The teacher defines the initial decision tree that can then be dynamically changed leveraging the individual student data.

A two-step teaching-learning solution has been implemented to support learners who might have difficulty accessing these notions and/or selecting the right source. The first step consists in the creation of the initial set of integrative materials. The teacher defines and prepares the materials that should be part of a learning unit. These can be accessed through links that are included in learning object content in the event that a learner has difficulty understanding something. First, the teacher defines some questions for testing the level of knowledge of a learner. Then, based on the learner responses, the learning unit is generated, assembling the learning objects and adding the integrative materials, corresponding to the knowledge gaps identified through the teacher questions.

Examples of initial questions for a learning unit concerning "Internet searching" might be:

- Do you know the difference between an internet browser and an internet search engine?
- Do you know the difference between e-marketing and e-commerce?
- Do you know the history of the internet?
- Do you know the basic functioning of a computer?
- Do you know something more about information retrieval?

The teacher can create integrative materials, such as:

- Browser definition
- Most popular browsers
- Search engine definition
- Bio of Tim Berners-Lee
- WWW definition
- What a network is
- History of the internet
- …

Fig. 3 shows the integrative materials associated with the question "Do you know the difference between an internet browser and an internet search engine?"
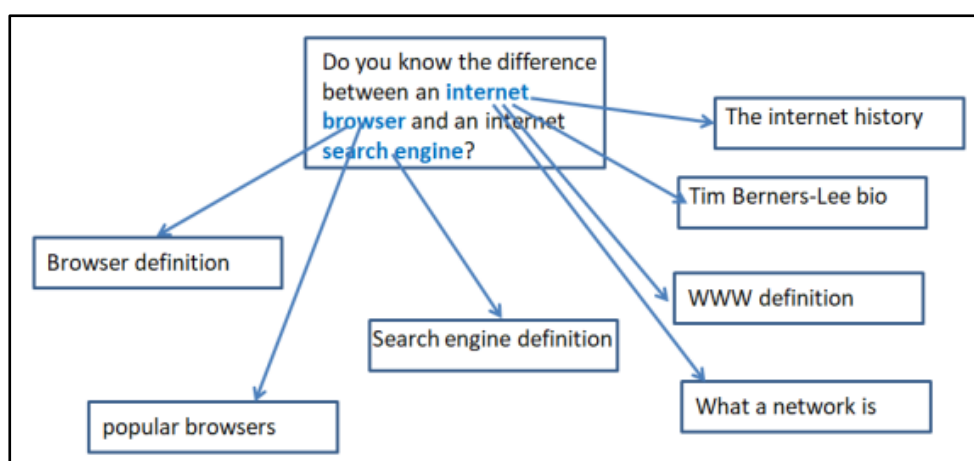
Fig. 3. Integrative materials associated to a question

The same integrative materials can be associated to various different learning units.

The second step consists in improving the integrative materials, analyzing learner behavior. Learners are regularly asked to evaluate their learning process (e.g. every two hours of connection). Their responses, as well as the length of time they have spent on learning objects, are presented in a dashboard visible to the teacher, who uses the information to improve the integrative materials.

Examples of questions are as follows:

- Did this learning object satisfy your expectations? (Not at all, Slightly, Fair, Very, Extremely)
- How do you evaluate the topicality of this learning object? (Very poor, Scant, Adequate, Good, Very good)
- How do you evaluate the learning object examples? (Very poor, Scant, Adequate, Good, Very good)
- How do you evaluate the learning object exercise? (Very poor, Scant, Adequate, Good, Very good)

A Likert scale is used for the learner evaluation.

Learners can also post comments and suggestions in forums and chat. Their posts are analyzed, and the results are presented in the teacher dashboard. The teacher uses all the information coming from learners to refine the learning units by improving the learning objects.

This second step can be iterated.

The solution has been implemented for the smart learning environment of the ASL project. The six project partners from five countries (Turkey, Latvia, Italy, Poland, and Greece) will use it to train lowly-qualified learners on basic and advanced notions related to digital technologies.

Each partner will organize two training courses. In the first, teachers will implement the first step of the solution, using the results obtained to then refine the second training course.

VI. FURTHER DEVELOPMENTS

The next main development will be the integration of adaptive learning functions in remote learning activities. The possibility of developing a collaborative group activity aimed at creating integrative materials will be investigated. Small groups of learners could use the internet to research for pre-knowledge materials as well as other information able to facilitate the learning process and the achievement of the learning objectives.

Free brainstorming tools could be experimented and integrated into the smart learning environment [21], [22].

Moreover, agents to analyze the forum and chat activities should be implemented to identify the learners' preferences and learning difficulties.

The idea is to design and develop a dashboard to help a teacher improve the learning units and their remote learning activities.

For this purpose, learning analytics will be used to create and update a set of learner profiles based on the learners' behavior [23], [24]. A weight that expresses the learner's preference and difficulty will be associated with each learning content.

The next step foresees the possibility of using Bayesian inference to implement an algorithm to automatically refine personalized learning paths [25], [26], [27].

An algorithm will be developed to identify the best learner profile based on a preliminary test before starting the e-learning course. The hypothesis is to use a Bayesian-based algorithm, since it should enable the association of a learner to a particular profile. If the learner's status corresponds to the likelihood of a particular profile, and there is other evidence, e.g. learner actions, supporting that probability, then the learner can be associated to a specific profile.

Indeed, the Bayes theorem describes the probability of an event, based on a prior knowledge of conditions that might be related to the event. It is expressed as:

$$P(A \mid B) = \frac{P(B \mid A)\, P(A)}{P(B)}$$

where $P(A)$ and $P(B)$ are independent probabilities of event A (learner profile) and B (learner status) respectively, and $P(A/B)$ is the probability of observing A (learner profile), given the event B (learner status) has happened.

In SALM, we aim to infer the parameters (θ) of our model as:

$$P(\theta / D) = [P (D/ \theta) . P(\theta)] /P(D)$$

where $P(\theta)$ is the prior belief; $P(D/\theta)$ is the likelihood of data D, given that θ is observed or true; and $P(D)$ is a normalizing constant.

VII. Conclusion

For a long time, most of the popular digital platforms were generally conceived in terms of content distribution systems, with little thought given to the interests or immediate reactions of singular learners in the virtual classroom.

The COVID-19 outbreak forced the creation of more interactive learning environments and experimental solutions that facilitate personalized teaching-learning.

This paper has presented a solution aimed at combining automatic and mediated adaptive learning. It results from research carried out on digital transformative learning focusing on smart learning environments that can support easy, engaged, and productive learning.

At this time, a solution has been implemented based on structured learning units and a pre-determined but flexible teaching strategy. It will be adopted for the training activity of the EU ASL project.

Acknowledgments

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Industry 4.0:Social Challenges and Risks

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Abstract - **Industry 4.0 is a term first introduced by the German government during the Hannover Messe fair in 2011 when it launched an initiative to support German industry in tackling future challenges. It refers to the 4th industrial revolution in which disruptive digital technologies, such as the Internet of Things (IoT), Internet of Everything (IoE), robotics, virtual reality (VR), and artificial intelligence (AI), are impacting industrial production.**

The new industrial paradigms of Industry 4.0 demand a socio-technical evolution of the human role in production systems, in which all working activities of the value chain will be performed with smart approaches.

However, the automation of processes can have unpredictable effects.

Nowadays, in a smart factory, the role of human operators is often only to control and supervise the automated processes. This new condition of workers brought forth a paradox: malfunctions or irregularities in the automated production process are rare but challenging.

This article discusses the challenges and risks that the 4th industrial revolution is bringing to society.

It introduces the concept of the Irony of Automation. This propounds that the more reliable an automated system, the less human operators have to do and, consequently, the less attention they pay to the system while it is operating.

The authors go on to discuss the human-centered approach to automation, whose purpose is not necessarily to automate previously manual functions but, rather, to enhance user effectiveness and reduce errors.

Keywords - human-centered approach Industry 4.0, Internet of Everything, irony of automation.

I. INTRODUCTION

Industry 4.0 is a term first introduced in 2011 by the German federal government when, at the Hanover Messe fair, it presented a project hypothesis aimed at supporting German industry to address the challenges of the future brought by the expansion and progress of digital technologies [1].

The term Industry 4.0 clearly calls to mind the fourth Industrial Revolution where the Internet of Things (IoT), the Internet of Everything (IoE), the Web of Things (WoT), robotics, virtual reality (VR), artificial intelligence (AI), and ultra-fast connections play a primary role [2].

The main innovation of Industry 4.0 is the redesign of technological and organizational processes as a result of the integration of different sources of information with management and production processes. This is the result of the unconventional use and combination of already existing technologies to create new business solutions.

Industry 4.0 leverages the opportunities offered by the digitation of data and by information technology. It encompasses some main specific fields:

- Autonomous driving. This encompasses three classes of vehicles: semi-autonomous, sufficient-autonomous, and fully-autonomous.
- 3D printing. This consists of creating physical objects by printing them from a digital model.
- Advanced robotics. This is a wide-ranging field that includes biomimicry, namely applications and systems that are modeled on biological entities and processes.
- New materials. These are materials that are recyclable and adaptive, such as metals with memory, ceramics and crystals that turn pressure into energy, and materials that possess capabilities that enable self-healing and self-cleaning.
- IoT and IoE applications. These aim to connect things (devices, products, services, places, etc.) and people through smart sensors and various platforms (Fig. 1).
- Biological applications. Genome sequencing and synthetic biology will not only have profound consequences in medicine but also in agriculture and biofuel production.
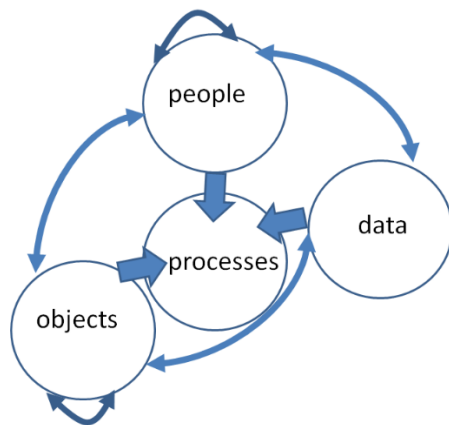
Fig. 1. The IoE paradigms (author's own source)

The digital revolution and the new industrial paradigms of Industry 4.0 demand a socio-technical evolution of the human role in production systems, in which all working activities of the value chain will be performed with smart approaches.

This article discusses some of the challenges and risks related to the fourth industrial revolution and Industry 4.0.

It introduces the concept of the Irony of Automation, and argues for a human-centered approach to enhance user effectiveness and reduce technical errors.

II. OBJECTIVE OF RESEARCH AND METHODOLOGY

The objective of this research is to investigate the social challenges and technical risks associated with the development of Industry 4.0. In particular, this research aims to identify strategies and solutions that may be adopted in order to overcome the technological pitfalls that, due to human factors, may affect the implementation of intelligent systems.

For this research, a procedure was adopted for the literature review aimed at attaining the research goal [3], [4]. The procedure followed the following phases:

- Define the research question: Industry 4.0 socio-technical issues and solution approaches.
- Define the search plan: identification of databases (Web of science, Scopus, IEEE, ACM, SAGE, Google Scholar) and period of investigation (2010-2021).
- Search for relevant literature: use of appropriate keywords.
- Apply exclusion criteria: including only evidence-based materials.
- Analyze materials: reading and evaluation of selected items.

The transformations in the labor market have been analyzed, considering the human factors underlying competition with machines and control of the automated process.

The technical risks have also been considered, focusing on the security and ethics of intelligent systems. This paper also takes advantage of the results of previous studies on

decision making and augmented cognition, as well as the experience gained in teaching Industry 4.0.

From the literature analysis, it emerged that:

- an evidence-based understanding of the implications of an algorithm's application is necessary before its large-scale use.
- human-centered automation may reduce errors and risks in intelligent manufacturing systems.

Moreover, over the last few years, many publications have dealt with the concept of "the irony of automation" that was first expounded by the cognitive psychologist Bainbridge (1983) [5], and have reconsidered Rasmussen's work (1983) [6] on operator performance in process systems in the light of intelligent system technology.

According to Google Scholar, the number of citations of Bainbridge's work have risen from around 1,800 in early November 2016 [7] to over 2,200 in March 2021, whilst citations of Rasmussen's article exceeded 4,700.

III. SOCIAL CHALLENGES OF INDUSTRY 4.0

The impact that Industry 4.0 will have on society divides experts [8], [9]. The techno-pessimists argue that technological advances will have a critical impact on the labor market, at least in the short term. They underline that, over the last few years, automation processes have begun substituting the jobs of many manual workers, as well as those of bookkeepers, cashiers, and telephone operators. The techno-optimists, on the contrary, claim that technology will soon bring economic growth.

Some economists talk about secular stagnation, a term coined by Alvin Hansen in 1938 [10], forecasting a situation of persistent shortfalls in demand and wage squeezing [11]. They believe that new technology can lead to a temporary fall in productivity due to the reorganization of workers' competence.

Brynjolfsson and McAfee (2014) [12] emphasized that, to take advantage of the fourth industrial revolution's opportunity, it is necessary to understand the critical impact that this revolution will have on society. Accordingly, an effort is required to recognize and deal with new social challenges facing people and organizations, and an investment must be made in analyzing the seriousness of the risks that are intrinsic in the extended use of intelligent systems in the social sphere and in industrial production processes [13].

From this perspective, the loss of traditional jobs and the reorganization of workers' competence, although crucial aspects in themselves, are only one part of the issue.

A hugely critical issue concerns internet-based participation. This can hide the risks of new forms of tyranny developing based on the consensus obtained through social media. E-democracy, e-participation, and virtual decision-making [14 open a question about responsibility. What is the responsibility of decision-makers in crowd-based participatory processes? They could shift blame by transferring responsibility for a problematic decision to the crowd. Taking inspiration from the famous book "Escape from freedom" by Fromm (1941)

[15], the problem could be reformulated as one of "escape from responsibility."

Another problem arises with the drive towards full automation. It might not be wise to automate tasks just because it is possible to do so. Indeed, there are problems with machine control and interaction that are connected with full automation. Moreover, interactions of humans with machines and intelligent programs bring new, possibly unforeseen, social risks that research should urgently address.

IV. IRONY OF AUTOMATION

The irony of automation argues that, in an automated system, there are always some circumstances that are not expected. An automated system is designed to handle only things that have been predicted. Design constraints limit even intelligent systems based on a machine learning approach.

Discussing how automation of industrial processes may expand rather than eliminate problems with the human operator, Bainbridge introduced the concept of the irony of automation:

The important ironies of the classic approach to automation lie in the expectations of the system designers, and in the nature of the tasks left for the human operators to carry out. The designer's view of the human operator may be that the operator is unreliable and inefficient, so should be eliminated from the system [5].

The above attitude of the automation designers is still diffused. They do not understand that automated systems should be designed to support human beings. Accordingly, they should reduce the human workload but not eliminate the human intervention.

However, if a designer is asked to design only some complex system's elementary functions, the designer task is completed when these functions work. Nevertheless, in a complex system, pieces of hardware and software are interconnected and depend on other hardware and software pieces. Consequently, integrated control and feedback are needed since unexpected events can occur in any complex system [16].

Moreover, according to [17], many types of automation failures, including software bugs and hardware failures, lie in how automation performs as the designer intended but not as the user intended.

Analyzing and discussing the still unresolved ironies of automation, Strauch observes that to solve them, one must recognize them [7]. In this regard, the author claims that the way to do it is necessary that system designers, trainers, managers, and regulators work together to address the potential adverse effects of automation.

V. TECHNICAL RISKS OF INDUSTRY 4.0

The disruptive spread of the IoT and IoE applications leads to new kinds of security problems and errors that could result from algorithms that do not control and manage unpredicted odd or rare circumstances. At the current time, securing the systems in the manufacturing

environment is an issue that is rapidly gaining attention in Industry 4.0.

Moreover, an inherent technical risk in complex process automation is the unpredictability of the human control over algorithms and the serious consequences this can have. Indeed, although machine performance is superior, in certain respects, to human abilities, software applications might not always be intrinsically reliable.

There are many problems that arise in relation to intelligent systems. One is the reliability of the humans who work on the control of automated processes.

Investigating and studying methods for addressing and overcoming cognitive bottlenecks is the aim of the research field of Augmented Cognition. It focuses on accelerating the production of novel concepts in human-system integration, addressing issues such as limitations in attention, memory, learning, comprehension, visualization abilities, and decision making, and leveraging technologies that assess the humans' cognitive status in real-time.

A second problem concerns automated responses to critical situations. Intelligent applications process the data that programs implemented by human experts are expected to use. Algorithms, even created by human experts, analyze the data and activate the optimal response, choosing it from among the range of possible responses previously identified by the same or other experts. At this time, intelligent applications cannot produce responses that go beyond the knowledge domain defined by human experts. Indeed, current research on machine learning is aimed at enabling computer programs to acquire knowledge and skills, and even improve their own performance. Big Data provides the raw material that allow machines to perform assigned tasks more efficiently. Nevertheless, situations can occur where a machine is not able to find the appropriate response. In such cases, human operators should intervene, but the more reliable the intelligent system, the less human operators have to do, and so the less attention they pay to the system while it is operating. In other words:

- Reliable systems tend to make it difficult for operators to notice when something is wrong; if an error is not noticed, it can eventually become the "new normal."
- The best way to avoid automation errors is rigorous Sampling and Testing. But this is expensive.

In this regard, it has been suggested to focus on keeping operators engaged, since they will be better prepared to notice when something is wrong.

However, the main issues with intelligent system lie in their expertise.

VI. HUMAN EXPERTISE

Intelligence is far easier to recognize than to define, and there is a profound difference between human and machine intelligent behavior.

Researchers in the AI scope are concentrated on programming machines to perform what is considered an intelligent behavior [18].

Accordingly, they focus on knowledge and expertise accumulation and application. In a machine, intelligent behavior depends on the knowledge of the context [19].

The basic assumptions about knowledge in the AI field are [20]:

- Knowledge is modular, it can be broken down into sub-parts and subsystems.
- All the important knowledge can be made explicit, verbalized, and then adequately represented as data structures and procedures.
- All the necessary knowledge exists in an expert's head.
- The problem space is closed, i.e., all the relevant knowledge for a set of tasks in a domain can be isolated and contained within a computer knowledge base.

From these assumptions, the dependence of an intelligent machine on the human approach to automation is clearly evident.

The unabated progress of Industry 4.0 increases the urgent necessity to pursue and conduct further research into an integrated and innovative approach to human-centered automation.

VII. THE HUMAN CENTERED APPROACH TO AUTOMATION

Human-centered automation is automation whose purpose is not necessarily to automate all manual functions, but rather to enhance user effectiveness and reduce errors.

In 1992, Sharidan identified 10 degrees of automation that should be considered in supervisory control. These degrees, that remain a landmark in current research on autonomous controlling, are shown in Table 1.

TABLE 1 SCALE OF DEGREES OF AUTOMATION
(SOURCE: SHERIDAN, 1992, P. 358)

1.	The computer offers no assistance, human must do it all.
2.	The computer offers a complete set of action alternatives, and
3.	narrows the selection down to a few, or
4.	suggests one, and
5.	executes that suggestion if the human approves, or
6.	allows the human a restricted time to veto before automatic execution, or
7.	executes automatically, then necessarily informs the human, or
8.	informs him after execution only if the asks, or
9.	informs him after execution if it, the computer, decides to.
10.	The computer decides everything and acts autonomously, ignoring the human.

It has been underlined that one test of whether a proposed piece of automation is human-centered is to pose the question: "Does it enhance user effectiveness?" [21]. Of course, if the answer is yes, the onus is on the designer to demonstrate how.

The analysis of issues particularly relevant in urban operations and chemical/biological incident responses suggests that the effects of technological change should be previously understood before introducing robot systems into an existing workplace [22].

In this regard, (Robin) Murphy's Law is often quoted, which states that: "any deployment of robotic systems will fall short of the target level of autonomy, creating or exacerbating a shortfall in mechanisms for coordination with human problem holders" [23].

Accordingly, the human-centered automation design should consider that intelligent human and machine agents must be combined appropriately.

One should not forget that machine agents are knowledge-based software objects with both strengths and weaknesses. They are expected to act in timely and consistent ways but have very fragile and domain-limited knowledge. They may be unable to behave reliably when an unpredicted or anomalous event occurs.

Human agents should be responsible for identifying and compensating for the limitations of the machine agents. In designing an automated system, a way should always be provided to allow the user to intervene and take control of the system. It is also essential that automation design supports the operator's awareness of both the current system state as well as the states of the machine agents so as to ensure that the two sets of agents are operating in complementary mode [21] .

Coordinating and integrating the interaction between humans and machines is not a speculative philosophical question. It encompasses technical problems that lie in the realm of human-robot coordination [24], [25], human-centered artificial intelligence [26], [27], and Digital Social Innovation [28].

A paradox has been recognized in designing human-centered automotive automation systems. It goes beyond the specific field of application:

"Trust in and understanding automation can be a vicious cycle. On the one hand, humans may not be able to fully understand an automation system until they can develop a certain level of trust in the system to reach their goal. On the other hand, the more humans understand the automation system, the more they can develop an appropriate trust system." [29]

Finally, according to Shneiderman, "an important research direction is to develop objective measures of the levels of control and autonomy, tied to diverse tasks. Such measures would stimulate more meaningful design discussions, which would lead to improved guidelines, evaluations, and theories" [23].

VIII. CONCLUSION

There is widespread concern amongst operators of complex systems that intelligent automation and Industry 4.0 may reduce the operator's ability to assume control of sophisticated systems in anomalous situations. Moreover, hyperconnected and intelligent systems are vulnerable to security risks [30].

Klaus Schwab, the German engineer and economist who is the founder and executive chairman of the World Economic Forum, claimed that:

"The fourth industrial revolution may be driving disruption, but the challenges it presents are of our own making. It is thus in our power to address them and enact the changes and polices needed to adapt (and flourish) in our emerging new environment." [31].

The authors' opinion is that in order to face the challenges of the fourth industrial revolution, it is necessary to capitalize the knowledge needed to understand and direct the ongoing transformations. To cope with these transformations, both technical knowledge and innovative skills are required. Integrated technical skills, digital literacy, critical thinking, and creativity are all essential to counter the narrative that sees technology serving a global conspiracy by cynical and unscrupulous multinationals.

Accordingly, teaching Industry 4.0 should reinforce the integration of student competence so as to face the challenges brought by the digital revolution. The experience obtained in introducing Industry 4.0 to the mechatronics study program of the Faculty of Engineering at the Rezekne Academy of Technologies has demonstrated the importance of creating a complete learning program that encompasses all the aspects that are connected to Industry 4.0 [32].

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Dominant Strategic Trade Policy

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Abstract - **In implementing trade policy measures, governments usually select from a range of instruments including quotas, subsidies (explicit or implicit) and tariffs. In this paper we consider the potential gain of a government pursuing a two-part trade policy: an import license for entry, along with a per-unit tariff on imports. The model is a three-step game between home and foreign countries in the Cournot duopoly. The paper demonstrates that two-part trade policy is dominant.**

Keywords - strategic trade policy, Nash equilibrium, tariffs, quotas, subsidies.

I. Introduction

Surveys have repeatedly shown strong support among economists for free trade policies who state that "The consensus among mainstream economists on the desirability of free trade remains almost universal". Despite this, trade barriers still exist and generally take the form of tariffs, quotas, non-tariff barriers and voluntary export restraints (VER's). In this paper, we consider the implementation of a two-part trade policy. The basic model is a two level game. At the first level each government implements its trade policy and at the second level, producers in both countries behave as Cournot competitors.

We use our model to demonstrate that a two part trade policy offers the authorities a superior outcome over a one part strategy and that a one part trade policy, consisting of a simple quota or simple tariff, is simply a special case of a two part policy. We show that the effectiveness of the two part trade strategy depends on the number of competing firms in the market, the degree of heterogeneity between cost functions, the degree of convexity of cost functions (and therefore which firms the policy will apply to) and the aims of the governments implementing the trade policy.

The classical problem in the theory of the policies of international trade concerns the effect of the tariffs and quotas or the effect of a variety of possible policies. In absolutely competitive models of trade, tariffs and quotas - are usually equivalent, that is the effect of the tariff can be duplicated by the accordingly chose model of quota. As it is stated by Bhagwati [1], it will not be true at imperfect competition. He has demonstrated, that the tariffs dominate above the quotas, when there is an imperfect competition in home market. It can be explained by the fact that the keen response of foreign firms at the quota is more exact, than at the tariff. Thus, the quota in comparison with the tariff raises monopolistic force of internal firms. Anderson [2] considered the duopoly model and showed, that under the certain conditions quotas tend to lower competition. Krishna [3] has shown in model of a Bertrand, that the quota constrains the ability of firms to compete effectively, when the goods are perfect substitutes. Accordingly, we could expect some interesting comparisons between the tariffs and quotas as strategic instrumental means of trade policy. The analysis of the quotas at oligopoly give additional penetrations.

Brander and Spencer [4] were the first to use an oligopoly model to explain export subsidies. They showed that when one home firm and one foreign firm produce a homogenous product and compete in a third market, an export subsidy is optimal in shifting monopoly rent from foreign to domestic firms. They demonstrate this finding in a Cournot model with constant returns to scale technology. Eaton and Grossman [5] extend paper [4] by replicating their analysis in a Bertrand model and show that a government in one of the first two countries has a unilateral incentive to impose export taxes (not subsidies) on its home firm. This tax allows the home firm to commit to a higher price (or act as a Stackelberg leader) and thus obtain higher profits for its country. Then, they confirm that when the governments of the first two countries can both credibly pre-commit to a policy, exporting governments optimally set taxes (not subsidies) in a subgame perfect Nash equilibrium under the Bertrand market structure. Eaton and Grossman [5] therefore broke

new ground by showing that the outcome of policy is sensitive to the nature of competition between firms.

The two-part trade policy provides for considering the import license for an entrance alongside with the tariff for the unit of import. Such policy was first introduced by Oi [6] in the classical analysis of a price dilemma of Disneyland. Philips [7] and Wilson [8] also considered the examples of nonlinear assigning of the prices. For the case of sole market with homogeneous functions of costs, Fuerst and Kim [9] have considered the two-part trade policy at complete, but imperfect information. In the market model of one country with homogeneous functions of costs they have found conditions, when the optimal two-part trade policy dominates above the simple tariff and simple quota. It is also fair both for a government, which is interested only in maximization of the income, and for benevolent government interested in internal welfare. The effect arises because the large payment for the import license imposes a smaller amount of distortions, than tariff. A government can reach the neutral income, reducing current tariffs and reimbursing the lost incomes by the payment for the license. With inhomogeneous functions of costs Fuerst and Kim [9] have considered numerical examples, which also have shown advantage of the two-part trade policy.

II. MATERIALS AND METHODS

In this paper we consider a two part trade policy in a model with reciprocal markets. In the model, there are two countries with N domestic firms and M foreign firms producing a homogenous product. Suppose q_i is the output of the i firm for the domestic market and q_i^* is the level of exports of the i firm to the foreign market. Similarly, suppose v_j that is the level of exports to the domestic market by a foreign firm, j and v_j^* is the output of firm j for the foreign market. The total sales in both the home market and the foreign market, Q and Q^* respectively, as in (1) and (2).

$$Q = \sum_{i=1}^{N} q_i + \sum_{j=1}^{M} v_j \qquad (1)$$

$$Q^* = \sum_{i=1}^{N} q_i^* + \sum_{j=1}^{M} v_j^* \qquad (2)$$

Demand is a function of price and firms face the usual inverse demand curves in both markets. Specifically, in the home market we have $P(Q)$ and in the foreign market we have $P^*(Q^*)$ where $p, p^* \in C^2$, $p' < 0, (p^*)' < 0$. It is also known $c_i(q_i)$ is the cost function of the i home firm and $c_j^*(q_j^*)$ is the cost function of the j foreign firm, where $c_i, c_j^* \in C^2$, and $c_i' > 0, c_i'' > 0, (c_j^*)' > 0, (c_j^*)'' > 0$. ($C^2$ - set of twice continuously differentiable functions).

We assume that firms aim to maximise profit and their output decisions are therefore guided by their profit functions, as in (3) and (4).

$$\pi_i = p(Q)q_i - c_i(q_i + q_i^*) + p^*(Q^*)q_i^* - t^*q_i^* - e^*, \ i = 1, \dots N \qquad (3)$$

$$\pi_j^* = p^*(Q^*)v_j^* - c_j^*(v_j + v_j^*) + p(Q)v_j - tv_j - e, \ j = 1, \dots M \qquad (4)$$

In (3) and (4) e and e^* are payments for the license to home and foreign governments respectively and t and t^* are the tariff per unit of sales imposed on home and foreign firms respectively.

We designate the two part trade policies of the home and foreign governments by the vectors, as in (5) and (6).

$$z = (e, \bar{v}, t) \qquad (5)$$

$$z^* = (e^*, \bar{q}, t^*) \qquad (6)$$

In (5) and (6) $\bar{q}, \bar{v}$ are the quotas on home and foreign. This description of trade policy incorporates the standard quota and tariff policy. For example, simple quota is (7). Similarly, a simple tariff is (8).

$$z = z_v \equiv (e, \bar{v}, 0) \qquad (7)$$

$$z = z_t \equiv (0, \infty, t) \qquad (8)$$

In the analysis of strategic trade policy, the third-market model is well known [4], [5]. In this model one or more firms from a domestic country and one or more firms from a foreign country compete only in the third market. Firms therefore produce only for export to the third market. This simplification is very useful in analysing the strategic effects of trade policy since neither government (domestic nor foreign) can implement direct trade policies (tariffs or quotas) which impact upon the behaviour of firms in the third market. The natural choice of policy instrument is therefore an export subsidy which gives the domestic firm a competitive advantage over its foreign rival. However, in this paper we show that a two-part trade policy, consisting of a negative tariff (subsidy) and a quota license, is optimal.

III. RESULTS AND DISCUSSION

We construct a two stage model; in keeping with much of the literature on strategic trade policy [4]. We analyse behaviour in a Cournot model. In the first stage of our model, the domestic government implements a two-part trade policy for domestic firms. At the second stage an interior and an exterior firm simultaneously choose an output level (or export) for the third market. In the second stage we use an inverse induction to find a perfect subgame Nash equilibrium. We then consider Nash equilibrium between governments in the first stage and we show that their respective trade policies impact on output levels of firms in the second stage. The payoff functions of firms i, j ($i = 1, \dots N, j = 1 \dots M$) are defined by relations, as in (9) and (10).

$$\pi_i = p(Q)q_i - c_i(q_i) - tq_i - e \qquad (9)$$

$$\pi_j^* = p(Q)v_j - c_j^*(v_j) - t^*v_j - e^* \qquad (10)$$

In (9) and (10) e and e^* are the payments for the license to home and foreign government respectively, t and t^* are the tariff per unit of production imposed on home and foreign firms respectively. We also impose a restriction on the model that cost functions are homogenous and are of the form $c_i(q) = c(q), \forall i;\ c_j^*(v) = c^*(v), \forall j$.

By stage 2, tariffs t and t^* have been predetermined in stage 1 and are therefore treated as exogenous. The first order conditions associated with maximization of (9) and (10), as in (11) and (12).

$$\frac{\partial \pi_i}{\partial q_i} = p'q_i + p - c' - t = 0 \qquad (11)$$

$$\frac{\partial \pi_j^*}{\partial v_j} = p'v_j + p - (c^*)' - t^* = 0 \qquad (12)$$

The second order conditions associated with maximization of (9) and (10), as in (13) and (14).

$$\frac{\partial^2 \pi_i}{\partial q_i^2} = p''q_i + p' + p' - c'' < 0 \qquad (13)$$

$$\frac{\partial^2 \pi_j^*}{\partial v_i^2} = p''v_i + p' + p' - (c^*)'' < 0 \qquad (14)$$

The first order condition (11), (12) makes it clear that a Cournot equilibrium is a Nash equilibrium in outputs since (11), (12) is implied by the Nash condition for the case in which each player's strategy set is simply the set of possible output quantities that might produce in a one-shot simultaneous-move game. The Cournot equilibrium therefore has the same 'no surprises' rationality property that any Nash equilibrium has. The first order condition (11), (12) could be solved in principle for the profit-maximizing choice of for any given set of output choices by the other firms. This resulting implicit function is the reaction function or best-response function. The common intersection of the best-response functions (one for each firm) is the Cournot equilibrium.

An additional regularity condition that turns out to be central to the characterization of the Cournot equilibrium, as in (15) and (16).

$$\frac{\partial^2 \pi_i}{\partial q_i \partial v_j} = p''q_i + p' < 0 \qquad (15)$$

$$\frac{\partial^2 \pi_j^*}{\partial v_j \partial q_i} = p''v_j + p' < 0 \qquad (16)$$

Condition (15), (16) is linked to many properties of the Cournot model. It is the so-called Hahn stability condition for certain proposed dynamic adjustment mechanisms and it implies that each firm's marginal revenue declines as the output of any other firm rises. (Note, however, that the pure Cournot model is a one-shot static game with no real-time dynamics. Any proposed dynamic adjustment is an extension to the model). Presuming that second order conditions are globally satisfied, global satisfaction of (15), (16) in this context is also the Gale-Nikaido condition for uniqueness of the Cournot equilibrium. Condition (15), (16) also ensures that the various comparative static properties of the model are 'well-behaved'.

Most importantly, condition (15), (16) implies that strategy variables q_i and v_j, are strategic substitutes. If $\frac{\partial^2 \pi_i}{\partial q_i \partial v_j} < 0, \forall i$, this implies that the marginal value, $\frac{\partial \pi_i}{\partial q_i}$ of increasing firm i strategy variable, decreases when the strategy variable of a rival increases.

The solution to the first order conditions will yield q_1 and v_1 as functions of tariffs t and t^*. The comparative static effects $\frac{\partial q_1}{\partial t}, \frac{\partial q_1}{\partial t^*}, \frac{\partial v_1}{\partial t}, \frac{\partial v_1}{\partial t^*}$ can be obtained by totally differentiating the first order conditions (11), (12) with respect to q_1, v_1, t and t^*, as in (17) and (18).

$$\begin{cases} \frac{\partial^2 \pi_1}{\partial q_1^2} \cdot \frac{\partial q_1}{\partial t} + \frac{\partial^2 \pi_1}{\partial q_1 \partial v_1} \cdot \frac{\partial v_1}{\partial t} = 1 \\ \frac{\partial^2 \pi_1^*}{\partial v_1 \partial q_1} \cdot \frac{\partial q_1}{\partial t} + \frac{\partial^2 \pi_1^*}{\partial v_1^2} \cdot \frac{\partial v_1}{\partial t} = 0 \end{cases} \qquad (17)$$

$$\begin{cases} \frac{\partial^2 \pi_1}{\partial q_1^2} \cdot \frac{\partial q_1}{\partial t^*} + \frac{\partial^2 \pi_1}{\partial q_1 \partial v_1} \cdot \frac{\partial v_1}{\partial t^*} = 0 \\ \frac{\partial^2 \pi_1^*}{\partial v_1 \partial q_1} \cdot \frac{\partial q_1}{\partial t^*} + \frac{\partial^2 \pi_1^*}{\partial v_1^2} \cdot \frac{\partial v_1}{\partial t^*} = 1 \end{cases} \qquad (18)$$

These equations can be solved using Cramer's rule, as in (19) - (22).

$$\frac{\partial q_1}{\partial t} = \frac{1}{D} \cdot \frac{\partial^2 \pi_1^*}{\partial v_1^2} \qquad (19)$$

$$\frac{\partial v_1}{\partial t} = -\frac{1}{D} \cdot \frac{\partial^2 \pi_1^*}{\partial v_1 \partial q_1} \qquad (20)$$

$$\frac{\partial q_1}{\partial t^*} = -\frac{1}{D} \cdot \frac{\partial^2 \pi_1}{\partial q_1 \partial v_1} \qquad (21)$$

$$\frac{\partial q_1}{\partial t} = \frac{1}{D} \cdot \frac{\partial^2 \pi_1}{\partial q_1^2} \qquad (22)$$

D is the determinant of the left-hand matrix in (17) and (18), as in (23).

$$D = \frac{\partial^2 \pi_1}{\partial q_1^2} \cdot \frac{\partial^2 \pi_1^*}{\partial v_1^2} - \frac{\partial^2 \pi_1}{\partial q_1 \partial v_1} \cdot \frac{\partial^2 \pi_1^*}{\partial v_1 \partial q_1} > 0 \qquad (23)$$

From (13) – (16) we get the conditions, as in (24).

$$\frac{\partial q_1}{\partial t} < 0, \frac{\partial q_1}{\partial t^*} > 0, \frac{\partial v_1}{\partial t} > 0, \frac{\partial v_1}{\partial t^*} < 0 \qquad (24)$$

Thus we have proved a Lemma.

Lemma 1. Suppose that:

1) the cost functions $c_1(q)$ and $c_1^*(q)$ are twice continuously differentiable and convex, for any $q \geq 0$;

2) the inverse demand curve $p(Q)$ is twice continuously differentiable and decrease, for any $Q \geq 0$;

3) the function $p(q + \widetilde{Q}) \cdot q$ is concave in q, for any $\widetilde{Q} \geq 0$. Then in the third-market model at two-part trade policy implies (23).

Corollary 1. $\frac{\partial v_1}{\partial t} = \alpha \frac{\partial q_1}{\partial t}$, where $\alpha \in (-1,0)$ and $\frac{\partial q_1}{\partial t^*} = \beta \frac{\partial v_1}{\partial t^*}$, where $\beta \in (-1,0)$.

Proof: Let $\tilde{q}_1(v_1)$ and $\tilde{v}_1(q_1)$ be the domestic firm's best response and the foreign firm's best response respectively.

Using conditions 1)-3) of Lemma 1 the first-order condition, as in (25).

$$\frac{\partial \widetilde{v_1}}{\partial q_1} = -\frac{p'' \cdot v_1 + p'}{2p' + p'' \cdot v_1 - (c_1^*)''} = \alpha \epsilon (-1,0) \qquad (25)$$

Next, we have conditions, as in (26).

$$\frac{\partial v_1}{\partial t} = \frac{\partial \widetilde{v_1}}{\partial q_1} \cdot \frac{\partial q_1}{\partial t} = \alpha \frac{\partial q_1}{\partial t} \qquad (26)$$

It is similarly proved that $\frac{\partial q_1}{\partial t^*} = \beta \cdot \frac{\partial q_1}{\partial t}$, where $\beta \in (-1,0)$. Proved.

As the basic model we shall consider the two stage game with complete, but imperfect information. In the first stage, players 1 and 2 (the home and foreign governments respectively) simultaneously choose their strategy and inform their respective home and foreign firms (players 3 and 4) which in the second stage simultaneously choose their strategy.

Let's designate $x_1 = (e, \bar{v}, t) \in X_1$ and $x_2 = (e^*, \bar{q}, t^*) \in X_2$ as the strategies of the first and the second players respectively, where $X_k = R_+ \times R_+ \times R$ is the set of strategy k of the player ($k=1,2$). Let $x_3 = q_1 \in X_3$ be the strategy of player 3 and $x_4 = v_1 \in X_4$ be the strategy of player 4, $X_i = R_+ \times R_+$ is the set of strategy i of the player ($i=1,2$). Let's designate $x \in X = X_1 \times X_2 \times X_3 \times X_4$.

Let's define the functions, as in (27) - (30).

$$f_1(x) \equiv p \cdot q_1(t, t^*) - c(q_1(t, t^*)) \qquad (27)$$

$$f_2(x) \equiv p \cdot v_1(t, t^*) - c^*(v_1(t, t^*)) \qquad (28)$$

$$f_3(x) \equiv \pi_1(x) \qquad (29)$$

$$f_4(x) \equiv \pi_1^*(x) \qquad (30)$$

Then it is possible to define the two-stage game for 4 players with complete, but imperfect, information, as in (31).

$$\Gamma = \langle I = \{1,2.3.4\}, \{X_i\}_{i \in I}, \{f_i(x)\}_{i \in I} \rangle \qquad (31)$$

The following existence theorem of Nash equilibrium in game Γ is fair.

Theorem 1. Suppose that:

1) the cost functions $c_1(q)$ and $c_1^*(q)$ are twice continuously differentiable and convex, for any $q \geq 0$;

2) the inverse demand curve $p(Q)$ is twice continuously differentiable and decrease, for any $Q \geq 0$;

3) the function $p(q + \widetilde{Q}) \cdot q$ is concave in q, for any $\widetilde{Q} \geq 0$;

4) $\exists \widetilde{Q}$, that $p(Q) = 0, \forall Q \geq \widetilde{Q}$,

then in game Γ there exists a perfect subgame Nash equilibrium.

Proof: I) Taking into account the imposing of quota by q_1 and v_1 we get that $q_1 \in [0, \bar{q}], v_1 \in [0, \bar{v}]$. Thus maximization π_1 by q_1 can be considered as a compact set $X_3 = [0, \bar{q}]$ and maximization π_1^* by v_1 by is a compact set $X_4 = [0, \bar{v}]$.

II) By conditions 1), 2) of Theorem 1. Functions $\pi_1(q_1, v_1)$ and $\pi_1^*(q_1, v_1)$ are continuous.

III) As according to the conditions 1) - 3) of Theorem 1. the theorems guarantee the conditions, as in (32) and (33).

$$\frac{\partial^2 \pi_1}{\partial q_1^2} = p'' q_i + 2p' - c'' < 0 \qquad (32)$$

$$\frac{\partial^2 \pi_1^*}{\partial v_1^2} = p'' v_i + 2p' - (c^*)'' < 0 \qquad (33)$$

The conditions (32), (33) guarantee concavity of the functions $\pi_1(q_1, v_1)$ and $\pi_1^*(q_1, v_1)$.

IV) Thus, from I), II), III) and the Nash theorem implies that there exists a Cournot equilibrium $\langle q_1^0(t, t^*), v_1^0(t, t^*) \rangle$ in the second stage of the game.

To see how this result is obtained, we first consider the first stage of the game between governments. We need to demonstrate that theorem 1 also guarantees the existence of a Nash equilibrium in the first stage of the game, and consequently the existence of the perfect subgame Nash equilibrium, which determines the optimum two-part trade policy.

V) To do this we first demonstrate that the problem of maximization $f_1(x)$ by t can be considered as a segment (compact set) $X_1 = [t_H, t_B]$ and the problem of maximization $f_2(x)$ by t^* can be considered as a segment (compact set) $X_2 = [t_H^*, t_B^*]$. This fact emerges immediately from the continuity and limitation of the functions $q_1(t, t^*)$ and $v_1(t, t^*)$.

VI) Since $p(Q) \in C^2$; $c(q) \in C^2$ and $c^*(v) \in C^2$, then the functions $f_1(t, t^*)$ and $f_2(t, t^*)$ are continuous.

VII) Further, we can prove concavity of the functions $f_1(t, t^*)$ and $f_2(t, t^*)$ by t and t^* .

We differentiate function $f_1(t, t^*)$ twice by t, as in (34).

$$\frac{\partial^2 f_1(t,t^*)}{\partial t^2} = (p''q_1 + 2p' - c'') \cdot \left(\frac{\partial q_1}{\partial t}\right)^2 + +2(p'' \cdot q_1 + p') \cdot \frac{\partial q_1}{\partial t} \cdot \frac{\partial v_1}{\partial t} + p'' \cdot q_1 \cdot \left(\frac{\partial v_1}{\partial t}\right)^2 \quad (34)$$

Using Lemma 1 and Corollary 1 and if $p'' < 0$, then the estimation is fair, as in (35).

$$\frac{\partial^2 f_1(t,t^*)}{\partial t^2} = (p''v_1 \cdot (\alpha + 1)^2 + 2p' \cdot (1 + \alpha) - -c'')\left(\frac{\partial q_1}{\partial t}\right)^2 < 0 \quad (35)$$

if $p'' \geq 0$ then the estimation is fair, as in (36).

$$\frac{\partial^2 f_1(t,t^*)}{\partial t^2} = (p''v_1 \cdot (\alpha + 1)^2 + 2p' \cdot (1 + \alpha) - -c'')\left(\frac{\partial q_1}{\partial t}\right)^2 \leq (p'' \cdot q + p') \cdot (1 + \alpha) + +p'(1 + \alpha) - c'' < 0 \quad (36)$$

The function $f_1(t, t^*)$ is therefore concave by t. Similarly we obtain a concavity for the function $f_2(t, t^*)$ by t^*.

VIII) So, from V), VI) and VII) and the Nash theorem implies that there is Nash equilibrium in the first stage of the game (t^0, t^{*0}). It also follows from IV) and VIII) that in the game Γ, there exists perfect subgame Nash equilibrium, as in (37).

$$X^0 = \langle (e^0, \bar{q}^0, t^0), (e^{*0}, \bar{v}^0, t^{*0}), q_1^0(t, t^*), v_1^0(t, t^*)\rangle,$$
$$e^{*0} = p(q_1^0(t^0, t^{*0}) + v_1^0(t, t^{*0})) \cdot q_1^0(t^0, t^{*0}) - c(q_1^0(t^0, t^{*0})) - t^0 \cdot q_1^0(t^0, t^{*0}),$$
$$e^0 = p(q_1^0(t^0, t^{*0}) + v_1^0(t, t^{*0})) \cdot v_1^0(t^0, t^{*0}) - c^*(v_1^0(t^0, t^{*0})) - t^0 \cdot v_1^0(t^0, t^{*0}),$$
$$\bar{v}^0 = v_1^0(t^0, t^{*0}), \bar{q}^0 = q_1^0(t^0, t^{*0}) \quad (37)$$
Proved.

From theorem 1 we derive a remarkable corollary.

Corollary 2. In the third-market model the optimum two-part tariff *t* which maximizes the government's revenue is negative, that is, a subsidy, and the optimum payment for the license is equal to the level of foreign profits.

We consider the third market model in Example 1 below.

Example 1. In this example we assume the existence of one market, two governments and two firms. We assume an inverse demand function of the form, as in (38).

$$p(Q) = 1 - Q \quad (38)$$

The cost functions of home and foreign firms are given, as in (39).

$$C(Q) = c \cdot q, C^*(q) = c^* \cdot q \quad (39)$$

To derive the optimum two-part trade policy we apply the method of inverse induction. Thus we consider the various combinations of applying or not applying the two-part trade policies by different governments.

The outcomes are given in TABLE I which shows that the optimum two-part trade policy is the subsidy at the positive payment for the license.

TABLE I.

		Home government	
		free trade	two-part trade
Foreign government	free trade	$G = 0; G^* = 0;$ $\pi = \frac{1}{9}(1 - 2c + c^*)^2;$ $\pi^* = \frac{1}{9}(1 - 2c^* + c)^2;$ $q = \frac{1}{3}(1 - 2c + c^*);$ $q^* = \frac{1}{3}(1 - 2c^* + c);$ $t = 0; t^* = 0;$ $e = 0; e^* = 0;$	$G = \frac{1}{8}(1 - 2c + c^*)^2;$ $G^* = 0;$ $\pi = 0;$ $\pi^* = \frac{1}{16}(1 - 3c^* + 2c)^2;$ $q = \frac{1}{2}(1 - 2c + c^*);$ $q^* = \frac{1}{4}(1 - 3c^* + 2c);$ $t = -\frac{1}{4}(1 - 2c + c^*);$ $t^* = 0;$ $e = \frac{1}{4}(1 - 2c + c^*)^2;$ $e^* = 0;$
	two-part trade	$G = 0;$ $G^* = \frac{1}{8}(1 - 2c^* + c)^2;$ $\pi = \frac{1}{16}(1 - 3c + 2c^*)^2;$ $\pi^* = 0;$ $q = \frac{1}{4}(1 - 3c + 2c^*);$ $q^* = \frac{1}{2}(1 - 2c^* + c);$ $t = 0;$ $t^* = -\frac{1}{4}(1 - 2c^* + c);$ $e = 0;$ $e^* = \frac{1}{4}(1 - 2c^* + c)^2;$	$G = \frac{2}{25}(1 - 3c^* + 2c)^2;$ $G^* = \frac{2}{25}(1 - 3c + 2c^*)^2;$ $\pi = 0; \pi^* = 0;$ $q = \frac{2}{5}(1 - 3c^* + 2c);$ $q^* = \frac{2}{5}(1 - 3c + 2c^*);$ $t = -\frac{1}{5}(1 - 3c^* + 2c);$ $t^* = -\frac{1}{5}(1 - 3c + 2c^*);$ $e = \frac{4}{25}(1 - 3c^* + 2c);$ $e^* = \frac{4}{25}(1 - 3c + 2c^*);$

It is also interesting to note that if the two-part trade policy is applied by only one government, the optimum rate of subsidy is increased because of the home firm's relative advantage. A subsidy also encourages the home firm to act more aggressively because of the competitive advantage given by the subsidy. As a result it captures more its foreign rival's market and output of the rival therefore contracts. The optimal domestic subsidy moves the domestic firm to Stackelberg leader output level, while the foreign firm produces the Stackelberg follower output. In effect, the government is able to convert its first-mover advantage into an equivalent advantage for the domestic firm.

If the two-part policy is applied by both governments, their optimum policy still will be the subsidy at the optimal licensing fee is equal to the operating profits of the foreign firm. However, where the government aims to maximize welfare ($G + \pi_1$ and $G^* + \pi_1^*$) a classic prisoner's dilemma situation emerges since both countries are in a worse position in a position as a result of implementing a strategic trade policy than if they both adopt free trade, yet each country has an incentive to deviate from the free trade option.

IV. Conclusions

In this paper we analyse the simultaneous use by government of quotas (and corresponding license fees) and tariffs. The use of quotas and tariffs as complements rather than substitutes enables us to identify a trade policy that dominates in terms of efficiency over other trade policy instruments. The qualitative outcomes of analysis depend on the type of government (whether it maximizes its revenue or public welfare), market structure and the cost structure of firms operating in the market.

We have shown that the two-part trade policy dominates the simple quota and simple tariff, and that the latter two are special cases of a two part trade policy.

We show that for the third-market model, the optimal two-part trade policy is a subsidy. For this case the analytical results (Lemma 1 and Theorem 1) are obtained. In this part of our paper we investigated the properties of cost functions and inverse demand functions which define the existence of optimal trade policy.

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Industry 4.0 – Challenge to Human Resources

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Abstract - **The report examines the key role of human resources in implementing the digital transformation of business processes in Bulgarian industrial enterprises. The survey was conducted in fifty-eight industrial enterprises in Bulgaria; the participants in the study were 232 HR managers and specialists. The main method of research is the questionnaire and the paper contains the results of the analysis of this questionnaire.**

Keywords - adaptability, competencies, digitalization, expertise.

I. Introduction

We are witnessing the new megatrend in the development of the industry after the globalization in the 80s, namely - its digitalization. The convergence of the real and virtual worlds is becoming more tangible and leads to Industry 4.0. The review of research and analysis to determine the main prerequisites for the rapid digitalization of the industry indicates technological changes in several interrelated areas - large databases, cloud technologies and platforms for sharing digital skills, mobile communications, social technologies and their applications [1], [2], [3], [4]. This, in turn, is a prerequisite for the key role of human resources in the implementation of processes related to the digital transformation of industrial enterprises.

The aim of the study is to determine whether the human resources (HR) in industrial enterprises meet the new requirements for the implementation of radical changes and what needs to be done regarding the skills, competencies, expertise and adaptability in the conditions of Industry 4.0.

To achieve this goal we make a literature review of the issues, describe the methodology of the study, indicate the results and on this basis formulate conclusions about the challenges facing human resources and their management in the conditions of Industry 4.0.

II. Literary Review

A. Basic views of Fourth Industrial Revolution

One of the most popular definitions of the nature of the fourth industrial revolution is that of Klaus Schwab, who characterized it as building on the foundations of the digital revolution and combining many technologies that led to unprecedented changes in the economy, society and the individual [5]. In The Fourth Industrial Revolution, Schwab describes the main features of the new technological revolution and outlines the opportunities and dilemmas it brings. The important contribution of the author is that he sees this revolution as our own creation and points out the ways in which we can steer it in a certain direction so that it can be used for the benefit of all. According to Klaus Schwab, the fourth industrial revolution is based on the merging of technologies, which blurs the boundaries between the physical, biological and digital spheres. Other authors, based on Schwab's concept, characterize the digital economy by emphasizing its benefits for Bulgaria and the European Union.

They also look at the obstacles that hinder the development of the digital economy, as well as the measures that have been taken to overcome them [6]. An in-depth study and analysis of the nature and distinctive features of Industry 4.0 was made in the book "The Fourth Industrial Revolution - Nature and Problems" (Damyanov, D., 2019). It examines the possibilities for bringing conventional technologies to Industry 4.0, as well as develops practical implementations of implementation models for Industry 4.0 [7]. In the Concept for digital transformation of the Bulgarian industry, the considered concept Industry 4.0 is defined as part of the application of new digital technologies in the manufacturing sector and includes a wide range of technological solutions and business models that contribute to qualitatively new forms of economic activity [8]. The term Industry 4.0 was first

defined by the German Federal Government as the main initiative for the adoption of a high-tech strategy for the development of German industry in 2011 (part of the High-Tech Strategy 2020 for Germany). years, the term appears in specific strategies (for example - the Trade and Investment Agency in Germany). The term "Industry 4.0" is used in the name of 8 of the 13 national policies in the EU for digitization of production processes (Fig.1).
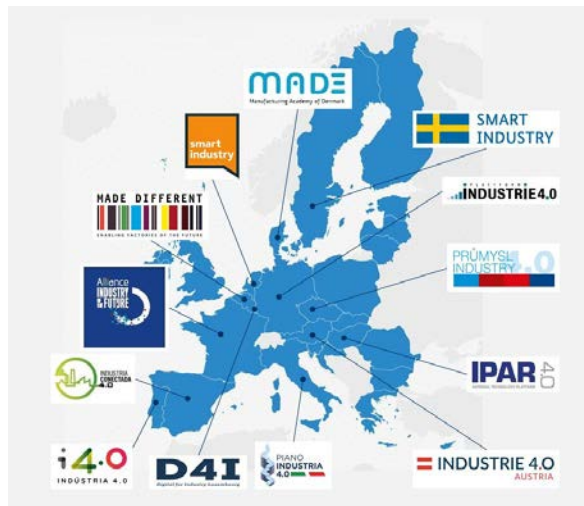
Fig. 1. Use of the term „Industry 4.0" in the national policies of EU countries

The article "Digital Transformation of Bulgarian Enterprises in the Conditions of Industry 4.0" is of high practical applicability, in which the authors give guidelines for creating an adequate digital infrastructure to support the transformation of Bulgarian industrial enterprises [9]. The aspect that is of interest for our research is related to the challenges to human resources in the conditions of Industry 4.0.

B. *Basic views of the challenges to human resources in the conditions of Industry 4.0.*

Industrial enterprises face opportunities forradical changes in business models and the overall organization of activities. The review of the specialized literature shows us a number of modern researches on the considered problems [10]. Most companies with a long history and experience are mobilizing to adapt to these changes: many seek to reach the next horizon of operational achievements through the direct use of emerging technologies, while others try to develop new business models (new production organizational models). factories, developing new virtual markets). Combined, these efforts will almost inevitably lead to a complete transformation of the entire organization in the industry [11]. Undoubtedly, all these changes are made by human resources. This implies anticipation and training of professionals with skills according to evolving technologies, which will have a direct impact on business and society, as well as on individuals [12]. In the article "Industry 4.0 - will machines displace people?" the key role of people in the process of digital transformation of enterprises is precisely and clearly substantiated. The main arguments are related to the fact that human resources will

create processes and innovations, they will implement and regulate them [13]. The article lists the 5 most important skills for Industry 4.0, summarized by Network World, as follows:

- Cybersecurity. Cyber security will be a major concern for companies. The reason is that many internet-based devices will be implemented in the production process, which will connect to existing machines. As the chain grows and connects to the World Wide Web, the risk of cyberattacks increases, including the extent of possible damage.

- Data specialists. Digital data is the lifeblood of Industry 4.0, which makes the people who work with it extremely valuable. The development of IoT will generate a huge amount of data that will need to be stored and analyzed. The aim is to be able to use them to improve the productivity of machines, reduce resource consumption, support quality control, improve the efficiency of supply chains and introduce new products and services.

- Networking. Here comes the skills of highly qualified network engineers to connect machines to each other and to management and control systems. They will have toassess the challenges posed by connecting systems and machines that have never been designed for networking. A significant factor in this process will be the cloud system.

- Software engineers, developers and programmers. The spectrum here is huge, as these jobs will be needed in different forms throughout the range of the industrial ecosystem. People will be needed to write and modify machine programs, as well as develop new interfaces. Companies will also need professionals who know how to encode high-level languages such as Java, but also older ones such as C and C ++. They will face the challenge of connecting existing systems and machines to new generations of platforms

- Architects. IT architects will play a role in assisting systems engineers in the process of unifying the physical and logical worlds. These people will have to understand in depth the dimensions of the existing business, its processes and goals in the direction of its digital transformation. And then they have to figure out how to tie it all together with technology. In short, these are the most important skills, competencies and expertise needed in the digital age to enable industrial enterprises to transform their business models and overall organization. The digitalization of Human Resource's activities has also been studied by the world-famous specialist in the field of HR theories and practice Prof. Dave Ulrich. He substantiates his claim that HR practices respond to changing external conditions (eg social, technological or political trends) and external stakeholders. Shifting the logic of HR to the outside requires HR professionals to truly understand the organization's business so that they can make the connection between their own work and the added value for stakeholders. The main conclusion he draws is that digitalization in HR work will not replace the human judgment and insight regarding the talent, leadership and organization needed to succeed in the marketplace [14]. The literature review on this issue allows us to find a

number of researchers on the role of Human Resource management (HRM) in the digital environment, the change of HRM activities to be sustainable companies in the digital age, the requirements for individual and organizational competencies in the new environment and cooperation mechanisms. "Human beings" and "smart things" [15].

III. MATERIALS AND METHODS

The survey was conducted in fifty-eight industrial enterprises in Bulgaria in the period June 2020 - January 2021. Twenty-nine of them are enterprises with foreign management (Germany, France, Austria, Sweden, Denmark, Italy, Belgium, etc.), and the rest are Bulgarian industrial enterprises. Industrial enterprises are large and medium-sized enterprises in the South Central region of the sectors: „Manufacture of food products", „Manufacture of clothing", „Manufacture of beverages", „Manufacture of tobacco products", „Manufacture of paper, paperboard and paper products" and cardboard", „Printing and reproduction of recorded media", „Manufacture of chemical products", „Manufacture o Industry 4.0 f machinery and equipment ", „Manufacture of electrical equipment ", „Repair and installation of machinery and equipment", „Manufacture of computer and communication equipment, electronic and optical products", „Leather processing; manufacture of footwear and other leather products". The surveyed enterprises employ 34,627 people. The participants in the study were 232 HR managers and specialists, with 4 HR specialists from each company participating. 142 are women and 93 – men. All of them are high educated ; 8 are with Ph,D. degree. Of these, 116 work in enterprises with foreign management. We conditionally designate these participants in the study with Group A. The other 116 respondents are HR managers and specialists in Bulgarian industrial enterprises. These are the participants from Group B. The study covers four stages: development of surveys; conducting the survey; processing of the results; determining the percentage of responses.

TABLE 1 RESULTS OF THE STUDY

№	Question	Group A	Group B
1.	How do you assess the digital competencies of your employees?		
	- high level;	12%	6%
	- average;	51%	25%
	- satisfactory;	21%	42%
	- low level.	16%	27%
2.	To what extent do you manage to recruit and select employees with the required digital competencies and expertise?		
	- to a high degree;	8%	5%
	- on average;	47%	32%
	- to a low degree;	39%	49%
	- we fail.	6%	14%
3.	Has a strategy been developed for digitalization of HR activities in the enterprise?		
	- Yes;	5%	2%
	- under construction;	48%	26%
	- no.	47%	72%
4.	What digital approaches and tools do HR professionals use to recruit and select HR?		
	- Social networks (Linkedin, Twitter, Facebook);	82%	65%
	- Applicant tracking systems;	25%	12%
	- Artificial Intelligence;	26%	15%
	- video interviews;	45%	26%
	- mobile selection tools.	68%	45%
5.	What digital approaches and tools do HR professionals use to train HR?		
	-interactive video training;	87%	74%
	-adaptive and personalized training;	42%	25%
	-microlearning (through short videos);	23%	10%
	-chat bot;	32%	16%
	- gamification.	53%	24%

The questionnaire contain 5 questions related to the needs for recruitment and selection of human resources with digital competencies and expertise; with the degree of success to select such specialists; with the development of a strategy for digitalization of HR activities and the use of digital tools in the processes of recruitment, selection and training of human resources (Table 1).

IV. RESULTS AND DISCUSSION

Conducting the third stage of the study - "Processing of results", allows us to make the following summaries: 1. In the enterprises with foreign management, 51% of the employees have an average level of digital competencies, while in the Bulgarian industrial enterprises, this percentage is significantly lower - 25%. 2. The selection of the employees with the required digital competencies and expertise is carried out successfully to a high degree by 47% of the surveyed enterprises from Group A, and in Group B - by 32% of the respondents. 3. The majority of

the surveyed enterprises from the first group - 53% have or are in the process of developing a strategy for digitalization of HR activities, while in the Bulgarian industrial enterprises, 72% do not have such a strategy. 4. Significantly more of the enterprises with foreign management, in comparison with the Bulgarian enterprises, use digital tools and approaches in recruitment and selection of HR - social networks (Linkedin, Twitter, Facebook); Applicant Tracking Systems (ATS); Artficial Intelligence (AI); video interviews mobile selection tools. 5. Significantly more of the enterprises with foreign management, in comparison with the Bulgarian enterprises use digital tools and approaches for training of HR - interactive video training; adaptive and personalized training; micro-learning (via short videos); chat bot; gamification. The results of the study were discussed with the representatives of the companies participating in the study by holding a remote round table. The main issues discussed, after acquainting the participants with the specific results, are related to the difficulties and problems in the digital transformation of HR activities.

V.CONCLUSIONS

Industry 4.0 poses a number of challenges to human resources - they need to have new competencies and expertise, as a result of which to adapt to the digital environment. In this regard, changes in human resource management are needed. The results of the study show that at this stage, Bulgarian industrial enterprises still, for the most part, do not have a strategy for digitalization of HR and a small percentage of them use the necessary digital approaches and tools for recruitment and selection, training and development of human resources. . In this regard, we can systematize the main guidelines for changing HR activities to respond to the changing external environment as follows:increasing the digital competencies and expertise of HR specialists;

- creating an atmosphere for improving the attitudes of employees towards digitalization of HR activities in industrial enterprises;

- use of the necessary digital approaches and tools in the implementation of recruitment and selection, training and development and motivation of HR.

In the report we tried to point out the new challenges that Industry 4.0 poses to human resources, as well as on the basis of our own research to reveal the current state of competencies and expertise of human resources. The problems that stand out as a result of the analysis of the information from the research are the basis for the formulation of guidelines for overcoming them. Through the effective management of human resources will be able to recruit and select, as well as prepare in companies the

right employees - with the necessary digital competencies and expertise, which will lead to successful digital transformation of business models and the overall organization of industrial enterprises.

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Algorithmic Procedures for Constructing Ontological Representations of Production Technologies

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Abstract - **This paper focuses on formalized description of technologies as a category of procedural knowledge. It describes the model of ontological representation of technologies. The authors present the algorithms of staged combined design of unified decomposition constructions that enable to form decomposition structures of technologies. The article introduces the extended algorithm to construct ontological representation of technologies.**

Keywords - algorithm, ontology, technology, unified decomposition construction.

I. INTRODUCTION

Modern researchers are increasingly focusing on the study of issues connected with improving approaches to knowledge representation in the field of systems analysis and design. Modern information space is being enriched rapidly with procedural knowledge that people gain in the process of life exploring new procedures, methods, ways of actions, getting new knowledge and exchanging it with other people in the process of cooperative activities and communication. Technological knowledge is mostly procedural as its intended purpose is substantive and practical work of every person aimed at transforming the surrounding reality [1].

In this respect, it is quite natural that the interest of some researchers in the construction of the ontology of processes has significantly increased over the past decades. However, some of them argue the fact that real methods of developing the ontology of processes exist [2]. Main areas of scientists' activities are given in works [3] – [17], which represent the most notable results in the field of ontological engineering of processes. It seems preferable to use multilevel ontological systems, computer-aided design systems and ontological systems with active semantics solving the problems connected with arrangement of formalized presentation of technological knowledge. At the same time, the cumulative disadvantage of these systems is that formal mechanisms of the technologies' description at the applied level are poorly elaborated. The problem is the absence of actions' consideration as holistic formations, the sets of participants in which could determine the relations between the corresponding concepts. Also, the problem is accompanied with the replacement of the axiomatics of ontological models with modern graphical tools for arranging and presenting knowledge.

This article focuses on algorithmic procedures that lay the foundation for the implementation of the software OntoTechnology [18], that is meant to be used for formalized description of technologies. These algorithms implement the logical procedures for automated and automatic construction of ontological representations of technologies [19]. Among them are the technologies of clothing production [20], a significant part of construction technologies [21] and mechanical engineering technologies [22].

II. MATERIALS AND METHODS

The author in work [23] represents by a tuple *the model of ontological representations of technologies* according to which the ordered set of unified decomposition constructions (UDC) forms decomposition structure of technology (DST):

$$Ont_{Tech} = <TD, P, F>, \quad (1)$$

where $TD = \bigcup_u TD_u$ - a set of concepts of technological actions; P - intra-level relation of immediate precedence that is used to describe the relations between fully formed private concepts of one level of decomposition UDC; F – inter-level relation of "part-whole" that is used to describe the relations between every fully formed private concepts and the already fully formed holistic concept UDC.

The model of the concept of technological action that is the basic representation of every technological action located in the nodes of DST, is represented by a tuple [24]:

$$TD_u = <TP_u, Y_u, X_u \mid W_u, H_u, Z_u>, \quad (2)$$

where TD_u – a concept of technological action, – a kernel of the concept, Y_u – a set of resulting components, X_u – a set of source components, W_u – a set of invariant components, H_u – a set of cost characteristics, Z_u – a set of own characteristics.

The process of constructing a formalized description of technologies is to implement the theoretical propositions formulated and proved in work [23]. They make DST formation possible by means of staged combined design of UDC starting with the root representations of technologies.

The implementation of main stages of UDC construction goes in accordance with the execution of the following algorithmic procedures (dotted line in "Fig. 1"):

1. The algorithm for the automated construction of decomposition of a preliminary formed concept (stage of downward design);

2. The algorithm for the automatic determination of relations between fully formed private concepts (stage of intra-level design);

3. The algorithm for the automatic determination of the complete formation of a holistic concept (stage of upward design).
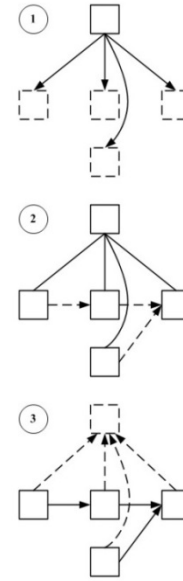
Fig. 1. Staged algorithmic procedures for constructing UDC

Further, the process of construction UDC will be described using the example of UDC at the apex with the concept λ DST level. Main patterns of this process' implementation are given in works [25] – [27].

III. RESULTS AND DISCUSSION

The algorithm for the automated construction of decomposition of a preliminary formed concept

The algorithm is given in "Fig. 2". Block 2 performs the initial initialization of each set determining the structure of the concept $TD_{\alpha_i, \beta_j, ..., \eta_l, \lambda_m}$ by empty sets. Then the elements of the kernel $TP_{\alpha_i, \beta_j, ..., \eta_l, \lambda_m}$ and set $Y_{\alpha_i, \beta_j, ..., \eta_l, \lambda_m}$ of the concept $TD_{\alpha_i, \beta_j, ..., \eta_l, \lambda_m}$ are manually entered. After that, the verification of the fact of their cumulative non-emptiness is implemented. If this condition is true, then a message is displayed stating that "Concept $TD'_{\alpha_i, \beta_j, ..., \eta_l, \lambda_m}$ is preliminary formed". Otherwise, a message is displayed stating that "Concept $TD_{\alpha_i, \beta_j, ..., \eta_l, \lambda_m}$ is not preliminary formed" and then we come back to manual entry stage.
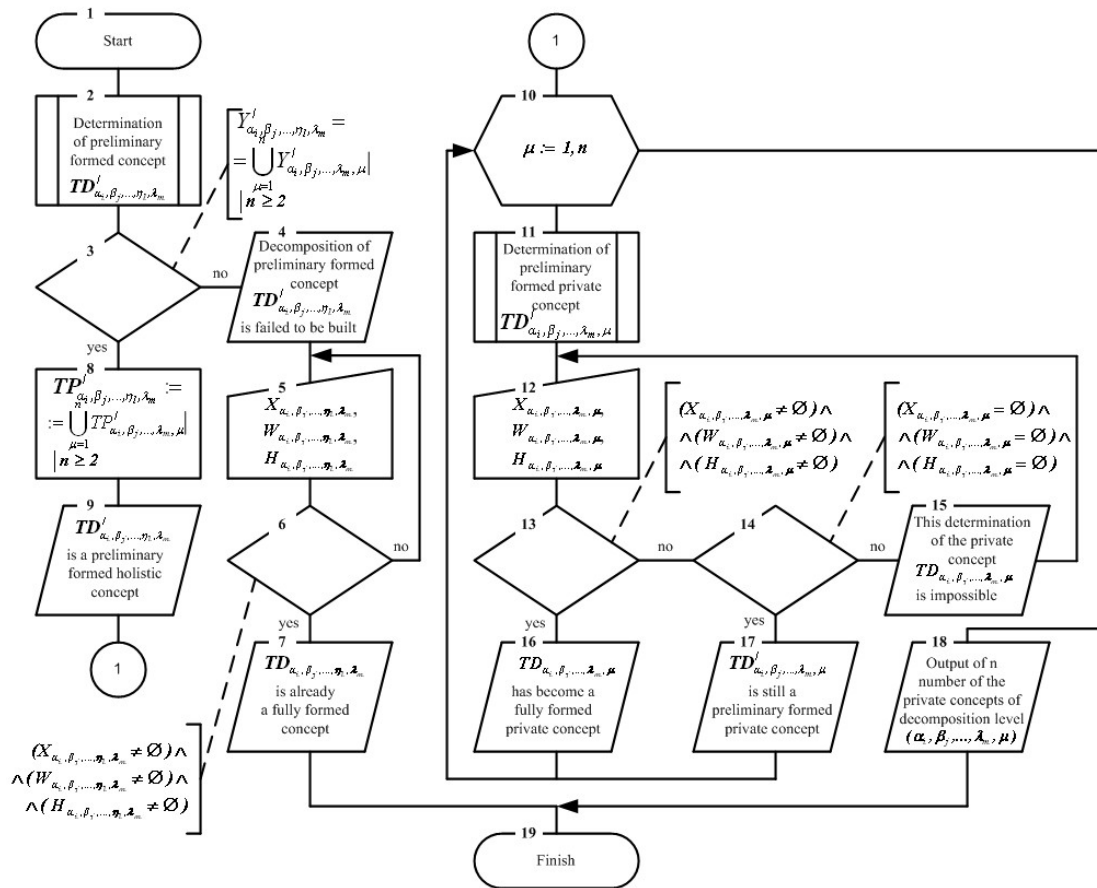
Fig. 2. Block-diagram of the algorithm for the automated construction of decomposition of a preliminary formed concept

Block 3 performs the verification of the determination of set $Y^{/}_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of preliminary formed concept $TD^{/}_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ as a collection of sets $\bigcup_{\mu=1}^{n} Y^{/}_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ if $n \geq 2$. If this condition is not true, then a message is displayed stating that "Decomposition of preliminary formed concept $TD^{/}_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is failed to be built" (block 4). After that, the elements of the sets $X_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$, $W_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ and $H_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ are offered to be entered manually in block 5. Then the verification of the fact of their cumulative non-emptiness is implemented in block 6. If this condition is true, then a message is displayed stating that "Concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is already fully formed" (block 7) and there is a transition directly to block 19 at the end of the algorithm. Otherwise, we come back to block 5. If the condition from block 3 is true, then in block 8 the kernel $TP^{/}_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is determined as a collection of sets of kernels $\bigcup_{\mu=1}^{n} TP^{/}_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ if $n \geq 2$ (axiomatic property 3) [23]. After that, block 9 displays a message stating that "Concept $TD^{/}_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is a preliminary formed holistic concept".

Block 10 illustrates how to loop through each of the concepts $\bigcup_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$. Block 11 performs the initial initialization of each set determining the structure of the concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ by empty sets. Then the elements of the kernel $TP_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ and set $Y_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ of the concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ are manually entered. After that, the verification of the fact of their cumulative non-emptiness is implemented. If this condition is true, then a message is displayed stating that "Concept $TD^{/}_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is a preliminary formed private concept". Otherwise, a message is displayed stating that "Concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is not a preliminary formed private concept" and then we come back to manual entry stage. After that, the elements of the sets $X_{\alpha_i,\beta_j,...,\lambda_m,\mu}$, $W_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ and

$H_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ of concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ are offered to be entered manually in block 12. Then the verification of the fact of their cumulative non-emptiness is implemented in block 13. If this condition is true, then a message is displayed stating that "Concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ has become a fully formed private concept" (block 16) and there is a transition directly to block 10 to the next concept. Otherwise, the verification of the fact of cumulative emptiness of sets $X_{\alpha_i,\beta_j,...,\lambda_m,\mu}$, $W_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ and $H_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ of concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is implemented in block 14. If this condition is true, then a message is displayed stating that "Concept $TD'_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is still a preliminary formed private concept" (block 17) and there is a transition directly to block 10 to the next concept. Otherwise, a message is displayed stating that "This determination of the private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is impossible" (block 15) and there is a transition directly to block 12. After looping through each of the private concepts $\bigcup_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$, their number is displayed n (block 18). Then there is a transition directly to block 19 at the end of the algorithm.

The algorithm for the automatic determination of relations between fully formed private concepts

This algorithm is given in "Fig. 3". Block 2 illustrates how to loop through each of the private concepts $\bigcup_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$.

Block 3 performs verification of the fact either certain private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is fully formed. If this condition is true, a message is displayed stating that "Concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is a fully formed private concept" (block 6). Otherwise, a message is displayed stating that "Concept $TD'_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is a preliminary formed private concept" (block 4). After that, a message is displayed stating that "It is impossible to establish a relation P for preliminary formed private concept $TD'_{\alpha_i,\beta_j,...,\lambda_m,\mu}$" (block 5) and there is a transition back to block 2 to the next concept.

Block 7 checks the existence of this fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$ for certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fulfill the condition that $Y_{\alpha_i,\beta_j,...,\lambda_m,\mu} = X_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$. If this condition is true, a message is displayed stating that "There is only one such fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$, which has a relation P with fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$".

Also, there is a graphical drawing of the relation P from fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$ (block 8), and there is a transition back to block 2 to the next concept. Otherwise, block 9 checks the existence of this fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$ for certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fulfill the condition that $Y_{\alpha_i,\beta_j,...,\lambda_m,\mu} \subset X_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$. If this condition is false, a message is displayed stating that "This fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$, there is a relation between P and certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ does not exist" (block 10), and there is a transition back to block 2 to the next concept. Otherwise, block 11 checks the existence of the set of these fully formed private concepts $\bigcup_{k=1}^{n'} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_{v_k}}$ for certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fulfill the condition that

$$\bigcup_{k=1}^{n'} Y_{\alpha_i,\beta_j,...,\lambda_m,\mu_{v_k}} \subseteq (X_{\alpha_i,\beta_j,...,\lambda_m,\mu_s} \setminus X^*_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}).$$ If this condition is true, there is a graphical drawing of the relation P from fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_s}$ (block 12), and there is a transition back to block 2 to the next concept. Otherwise, and there is a transition back to block 8, and then back to block 2 to the next concept. After looping through each of the private concepts $\bigcup_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ (block 2) there is a transition back to block 13 at the end of the algorithm.
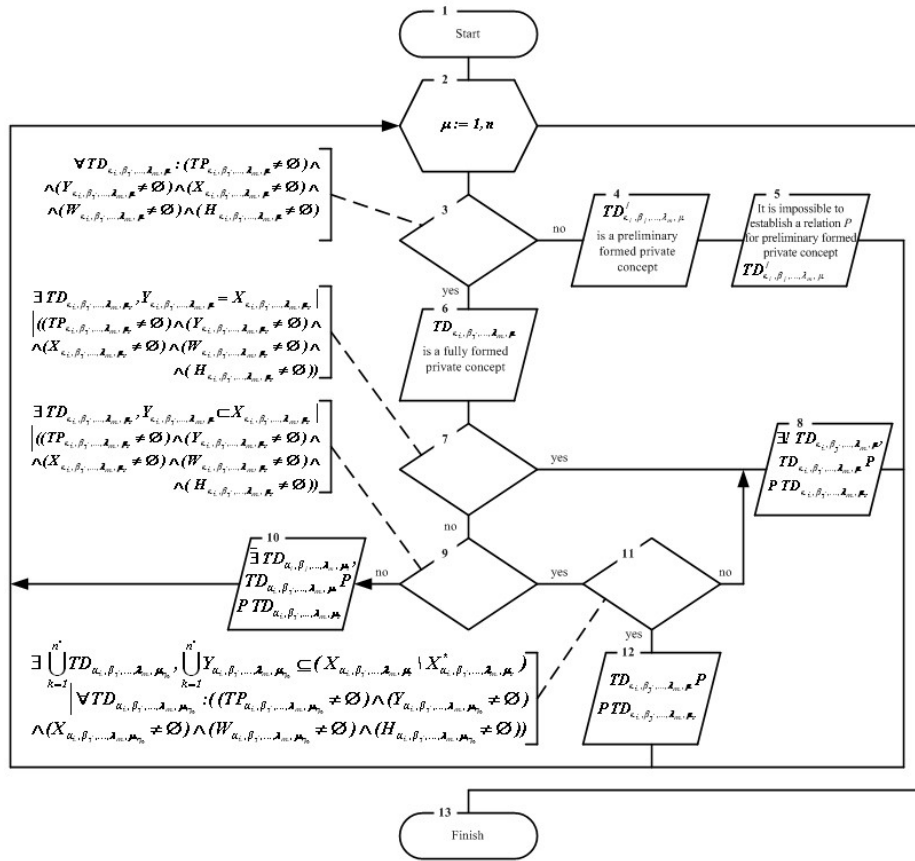
Fig. 3. Block-diagram of the algorithm for the automatic determination of relations between fully formed private concepts

The algorithm for the automatic determination of the complete formation of a holistic concept

This algorithm is given in "Fig. 4". Block 2 illustrates how to loop through each of the private concepts $\bigcup\limits_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$. Block 3 checks the existence of this fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_q}$ for certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fulfill the condition that $Y_{\alpha_i,\beta_j,...,\lambda_m,\mu_q} = X_{\alpha_i,\beta_j,...,\lambda_m,\mu}$. If this condition is true, set $X_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of a holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is the same (block 4) and there is a transition to block 8. If the condition from block 3 is not fulfilled, block 5 checks the existence of this fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu_q}$ for certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to fulfill the condition that $Y_{\alpha_i,\beta_j,...,\lambda_m,\mu_q} \subset X_{\alpha_i,\beta_j,...,\lambda_m,\mu}$. If this condition is true, the set $X_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of the holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is replenished with a complement $\backslash X^*_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ of a set $X_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ of a fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ (block 6) and there is a transition to block 8. If the condition from block 5 is not true, the set $X_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of the holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is replenished with a set $X_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ of a certain fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ (block 7) and there is a transition to block 8.

In blocks 8-9 there is a determination of sets $W_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ and $H_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of the holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ (in accordance with axiomatic properties 7 и 8) [23]. After that, there is a transition back to block 2 to the next concept. After looping through all fully formed private concepts $\bigcup\limits_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ (block 2), the message is displayed stating that "A fully formed holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ is obtained" (block 10). Looping through all fully formed private concepts $\bigcup\limits_{\mu=1}^{n} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ is organized again (block 11) with the aim of graphical drawing of the relation F from

each fully formed private concept $TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$ to the already fully formed holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ (block 12). When the process is finished, there is a transition to block 13 at the end of the algorithm.

It is significant to note that the information about every sets' objects of the source components of fully formed private concepts $\bigcup_{\mu} TD_{\alpha_i,\beta_j,...,\lambda_m,\mu}$, taking part in formation of set $X_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ of fully formed holistic concept $TD_{\alpha_i,\beta_j,...,\eta_l,\lambda_m}$ can be kept in specialized domain ontologies grouped by raw materials. Model of each ontology of this kind Ont_{Obj}, can be determined as the following tuple [28]:

$$Ont_{Obj} =< D_{Obj}, E_{Obj}, G_{Obj} >, \quad (3)$$

where D_{Obj} – set of objects' concepts; E_{Obj} – set of properties of objects' concepts; G_{Obj} – "genus-species" relation with multiple inheritance.

Thus, the systematization of the concepts of the sets' objects of the source components of fully formed concepts TD by means of automated methods constructing of domain ontologies allows to make the "repair" of DST in terms of adjusting the subject orientation of fully formed concepts TD [29].
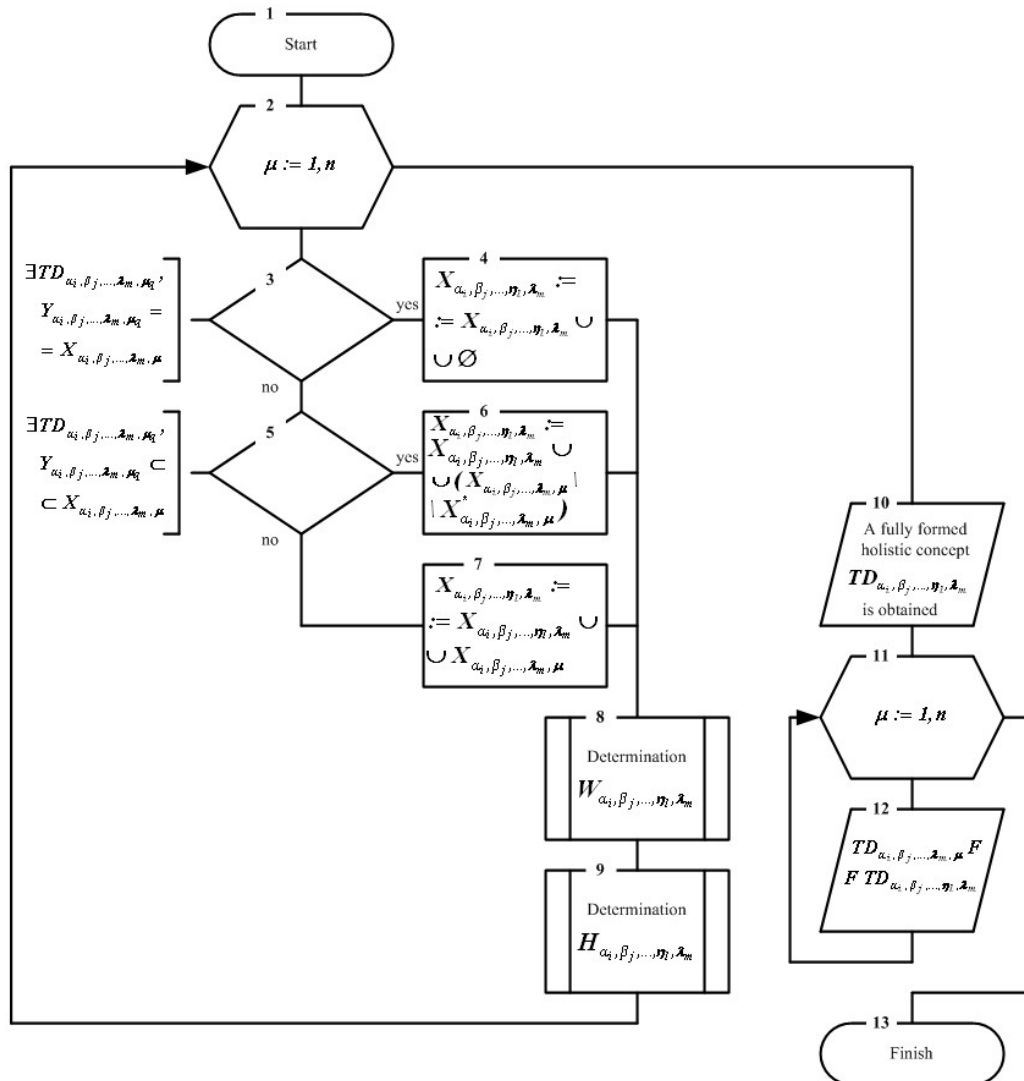
Fig. 4. Block-diagram of the algorithm for the automatic determination of the complete formation of a holistic concept

Extended algorithm for the construction of the formalized description of technologies

This algorithm is given in "Fig. 5". Block 2 performs the initial initialization of some positions in index sequence of root concept DST. Blocks 3-4 give the illustration of stages of downward and intra-level design of UDC. Then, the values of index sequences of preliminary formed concepts of this decomposition level are identified (block 5). Block 6 checks either all concepts of this decomposition level are fully formed. If

this condition is not true, there is a fixation of a preliminary formed private concept with the already incremented number of positions in index sequence (block 7) with the transition back to block 3. In case the condition of block 6 is true, stage of upward design of UDC is implemented (block 8). After that, there is a fixation in block 9 of a fully formed holistic concept with the already decremented number of positions in

index sequence. Block 10 verifies either the root concept of UDC is reached. If this condition is not true, there is a transition to block 4. This way, if the condition of block 10 is true, a message is displayed stating that "The formalized description of the technology is BUILT!" (block 11) and there is a transition to block 12 at the end of the algorithm.

Fig. 5. The extended algorithm for the construction of the formalized description of technologies

IV. CONCLUSION

This article describes original algorithms of construction of formalized description of technologies that are different from existing ones as they constructing ontological hierarchies of concepts based on predetermined decomposition features, automatic establishment of relations between concepts of the same decomposition level and automatic receiving full information about concepts located in root nodes of DST based on the implemented principle of level-by-level knowledge aggregation.

The consideration of the models' peculiarities and algorithms that are constructed lets us conclude that the method of formalized description of technologies is developed. This method is different from existing ones as it gives a possibility to form DST based on staged combined design of UDC with the aim of structuring the representation of knowledge about technologies with varying degrees of details [23].

The developed models and algorithms of formalized description of technologies and the software OntoTechnology [30] that has proved its efficiency can serve as a basis for creating tools for computer operation of technological knowledge in order to improve the

efficiency of solving a wide range of practical problems: constructing specialized stores for describing technologies, selecting the most suitable technologies, analyzing expert studies of technologies, developing educational and methodological and training complexes, and also can become the basis for supporting the processes of technology synthesis.

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Comparison of Object-Oriented Programming and Data-Oriented Design for Implementing Trading Strategies Backtester

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Abstract - **This research proposes a way to accelerate backtesting of trading strategies using data-oriented design (DOD). The research discusses the differences between DOD and object-oriented approach (OOP), which is the most popular at the current moment. Then, the paper proposes efficient way to parallelize a backtesting using DOD. Finally, this research provides a performance comparison between DOD and OOP backtester implementations on the example of typical technical indicators. The comparison shows that use of DOD can speed up the process of quantitative features calculation up to 33% and allows for parallelization scheme that better utilizes resources in multiprocessor systems.**

Keywords - algorithmic trading, data-oriented design (DOD), high performance computing (HPC), parallel computing

I. INTRODUCTION

Term backtest refers to testing of a trading strategy on historical data in order to assess its effectiveness or optimize parameters [1]. In essence, backtest is a simulation, in which the algorithm being tested is placed in conditions as close as possible to the real exchange trading that took place in the past. Even though the results of such test are hypothetical and in no case can be unambiguously considered a reliable indicator of the strategy success on the real market, they allow, at least, drawing conclusions about its adequacy and obtaining an estimation of many of its properties, such as the ratio of purchases to sales, the number of transactions per unit of time, etc. Although various studies indicate a high probability of overfitting when a strategy's model is constructed and optimized based on the results of a backtest [2], the testing of trading algorithms on historical data is still the main tool for trading strategy development and can often be seen both in practice and in academic research.

Regardless of the goals and methods of using the backtest results, the procedure itself requires a lot of computational power. Due to the development of trading platforms and the growing popularity of algorithmic trading, the amount of data that needs to be analysed and processed is constantly growing [3]. Modern trading robots are capable of performing hundreds of transactions per second. To remain competitive a trading system must be able to respond to even the smallest events. Many exchanges, in turn, provide an opportunity to receive sufficiently detailed data in the form of real-time anonymous order flow. Just for single trading instrument the number of orders, passing through the trading system per day, can run into millions. For reliable strategy testing all this amount of data must also flow through the backtesting system. Of course, one strategy can work with a large number of instruments at once, and the tested period can be as long as several years, which only increases the number of calculations.

This work is devoted to the computational side of backtesting. To increase the speed of computations it is proposed to use data-oriented design (DOD) [4]. Currently,

DOD is mainly used in the video game development and serves as a tool for optimizing resource-intensive computational tasks; it also offers techniques for parallelizing data processing efficiently. The goal of the research is to compare DOD with the most popular at the moment OOP approach and evaluate performance of backtesting software developed using both approaches.

II. MATERIALS AND METHODS

To understand the context of the study, it will be useful to define some abstract architecture that any software for testing trading strategies on historical data will sufficiently implement. First of all, let's consider the input data. Most of modern markets are double auction markets, meaning that buyers and sellers simultaneously offer their prices by submitting bids to the exchange's trading system. Those bids form an order book (table of quotes), which reflects the current supply and demand at various prices and is available for all bidders. If the system receives an order, which satisfies certain conditions (usually, the condition is that the order price is not worse than the price of one or several opposite orders), an execution (deal or trade) occurs at the best price for both parties. Thus, the main sources of the data, from which a strategy generates a trading signal, are order book and a table (list) of deals. As mentioned above, the most detailed type of data is the flow of all orders, entering the exchange. However, this format is not available on certain trading platforms. Instead, an exchange might broadcast two separate data streams: a simplified representation of the order book, consisting of price levels (price and quantity pairs), and trade executions with varying degrees of detail (for example, some platforms broadcast passive participants of transactions only or vice versa).

Usually, data is transmitted in incremental manner - instead of entire current state, each data packet contains only a change of a state since previous packet (or information about particular event in exchange's trading system). Typically, these features are reflected both in the market data storage system (information is stored as incremental updates) and in the architecture of the backtest software, which is implemented as an event-driven system. Market trading, as a rule, isn't going on continuously. Instead, the trading day is separated into several sessions with short breaks between them. Similarly, backtesting is often applied to one or more sessions. One day is often chosen as the minimum time unit for backtesting.

Thus, the primary function of the backtester is to read the raw data of a trading session from some source (file, database, TCP connection, etc.) and restore the order book and deals table - i.e., restore a structured data.

The next function of the backtester is strategies calculation. In this paper it is understood as the computation of a set of simple predicates that compare certain computable features, with some threshold values. The fixed thresholds, as well as the weights and coefficients needed to extract the features, are called strategy parameters. From this point of view, a strategy is, in fact, a decision tree, the output of which is a trading signal that tells to buy or sell certain volume of a given trading instrument.

The next function of the backtester is to extract some quantitative features from structured market data. By analogy with indicators in technical analysis, in this study, a module that calculates a certain feature, is called an indicator. Thus, an indicator is a module that makes any calculations based on market data of a specific financial instrument. The main structural function of such modules is to minimize the computation graph by reusing already calculated features. As a rule, the indicator algorithm depends not only on the market data, but also on additional parameters, i.e., it implements the calculation of a whole class of features instead of just one. Despite the apparent simplicity, it is the effectiveness of the organization of indicators that determines the performance of the entire system. Since different strategies within a single backtest session can use the same indicators, the backtester must provide a mechanism for reusing the results of calculations. This is important, because in the problem of parameter optimization, in the vast majority of cases, heuristic search techniques are used, such as a particle swarm [5, 6], genetic algorithms [7, 8], and machine learning methods [9] - [12]. The use of such techniques implies computation of a large number of combinations of parameters, many of which would partially repeat each other, which would inevitably lead to repetitive calculations.

The last and the main function of the backtester is the simulation of executions, and the calculation of various trading metrics, starting with simple numerical characteristics of the strategy, such as the number of orders sent, the maximum position size (the number of units of a trading instrument in the portfolio) or the ratio of purchases to sales, and ending with financial metrics for assessing efficiency of investment portfolio (e.g., Sharpe ratio).

In addition, the backtester must provide an adequate simulation of the conditions in which the algorithm being tested is supposed to operate. Thus, it is necessary to control the number of transactions and comply with the restrictions on lot sizes or the minimum price step set on the specific trading platform. The number of different rules that must be checked during simulation can vary greatly depending on the exchange, regulatory rules, or the needs of a trader.

So, to summarize: strategy testing software performs the following operations:

a)   Reading data from a certain source and restoring structured data necessary for calculating trading signals;

b)   Extracting quantitative features from structured data;

c)   Generation of trading signals;

d)   Simulation of executions and computation of effectiveness metrics of the trading algorithms.

This study is mainly devoted to extraction of features and generation of trading signals. Since simulation of executions may greatly vary depending on many factors,

the process of trading simulation is not considered in this paper.

The classic implementation of the backtester performs all the processing steps sequentially for each individual event. In the most common OOP paradigm different types of indicators are represented by classes. Each instance of such class encapsulates the thresholds, coefficients and intermediate values required for calculations. Strategies are implemented in a similar way. Together the instances of these classes represent the computing core of the trading system, for which an example of a UML class diagram is shown in "Fig. 1". The indicator instances implement the calculate method in which, based on the incoming data packet and the internal state, some features are computed. Instances of strategies, in turn, generate trading signals, based on values calculated by indicators. Later the signals can go through several more stages of processing, but this is not essential in this study.
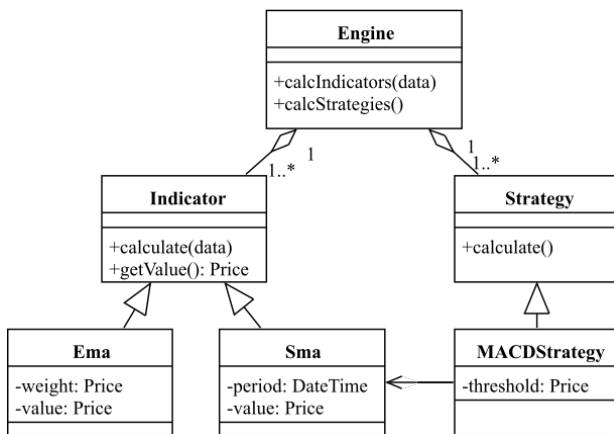
Fig. 1.   UML class diagram of backtester's core.

It can be seen from the diagram that the main cycle of the system looks as follows: iterate over all indicator instances and call their calculate method, and then repeat the same for all strategy instances. Data-Oriented Design offers an alternative approach to computing. One of the main principles of DOD is: "structure of arrays versus array of structures" (SoA versus AoS). Its essence lies in the reorganization of data in such a way that instead of sequential placement of records corresponding to a certain entity, individual components inherent in this entity are sequentially located in memory. For example, if the task is to process an array of N pixels in RGB format, the traditional representation as a vector of N tuples of the form (R, G, B) is replaced with a 3xN matrix, where each row corresponds to a colour component, and the column represents the entire pixel. This layout can significantly improve performance due to greater data locality. Of course, the speed gain depends on the pattern of accessing the fields of such records. The greatest increase of performance is achieved when the computations is done on the individual rows of the matrix. It should be noted that hereinafter it is assumed that matrices are implemented as a set of separate one-dimensional arrays that makes it easy to add or remove rows.

In the backtester, the principle of "structure of arrays versus array of structures" finds several uses. The first relates to the backtester's computational core. In this paper, the following organization of computing units is proposed. To calculate K indicators of the same type, which require C coefficients for calculations, a matrix of parameters IP: CxK is allocated, where a row represents separate indicator coefficient. The module that performs calculations receives IP and market data as an input. The calculation results are placed in the output matrix I: LxT, where L is the number of output values of the indicator, T is the total number of all indicators involved in the current backtesting. Thus, in proposed architecture each OOP instance of the indicator class is represented by a column in the parameters matrix, and instead of calculating each feature separately all indicators of the same type are processed at once. At a minimum, this allows reducing the cost of a function call (which can be very significant in the case of using polymorphism and virtual functions), at best, this approach increases the locality of the instruction and data cache.

In a similar way, the instances of strategy classes are replaced by the matrix of parameters PS. The input data for the strategy calculation module are matrices I, PS and PM. The essence of the PM matrix is as follows: the number of strategies can be greater than the number of indicators, since the calculated values of the latter can be used in the signals generation by several different strategies. Therefore, it is necessary to provide a way to map the index of the strategy to the corresponding value in the matrix I, what is accomplished with PM.

Such organization is, in fact, an implementation of the ECS (entity-component-system) pattern, in which each object (called an entity, according to the pattern) is represented by a set of components that only store data or state. All logic of a program is executed by so-called systems that perform calculations with specific components [13, 14]. In terms of this pattern, indicators and strategies are systems, and their parameters are components. In this case, the trading system itself can be considered an ECS-entity. "Fig. 2" shows the OOP architecture after applying proposed transformations.
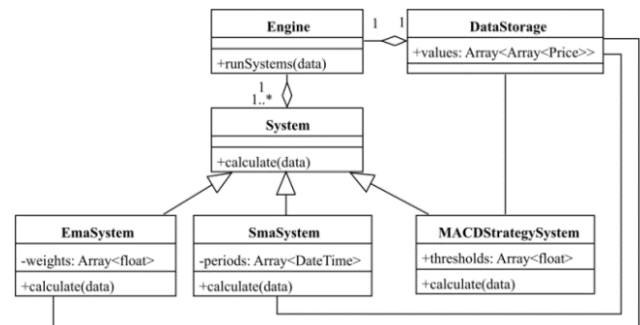
Fig. 2.   UML diagram of DOD backtester's core.

The principle of "structure of arrays versus array of structures" is well suited not only for storing intermediate calculations during backtesting, but also for representing input data. One of the main types of input data for a strategy

testing system is a table of deals. Minimum set of fields that are required to represent a deal record are the following:

a. Instrument id - trading instrument identifier;
b. Timestamp - time of the transaction;
c. Price - the price of the deal;
d. Quantity - the volume of the deal;
e. Flags - a set of bits used to encode the direction of the deal (buy or sell) and utility information.

In addition to the specified fields, for example, the identifier of the exchange or market may be added (in case if a backtest involves instruments on different exchanges). Also, some trading platforms may broadcast the identifiers of orders involved in the transaction. In general, the set of fields can vary in different implementations depending on the needs of the users, but one way or another, the fields specified above should be present.

It is important to understand that, as a rule, not every field is required for calculating indicators (basically, the price, volume and direction of the transaction are needed). When reading transaction records using the classical approach of the "array of structures" a significant part of the processor's cache lines is wasted on utility fields that are not involved in the calculations. Organizing records as a SoA solves this problem. In addition, such a layout makes it possible to use SIMD instructions more efficiently due to a more optimal "vertical" arrangement of data in memory [15].

One of the advantages of a more vertical data arrangement as a "structure of arrays" is the ease of parallelization. As it was said, data processing in the strategy testing system can be logically divided into 4 stages. These stages, in the case of an OOP system, are sequentially executed for each packet of incoming data. With such approach, parallelism is possible only at the level of trading sessions and only if the strategies being tested are designed for short-term trading and remain position-neutral most of the time, i.e., always have empty portfolio at the end a trading session.

To ensure efficient parallel execution, this paper proposes to combine the stage of generating trading signals and trading simulation in one stage. Instead of sequential processing of data packets, it is proposed to move to sequential processing of stages. Thus, the first stage (responsible for reading data) prepares not just single piece of data for the subsequent calculation of features, but processes all incoming data at once. The results are saved in SoA format, namely in the form of a matrix D: PxN, where P is the number of values calculated at this stage, N is the number of data packets. The amount of calculations required is determined by a set of indicators. However, there is a mandatory row which must always be present in D - an array of time stamps of data packet arrival. Without this array time averaging, which is often found in financial calculations, is impossible. Time also plays an important role in the trading simulator module for emulating delays in sending and receiving orders and other messages. This stage differs little from the OOP approach, because I/O operations are performed most of the time and use parallelism is limited by storage devices.

The next stage is the calculation of indicators. It takes D and a matrix of parameters as an input and performs computation of the required features. A new matrix I is formed as the result of this stage. It should be noted that strategies do not always generate a signal upon the arrival of each individual packet. It is a fairly common practice in trading systems to split a continuous data stream into intervals within which the features are calculated. Thus, the number of columns of I is limited by the number of packets, and the number of rows can be infinitely large, since the indicator can calculate more than one feature. Such organization of computations ensures the independence of indicators from each other, which allows them to be processed in parallel. At this stage, almost any number of processors can be involved, of course, within the limits of the number of indicators.

The third stage is the calculation of strategies and trading simulation. The strategies receive parameters matrix and matrix I, on the basis of which trading signals are calculated. Ultimately, the signals become trade orders for placing or cancelling bids with certain parameters (price, volume, etc.). Trade orders together with the data D prepared at the first stage are sent to the trading simulation module, where the placing of orders on the exchange and their execution are simulated. Information about executed orders is fed back to the strategy to update information about the current position. Also, based on the executions, various financial metrics of the strategies are calculated, which are the final result of the entire system. Similarly to indicators, each individual strategy is completely independent and its financial metrics calculation and trading simulation can be done in parallel.

For efficient use of resources a work-stealing task scheduler is used in the system [16]. Also, it is necessary to take into account the priority. It means that strategy processing and trading simulation is of the highest priority, since the user is interested in getting the results as early as possible. The read data step only needs to be performed if no other tasks are available. In addition, dynamic load balancing is implemented. Since the number of threads, as a rule, is less than the number of indicators and strategies, it is necessary to group their calculations. In this way, the grouping that provides the greatest locality of data and instruction cache is more preferable, i.e., grouping in which the number of ECS-systems processed by one processor is minimal. Since the backtesting procedure assumes repeated execution of the same algorithms, it is proposed to store information about the time spent on a certain type of computation at each stage with subsequent averaging over all observations. The resulting value can be used as an estimate of the execution time. Based on the estimate, ECS-systems are distributed among threads, so that all of them spend approximately the same amount of time.

III. RESULTS AND DISCUSSION

In order to demonstrate the effect of the proposed transformation, for this study a backtesting system that implements OOP and DOD approaches has been

developed. Several performance tests were conducted. The first test was to calculate a simple technical indicator SMA on simulated dataset consisting of 1 million records. In different launches of the program, a different number of indicators are calculated, with each launch repeated 10 times. The average time of all launches is considered to be the result. Subsequent performance tests in this work are carried out in a similar fashion. The results of the program runs are shown in "Fig. 3". The vertical axis shows the time in milliseconds, i.e., the smaller the result, the better. The horizontal axis shows the number of calculated indicators. The program in this and subsequent tests is built with g++ compiler version 9.3 with O3 optimization level and is executed on a multiprocessor server system with 120 Intel Xeon CPU E7-8880 v2 @ 2.50GHz processors under the Gentoo Linux operating system.

As it can be seen from the graph, in the case of a small amount of calculations, the architecture proposed by DOD shows the result no worse than OOP, but significantly exceeds the performance of object-oriented approach with an increase in the number of indicators. So for 8 indicators the speed increase is 23%, and for 64 the acceleration reaches 36%.
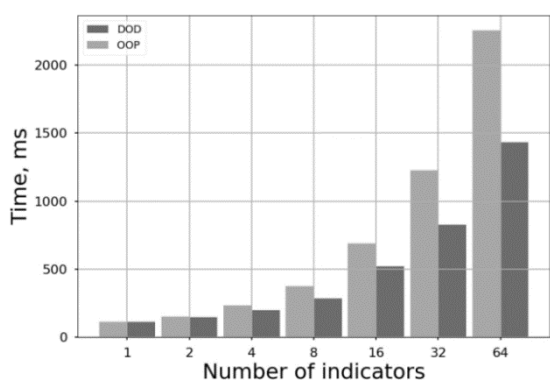
Fig. 3. Plot of execution time versus number of indicators.

The effectiveness of the proposed data organization is demonstrated in "Fig. 4". The graph shows the results of calculations of the weighted average price VWAP for an array of 10 million transactions, represented by structures of different sizes. OOP stands for the classic AoS approach, and DOD stands for the SoA approach. The horizontal axis marks the size of the deal data structure.
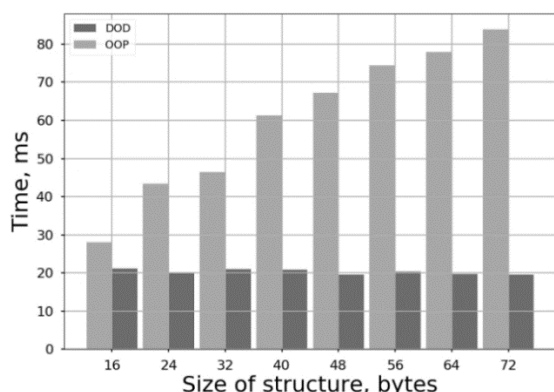
Fig. 4. Plot of performance versus data structure size.

Assuming that 64 bits are allocated for each field of the structure, at least 40 bytes are required for single deal record. As it can be seen from the graph, with the DOD approach the processing speed does not depend on the size of the structure, and the performance gain is observed even for 16 bytes (as if only two fields were allocated to represent the transaction - price and volume). Speedup only grows with and increases in memory size and for 40 bytes the performance gain is 66%.

Also, in this study similar testing of the data structure for order book processing was carried out. The paper [17] is taken as a basis, in which it is proposed to use an array of price levels in the form of pairs (p, q) where p is the price and q is the volume. The order of such array is maintained when inserting and removing elements. According to the principle of "structure of arrays", this scheme is converted into two one-dimensional arrays - separately for all prices and all volumes. Various metrics were measured for the new data structure:

a. The time of processing all incoming data packets within one session;

b. The time during which the following features are repeatedly calculated on the basis of a fixed number of the first price levels: average price; average volume; weighted average price; the price of a level at which the volume is not less than a certain fixed number. The testing was carried out on both simulated and real data for the most active trading instruments on the MOEX exchange. None of the designated tests found a significant difference in execution speed between SoA and AoS.

The performance of proposed parallelization scheme was tested using the classic MACD strategy as an example. In the test system within one trading session 2000 different combinations of MACD parameters are processed, for which it is required to calculate 1000 different moving price averages, in this test SMA was used. "Fig. 5" shows a graph of the performance of the sequential OOP version and the two types of proposed DOD system. In first case DOD system is tested when the calculations are perfectly balanced between the threads (Balanced). In second case one of the threads performs 1.5 times more work than any other (Unbalanced). It is worth noting that OOP, as well as DOD, implements all the optimizations proposed. Because the OOP version cannot be executed in parallel for one trading session, its performance does not change on the chart. DOD version, in turn, expectedly demonstrates a speedup of almost N times for N threads, in the case when computations are perfectly balanced.
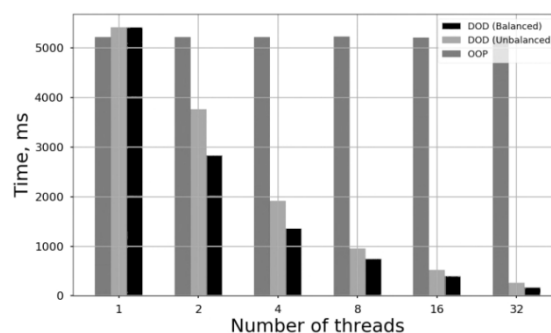
Fig. 5. Plot of performance versus number of threads.

The proposed computation scheme scales better for a large number of processors, compared to sequential computations in the classical OOP approach. Trading instruments also introduce an additional degree of parallelism. In the case when the strategy operates with several securities at once, the calculation of features for a separate security does not depend on the others and can also be performed in a separate thread.

Nevertheless, the proposed method for parallelizing computations has its drawbacks. It is easy to see that the proposed system allocates a large amount of memory. Because the calculated values are stored for each data packet, the upper limit of the total number of data cells is $N_{strategies} * N_{indicators} * N_{packets}$. Considering that the number of packets is running into millions, and the number of strategies and indicators is in thousands, the system consumes a significant amount of RAM even for simple backtest scenarios. Of course, this problem can be solved by artificially reducing the size of the trading session, but such a solution inevitably leads to additional overhead.

Another disadvantage is the bandwidth. Despite the fact that the proposed architecture is highly scalable, under certain conditions its performance does not exceed the one of sequential OOP system. This situation occurs when the number of sessions being tested equals or greater than the number of available threads. Because a sequential system can process individual sessions in parallel, it is capable of performing the same amount of computation at the same time. Considering that sequential execution does not require a large amount of memory for intermediate calculations, the classical system would be much more efficient in terms of resource consumption. However, the backtest results for each individual session would be available much later. Thus, in the proposed and sequential systems, the same backtesting of N sessions will be performed in the same time T. But the time for complete processing of single session in a sequential system will be T, and T/N in parallel one.

IV. Conclusions

This work shows how DOD optimization techniques can be applied to the automated trading and, in particular, to the testing of trading strategies on historical data. The empirical performance tests carried out show that in such a computationally expensive task like backtesting, escaping the traditional object-oriented approach towards organizing data in a more vertical layout of "structure of arrays" can give a significant increase in performance. Empirical testing shows that use of DOD can speed up the process of features calculation up to 33%, and that organizing data in AoS format may additionally increases performance up to 66%. It is worth noting that the optimizations proposed, except for parallel execution, can also be implemented in real-time trading systems.

The proposed parallelization method, despite having certain drawbacks, has greater scalability, which is very important for multiprocessor systems, especially considering how rapidly the number of cores in modern processors is growing. It should also be said that the proposed data organization scheme is very well compatible

with the modern machine learning tools. This is quite useful, because artificial intelligence methods are increasingly being used for the financial information analysis and the development of trading strategies. Also, a more vertical representation of data contributes to better integration with columnar databases, which are often used to process large amounts of data [18].

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E-Commerce Retail Customers Repurchase Factors Influencing Identification

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Abstract - **With the fast-paced technological development era and the importance of using the Internet in our daily lives, e-commerce as shopping no longer seems new or unusual. Regardless of type or size, companies are using e-commerce advantage to compete in the market. Each of these companies needs a circle of independent and loyal customers. When the customer is satisfied, he gives positive feedback about the company and makes a repeat purchase. In this way, he attracts new customers to the company and provides an independent income for the company. Certain factors influence the customer's attitude and behavior. It is essential to determine what influences their customers' choices when competing to earn profit in the market; the customer must be satisfied in order for him to want to make a repurchase. Repurchases from customers indicate a loyalty to the company. Customer loyalty can be the result of a company consistently meeting and exceeding its customer expectations. Customer loyalty can have a significant impact on business growth. To assess and identify the factors influencing customer satisfaction, they are identified and offered a conceptual reflection of the current situation and offer a conceptual model of Identification Causes and Effects of Customer Satisfaction Framework (IceCSF) in e-commerce retail.**

Keywords - e-commerce, unsatisfied consumer identification, consumer behavior identification, repeat purchase identification.

I. INTRODUCTION

At the beginning of 2020, 99.9% of enterprises in Latvia used the Internet, and 62.6% of them had their website, including 94.1% of large enterprises, 81% of medium-sized enterprises, and 58.4% of small enterprises, according to the annual survey of the Central Statistical Bureau on the use of information and communication technologies (ICT) and e-commerce in enterprises [1].

Seeing the importance of e-commerce in our daily lives today. A returning customer is a customer who has made the first purchase and has returned to do so again. Increasing the company's profitability begins with creating its regular customer base; they are significant customers. Customers who make repeat purchases are loyal; it is also a powerful tool for attracting new customers. Loyal customers increase the company's profit because they buy more often than those who have made only one purchase. Besides, attracting a new customer to a company can cost five times more than retaining an existing customer. By increasing the number of regular customers by 5%, its profit could increase from 25% to 95%. It is crucial to identify the factors that encourage customers to make repeated purchases and become loyal to the company, but it is equally important to identify the factors that cause customer dissatisfaction[2].

To look for answers that affect customers repurchase factors influencing identification in e-commerce retail. The method of systematic analysis of scientific articles is used in work. By marking the current situation, identify possible challenges and propose a conceptual model that would identify the influencing factors that indicate the customer's repeated purchase. The following research question (RQ) is raised:

RQ1: What factors affect a repurchase?

The goal is to identify the factors that affect customer repurchase in e-commerce retail. After identification, offer a unifying conceptual model that would reflect the current situation and offer a conceptual model of IceCSF. The rest of the paper is organized as follows: Section II related work, Section III results, and Section IV conclusions.

II. RELATED WORK

Examining the identified scientific articles, the authors conducted an empirical study on the impact of different shopping websites on utilitarian and hedonic values when shopping online. The [2] study confirms that new purchases must be converted into recurring ones for a successful business development strategy. The authors confirmed that the quality => value => satisfaction => loyalty (intention to make a repeat purchase) chain mechanism explains the key to the success of an e-commerce business. This chain mechanism differs significantly from that used by researchers in consumer behavior and marketing literature, who argue that these consumers' loyalty and repurchase intent could be based directly on a higher quality of product/service. The study [2] shows that quality cannot be considered an excellent factor to encourage repeat shopping in an e-commerce environment, as consumers value products and services primarily based on their needs, desires, entertainment, and usefulness. Utilitarian and hedonic values are what lead consumers to intend to repurchase. Besides, the results obtained indicate that the chain mechanism may work slightly differently, in some cases when such demographic factors influence it as consumer income level, gender, age.

The authors of the article [3] believe that too much attention is paid to understanding e-commerce shopping behavior, and too little attention is paid to retail ethics (PCORE model). The obtained results indicated that consumers' perceptions of retail e-commerce ethics consist mainly of 5-factor dimensions - security, privacy, non-deception, performance, reliability, and service recovery. The findings of the study suggest a link between the PCORE model and customer satisfaction. The results also confirm previous research that retail e-commerce ethics can significantly impact customer satisfaction, suggesting that companies with good ethics can build favorable relationships with potential customers, thus enhancing customer satisfaction and trust.

The author of this [4] study has summarized consumers' central perceived values, such as emotional values, quality/performance values, and monetary values, which can directly influence e-commerce consumers' intentions about whether they want to buy a company's products services. On the other hand, this paper [6] presents an adaptive hybrid intelligent computing model (AHICM) to analyze consumer behavior for business development. Trust is an essential factor when looking at it directly in the context of online shopping behavior. In publication [7] emphasizes the sensitivity of individuals to the ratio of payments. The results of the study strongly show how closely trust is linked to consumer behavior as such.

Precious research has been done by authors [8] who have studied whether a deep hybrid learning approach using various customer data can help predict customer repeat purchases and future behavior. The results were surprising; with a deep hybrid machining approach, predicting up to 90% of consumer behavior concerning repeat purchases is possible. Customer loyalty to the brand was considered a critical underlying factor.

ECT (Expectancy confirmation theory) theory is a general approach to study e-commerce customer satisfaction and behavior research, including product repurchase, further use of the service. The ECT theory's basis states that the customer's behavior to make a repeated purchase or not stop using the service is mainly influenced by the satisfaction with the product or service experienced in the past. The study conducted by the authors has confirmed the theoretical position that satisfaction is the main factor influencing repeat purchases. [10]

In the research [11], the authors have assessed various possible factors influencing customers' repeated purchases in social e-commerce, including word-of-mouth (WOM) intentions. In particular, research has shown that trust and satisfaction influence customer behavior, including the intention to make repeated purchases, but the availability of information quality and a company's reputation are key factors that will affect trust and satisfaction.

The authors' [12] empirical study examines the impact of delivery services on e-commerce customer satisfaction, trust in the company, and the intention to make repeated purchases. Three post-service factors related to customer satisfaction were identified: the possible exchange or return of products and the refund process. The results revealed a relationship between customer satisfaction with the service and the intention to make a repeat purchase.

In turn, paper [13] has looked at the factors influencing customer satisfaction by studying the online shopping experience in general, using data collected by researchers from the 2016 U.K. consumer survey. As a result, the study confirmed that the online shopping experience is influenced by order fulfillment, ease of return, and customer service quality, which significantly affect customer satisfaction. However, customer satisfaction leads the customer to the intention to make a repeat purchase.

The papers [14] aimed to understand the four most important dimensions of e-commerce service quality, which affect customer satisfaction, trust, and behavior. The quality model predicts customer behavior and examines the impact of customer satisfaction on their behavior, such as purchase intent, repeat site visits, trust in the company. The study's analytical results highlighted three factors: quality, namely, site design, security/privacy, performance, which generally affect the quality of e-services. Customer service is not significantly related to the overall quality of e-services. The results show that quality is statistically significantly related to customer behavior, which leads to satisfaction and is ultimately related to making repeated purchases.

The authors [15] have developed the Online Susceptibility Scale (OSS), which assesses the factors that influence consumer decisions when making purchases online; the main reason for defining the scale is that the literature looks at very few factors that directly affect it. This study provides a broad scale of the OSS scale by introducing three factors: online impact of evidence, confirmatory online impact, and online experience. The focus of the study indicates the importance of information when making a purchase decision. Social communication

and information, and feedback available directly to the consumer play an essential role.

The paper [16] conducted a study offers to get acquainted with and at the same time test a model that examines the quality of relationships as factors between corporate reputation and consumer behavioral intentions. The study's preliminary results showed that overall customer satisfaction is related to company identification, customer commitments, and purchase intentions. Subsequent results confirmed that the corporation's reputation positively impacts customer satisfaction, engagement, and repetition. What significantly influences customers' commitment to repurchase is customer satisfaction.

The main goal of this [17] study was to analyze customer satisfaction in the e-commerce environment. Factors affecting customer satisfaction and the relationship between customer satisfaction and customer spending in e-commerce were identified. The results confirm the customers' satisfaction with the money spent or the desire to make purchases. Further, a link can be observed between if customer satisfaction and spending are positive, a higher level of e-satisfaction emerges, which contributes to the growth of e-commerce. There are direct relationship factors between e-services that affect each other, e-satisfaction and e-loyalty.

The authors [18] believe that the sale of products and their return policy is two signals that can influence consumers' intentions to repurchase online. Also, these signals worked across different market sectors and customer groups, making it a sufficiently important topic for research that could help e-commerce marketers make more profit. Thus, to help online merchants earn more by making effective decisions, a multi-stage hidden Markov model (MS-HMM) is offered, which explores consumer motivation related to customers' intention to make repeated purchases.

The authors of this paper [19] write that e-coupons (electronic coupons) have been one of the foundations of marketing, attracting consumers, and promoting products. To making repurchases, it is necessary to distribute e-vouchers; delivering them to the right customers is essential. The analysis of consumer preferences for e-vouchers took into account consumer behavior online and the impact of the resulting data imbalance on low consumer engagement. The authors propose using a two-step hybrid model; the proposed model is applied to actual online consumption data, mainly to properly segment consumers to achieve the desired results and encourage the intention to make repeat purchases.

E-commerce is playing an increasingly important role in consumers' daily lives, mainly due to the crisis caused by COVID-19, the effects of which have changed consumers' attitudes towards online shopping. These rapid developments further reinforce the need to focus on research into consumer behavior. Acquainting with the latest research conducted by various authors, it must be concluded that each emphasizes the vital relationship between consumer behavior, satisfaction, and trust - these

are the main key factors that make the customer consider the idea of repurchasing. In turn, the repeated purchase means expanding the circle of regular customers, which is interconnected with gaining and maintaining the customer's trust or loyalty. Upon reaching this stage, e-commerce retailers increase their sales, which facilitates sales. These are the unifying factors for any e-commerce product or service industry.

III. RESULTS

The findings are summarized in a conceptual model to identify the factors that affect customer repurchase in e-commerce retail.
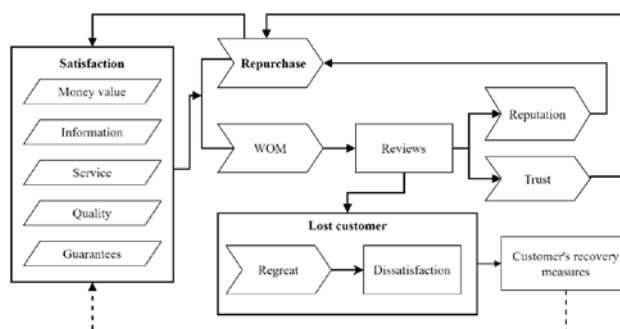
Fig. 1.   The factors that affect customer repurchase in e-commerce retail [2-19].

Such factors influence consumer satisfaction as money value, information, service, quality, guarantee. The consumer goes through several stages until he decides to make a purchase, receives it - then he begins to form an idea of the purchased product or service received and the company from which he received it. If the customer is satisfied, they will make a repeat purchase. The customer can express their feedback on the product or service to others; it can be positive and negative. If the feedback is positive, he/she will make repeated purchases himself but will recommend it to others; it will create a good reputation for the company and loyalty to the company. If the customer is dissatisfied, he/she experiences regret about the last purchase or service received. He/she can express his/her dissatisfaction out loud, but he/she can also keep it quiet. In this case, it can be assuming that it is a lost customer or a repurchase will not take place.

By creating successful customer satisfaction, it is needed to know much different data needs to be collected. The next step would be to be aware of how customer satisfaction can be measured with mathematical models and the factors that affect it. Before, the last step would be to predict the possible occurrence or non-occurrence of satisfaction. In the end, obtaining both negative and positive results, perform various activities that would turn from negative results to positive ones and identify positive results to keep repurchases in the future. Combining the problem in a conceptual model that should be developed as a framework for the future. Identification Causes and Effects of Customer Satisfaction Framework (IceCSF) is offered as a solution.
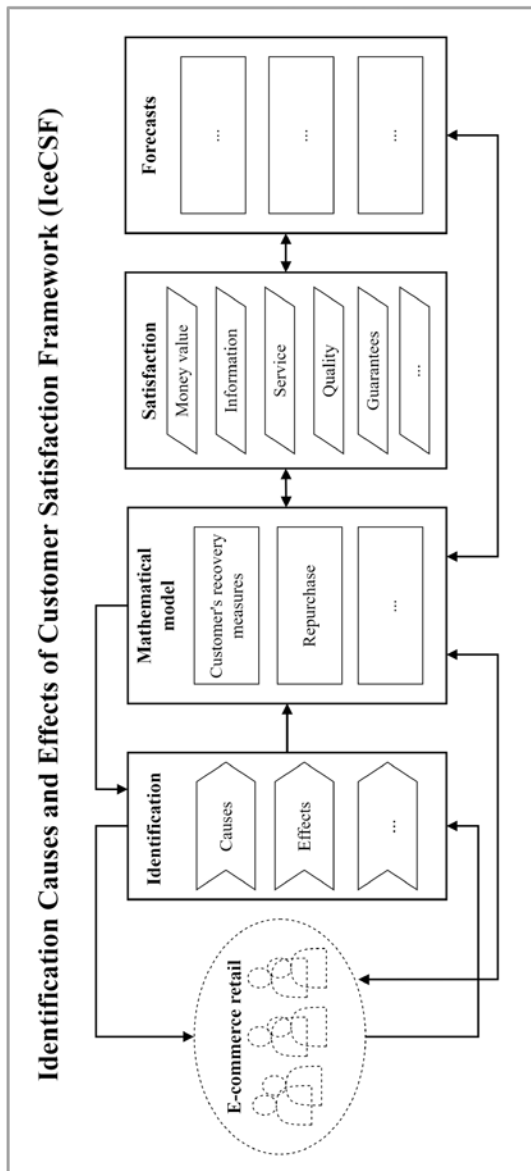
Fig. 2. Conceptual model of Identification Causes and Effects of Customer Satisfaction Framework (IceCSF) in e-commerce retail [Created by the author]

It can be concluded in Fig. 2 that this offer is at the conceptual level, and it is necessary to go into each element in depth.

IV. CONCLUSIONS

A review of recent critical literature on the factors influencing customer behavior, satisfaction, and repeat purchase intentions in e-commerce in recent years has provided a summary of the main influencing factors. Combining the best results of the research, we developed our conceptual model, which answers the question raised by the research: What factors affect a repurchase? The main factors that affect customer satisfaction are money value, information, service, quality, guarantee. These groups of factors make up the customer's satisfaction with the product or service received. Satisfaction leads to other consumer behavior - if he is satisfied, he will make a repeat purchase

and recommend the company to others. By expressing our feedback and opinion, whether it is assessed as positive or negative, the customer builds its reputation, followed by reliability. If the customer's feedback is positive, it will encourage other potential customers to make purchases; thus, the company acquires a new circle of regular customers. Also, if the customer has made several repeated purchases, the importance of loyalty and the loyal customer base's contribution to the company could be studied in this context. On the other hand, if the customer is dissatisfied with his experience, he can also express negative feedback loudly or by holding it to himself. In this case, it can be considered that the customer is dissatisfied, and the possibility that he will make a repeat purchase is negative.

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E-learning: Developing Tomorrow's Education

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Abstract - **E-learning refers to the term to deliver education or training using digital resources. Computer-based learning, which is considered the keystone of today's E-learning concept, was born in the 80s. Earlier E-learning provides education using only text as with the development in technology it allows adding various forms, i.e., Graphical Text, Images, Video Conferencing etc. In today's time, the concept of is E-learning growing at a rapid pace. Improved bandwidth and growing technology helped in pushing the expansion of E-learning. Along with the university, large corporate companies are also resorting to E-learning. E-learning provides many advantages as compare to Instructor-led training (ILT). E-learning saves the times of travel as physical presence is not required. Education can be provided from anywhere at any time. E-learning is cost-effective also as the course, once developed, can be modified easily. There can some concern which can be faced by the trainer and leaners in future. Adopting E-learning will be a step towards saving the environment. It will be environmentally friendly as tablets will replace books; paper notes will be replaced with digital messages. Digital tools will help to reduce the burden of a student. Artificial Intelligence is a prevalent concept in computer science. A branch of AI, known as a Neural Network, is based on the human brain. The research's main aim is to review existing methods and analyse further possibilities of E-learning systems with neural networks.**

Keywords - E-learning, education, E-learning limitations, new technologies, Artificial Intelligence, Neural Network

I. INTRODUCTION

Education is an essential element of life in today's time. Any obstacle during education affects the interaction between a teacher and student to some extent. Obstacles can come in any way and can come in any way, such as deteriorating health or being unable to provide timely training, lack of teachers, or lack of teaching resources such as textbooks. These problems can be overcome using digital resources involving various methods, computer-based operation network, computer-assisted instruction, audio conferencing and video conferencing, internet worldwide websites and a systematized feedback system (see Fig. 1). It is not related to only training and teaching but also about learning tailored to individuals.

Fig. 1. Structure of E-learning (Source: servicedesignblog.com).

E-learning makes the process of delivering education by removing the necessities of the physical presence. Ever since the internet has been used to provide education, the quality of education has increased a lot [1]. It boosts the study process by offering various ways of giving education [2]. Using E-learning, students of any age and abilities have the chance to learn anywhere, at any time and in their place. A single definition of E-learning has not been found yet. Terms that are commonly used to define E-learning include online learning, networked learning, distributed learning, virtual learning, internet learning, web-based learning, and distance learning [3]. E-learning delivers content via Internet, Intranet and Extranet.

II. TYPES OF E-LEARNING

Fundamentally, there are two types of E-learning [4].

Synchronous E-learning.

This type of E-learning is known as real-time learning also. In this type of e-learning, the teacher and learner are online at the same time and interact from different places (See Fig. 2).
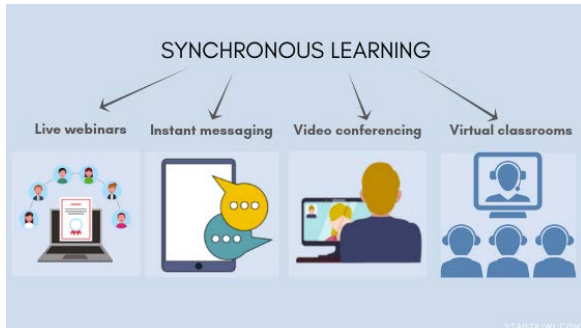
Fig. 2. Synchronous Learning (Source: Startkiwi.com).

They communicate via video conference, audio conference, chat. In this type of learning, sharing and ideas can be done during the session-this type of e-learning gaining popularity because of improved internet bandwidth capabilities. This type of E-learning delivers content two ways or more at the same time. Activities that are used in this type of learnings are:

- Chat and IM.
- Video Conference.
- Audio Conference.
- Live webcasting.
- Application sharing.
- Polling.

Asynchronous E-learning.

It is also known as a pause-and-resume kind of learning. In this type of e-learning, the teacher and students are not online at the same time. It's also known as self-paced learning (See Fig. 3). In this, learners can learn at any time, download eBook's forums, CDs, DVDs etc.
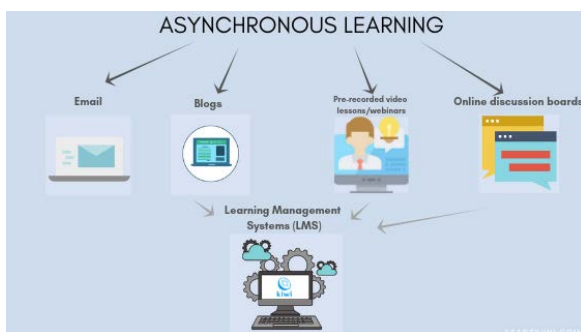
Fig. 3. Asynchronous Learning (Source: Startkiwi.com).

This type of E-learning delivers content in one way at one point in time [4]. This type of E-learning is gaining more popularity than synchronous because learners can learn at their preferable time, not by affecting their daily routines.

Activities used in asynchronous learning are:

- Email.
- Discussion forum.
- Personal or Public blog.
- Webcasting.
- CD-ROMs.
- Broadcast television that delivers learning contents

In this learning, audio and video sessions can be recorded during the lecture and made available for the learners who cannot attend the live event.

III. CATEGORY OF E-LEARNING

These are considered as follow:

1) *Courses*
Most discussion on E-learning focuses on educational courses. Education courses are added with different media or modified to a network for online access for a learner. Some learning management systems are top-rated today, such as *TalentLMS*, *LearnDash* and *SkyPerp*, which education institutes commonly use. The designer has begun to add innovative components in courses such as storytelling and simulations into the material to achieve more motivational courseware.

2) *Informal learning*
Learning from self-directed learning or learning from their own experience is mainly known as *Information learning*. Sometimes for the need for information drivers our search [5]. Search engines (Google, Bing) connected with some storage tools or personal knowledge management like blogs or wikis present a powerful toolset in knowledge.

3) *Blended learning*
This learning is a combination of a face to face and online learning. It combines several different delivery methods as web-based courses and computer communication practices with face-to-face instruction. Blended learning utilizes the best of classrooms with the best of online knowledge [6].

4) *Knowledge management*
E-learning has the potential to improve the learning opportunities to a much larger audience as compared to standard face to face training session. Usually, knowledge management creates an atmosphere between people to share knowledge on distribution, adoption, and information exchange [7].

5) *Learning network*
A learning network is a procedure for developing and preserving the relationship between learners [8]. The reason learning networks are enhancing is it offers to exchange with expertise, engage with other learners.

IV. E-LEARNING TOOLS

1) Curriculum tools

These tools are widely used in today's time while providing education in school or universities (See Fig. 4).
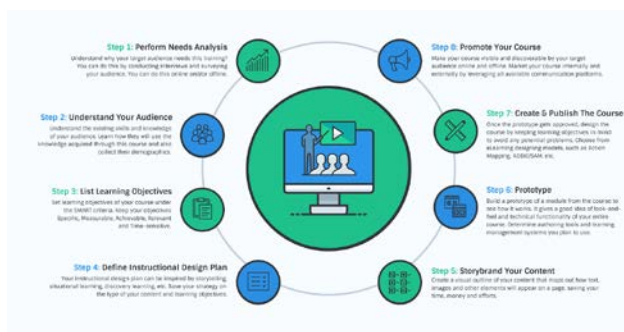
Fig. 4. Graphical Representation of Curriculum Tools (Source: venngage.com).

Curriculum tools are included with three tools:

a) Instruction tools

This tool includes curriculum design, online quizzes.

b) Administration tools

These tools include authorization, administration, and file management.

c) Student tools

Explore study material, Sharing, self-testing and evaluation.

2) *Digital library tool*

This tool helps the learner to find the correct information from a vast amount of digital material. It includes discovering a unique collection or searching among the enormous digital database (see Fig. 5) [3].
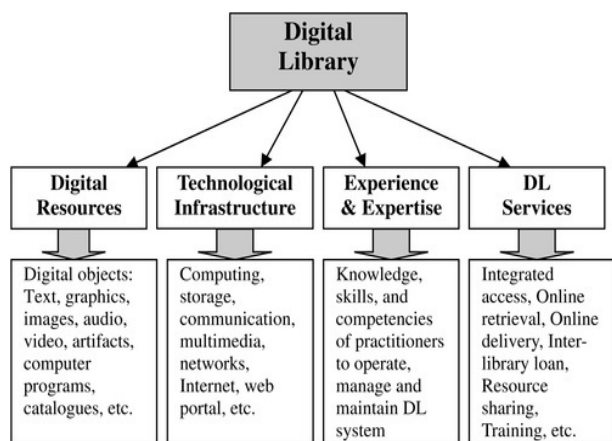
Fig. 5.   Digital Library (Source:IndiaMart.com)

V.   BENEFITS OF E-LEARNING

Reduced costs- E-learning is cost-effective compared to face to face (f2f) traditional method-few significant benefits of E-learning over f2f learning [9].

Quick delivery of Lesson – Compared to the traditional classroom method, E-learning provides the lesson's fast delivery. Reasons how E-learning helps to save time:

• It saves times of travel. The lesson can be acquired at own place with a high level of comfort.

• The learner can focus on the area of interest instead of focusing on each area. They can skip the area which is out of curiosity.

• To some extent, obstacles arising from nature cannot affect the process of E-learning.

Vast audience – In traditional classroom learning, learners' gathering is limited due to limited sitting space. With E-learning number of learners can be increased as compared to f2f education. The number of learners cannot be unlimited due to application limits, but it is still very much compared to the f2f method.

Lectures can be taken numbers of time – Because digital media and resource gave, the lecture can be stored on clouds or local storage. These lectures can help learner for revising the content or preparing for the exam [8].

Environment friendly – E-learning is paperless learning. It helps to save the environment to some extent. In a study, it has been found that E-learning generated 85% less amount of CO_2 as compared to campus-based learning. E-learning is highly eco-friendly as there is no need to cut trees for papers [9].

24/7 Access to Learning – Using E-learning, the learner is free to study accordingly to their plans. Lerner can build their schedule based on their most productive hours.

VI.   ARTIFICIAL INTELLIGENCE AND E-LEARNING

Technology is growing at a very rapid speed in today's time. In a way, everything is shifting to the digital world, but the ordinary programming language still can't deal with qualitative information. With the power of computer science, computers can decide for themselves. The term "Artificial Intelligence" (AI) was coined by John McCarthy in 1956 [10]. It can be defined as holding multiple ideas in mind simultaneously and still retain the ability to function (see Fig. 6). AI is programmed to work with its developed programming language to manipulate knowledge more effectively. AI's scientific goal is to understand intelligence by building computer programs that exhibit intelligent behaviour using symbolic inference or reasoning inside the machine. The two central attempts to make computer ability to think intelligent are game playing and theorem proving. There are six branches of AI (see Fig. 6).

Fig. 6.   Components of AI

In this paper, the authors mainly discuss the implementation of Neural networks (NN) with E-learning.

Neural Network – It is a network that works similar to the tasks performed by neuron of humans. Neural. The structure of the human brain inspires this network to help the computer more like a human.

Working of Neural Network – NN adapt itself during the training period. After sufficient training, NN can relate input to outputs and solve a solution to the problem (see Fig. 7).
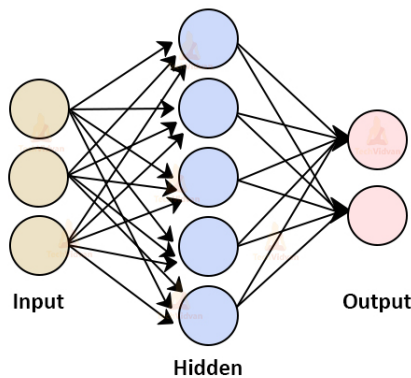
Fig. 7. Neural Network Architecture (Source: upgrad.com)

In NN, all layers are connected. Mainly two layers The input and output are layers visible to the external world. Input layers take information and process according to the neuron's hidden layer and activation after getting the specific weights. In the end, it generates to provide the solution to the output layer. The main computation of NN takes place in between hidden layers [11].

Algorithm of NN-

Training dataset – in this sample of data process to input layer to train the NN.

Validation dataset – in this dataset is used for tuning the performance of NN.

Test dataset – the dataset is used to check the accuracy of the neural network.

Neural Network can be implemented in different approaches in E-learning. In this paper, the authors discuss a one-way communication approach. The system authors trying to develop using a neural network will communicate in one way with the learner.

One way communication approach – In this approach, the dataset used to train the NN will be based on the preliminary information from the individual learner as per their goal, achievement, area of interest and motivation; after training, NN will design the course for individually for the learner. Facial expression is one of the essential features of human emotion recognition. The system will capture the emotion of the learner during the ongoing session. To capture the emotion Convolutional neural network (CNN) [12] will be used. The facial expression will help to get the honest feedback of a learner towards the session. These emotions will be used as feedback to design the next session (see Fig. 8).
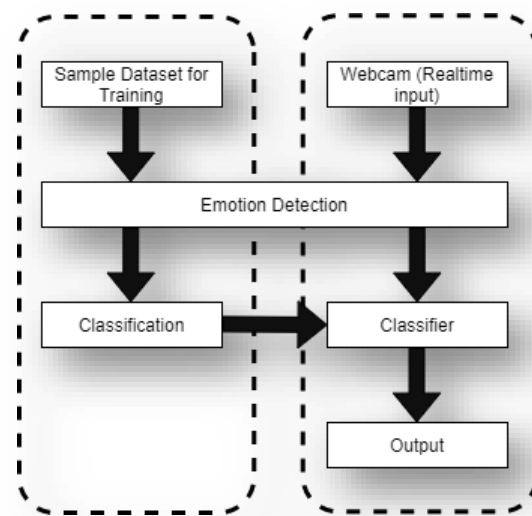
Fig 8. Workflow of the emotion detection model

The emotion model that the author will implement in the system will follow simple steps.

- For training the neural network, it will take a sample dataset.

- After successful training, it will take a real-time image of a learner using a webcam to capture the current emotion.

Using Neural Network with E-learning can prove to be very beneficial in the futures [13].

1.   *Real-time questioning* – NN will work as a Virtual tutor and answer any questions quickly. One most considerable benefit of this will be a student can pause the learning process and ask any question as soon as it pops up in mind [12].

2.   *Fresh Content* – NN is also experimented with generating new and fresh content. In recent time a movie's script name "Sunspring" was developed by NN. NN can be used to create the entire scope of a course. It will reduce the burden of a course designer.

3.   *Personalize Learning* – With the help of NN, it is also possible that the delivery of content to each student will be very to their goals and previous knowledge. AI can track the previous achievements and deliver the content accordingly.

VII. CONCLUSIONS

Shifting from standard f2f learning to E-learning will be a huge step. It can be very beneficial in many ways. Moving to E-learning will solve any natural cause that interrupts learning. However, embedding E-learning with regular system process is both complex and far-reaching. As discussed above, AI with E-learning and rapid development will help provide exciting ways for a learner. Students will get rid of papers notes as things will be on clouds, and they can access them anytime. It will be helping to protect the environment. The concept we are developing using the neural network will provides benefits to an institution in various ways, i.e., in financial costs of a course and reduce the workload of employees of an institute. As discussed, CNN will be used to easy to get the current emotion of a learner using an automatic system during the learning process, which will help find the right motivation for each learner.

The authors are developing a fully automated system that will work based on user provided input according to their area of interest and previous knowledge in the field. This system will generate entire course according to the each individual user.In present time system will work only one way direction.

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COVID-19 News and Audience Aggressiveness: Analysis of News Content and Audience Reaction During the State of Emergency in Latvia (2020–2021)

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Abstract - **This research focuses on the interrelation between news content on COVID-19 of three largest online news sites in Latvia (delfi.lv, apollo.lv, tvnet.lv) and the audience reaction to the news in the Latvian and Russian channels during the state of emergency. By using a tool for audience behaviour analysis, the Index of the Internet Aggressiveness (IIA), for analysis of audience comments, the study aims to uncover how and whether news about COVID-19 affect the level of audience aggressiveness. The study employs two data collection methods: news content analysis and IIA data analysis, in which ten index peaks are selected in each of the two emergency periods (spring 2020, fall and winter 2020/21). The study data consists of content analysis of 400 news items and analysis of ~80,000 comments, identifying the level of aggressiveness, the number and structure of comment keywords. The results show that the level of public aggressiveness is only partially formed by the attitude towards COVID-19 news: less than half of the most aggressively commented news is devoted to information about COVID-19. An increase in the level of aggressiveness of the audience of online news sites can be observed at the end of 2020 and at the beginning of 2021 when it is higher than over the course of 2020.**

IIA is an online comment analysis platform, which analyses user-generated comments on news on online news sites according to pre-selected keywords, allowing to grasp the dynamics of commenters' verbal aggressiveness. In addition, IIA exploits a machine learned classifier to recognize not only potentially aggressive keywords but also to analyse the entire comments. In January 2021, the IIA data set consists of ~24.89 million comments (~611.97 million words) added to ~1.34 million news articles.

Keywords - big data; COVID – 19; internet users' comments; online news; verbal aggressiveness

I. INTRODUCTION

Latvia, just like other countries, conveyed information related to the COVID-19 pandemic in 2020 and 2021 – restrictions, officials', and experts' recommendations on health preservation – to the society through media. Whereas the residents' mobility opportunities are reduced the role of Internet media in communication is soaring. In Latvia, the largest news portals – Delfi, Tvnet and Apollo, with over half a million unique users per day [1] – constantly provide updates on the COVID-19 pandemic and give the opportunity to react to the news in comments. This study is based on the assumption that society's attitude is partly expressed in the comments section of the COVID-19 news and it can be measured with the help of The Index of the Internet Aggressiveness (IIA).

Given that the pandemic caused many inconveniences, increased insecurity in various groups of the society and affected the general mood of the society the aim of this study is to find out whether the information provided by online media about COVID-19 affects the level of users' aggressiveness on news sites' comment sections. Using data from the original digital research tool IIA, this study analyses the data on COVID-19 news content and

audience attitudes expressed in comments, focusing on the level of aggressiveness towards COVID-19 news.

In Latvia, the pandemic is characterized by two periods of state of emergency (spring 2020 and autumn 2020/winter 2021). Each of them is different in the severity of the pandemic: in the first stage Latvia had a very low incidence of the new coronavirus disease and high public confidence in information sources (media, government, experts, etc.) [2], while in the second stage the epidemiological situation in Latvia was much more serious – the health care system was in danger of collapsing [3], the organization of vaccination was delayed [4], while the level of public confidence in the government and the media decreased rapidly [5]. By mid-February 2021, Latvia ranked the 6th in the European Union and the European Economic Area in terms of cumulative infection rates [6]. Hypothesizing that the attitude of Internet news commenters conditionally characterizes the public mood, but the course of the pandemic depends on the attitude of the population towards the information related to COVID-19, the following research questions are defined in this study:

1) How does the news about COVID-19 in the two emergency phases affect the level of aggressiveness in the online comments recorded by the IIA?

2) How does the content of COVID-19 news affect the proportion of aggressive keywords included in the content of comments in Latvian and Russian languages?

To answer the research questions, a study design was developed, which analysed the data automatically provided by the IIA and the news content analysis data, comparing the number of comments, the number of keywords describing aggressiveness and the content of the news in two languages and over two emergency periods. The data were evaluated in the context of theoretical findings on verbal aggressiveness in Internet comments.

II. LITERATURE REVIEW

User comments are one of the most popular forms of audience participation [7]. Scholars have had different views about the importance of interactivity in the process of news consumption [8], [9]. Distribution, content, and interactivity opportunities of online news audience comments have developed studies that evaluate the influence of Internet media user activities on the development of the public sphere [10], [11], as well as the quality of discussions and the involvement of the public at large in discussing important issues. Data from these studies have shown that an opportunity to take part in a debate does not mean an increase in the diversity of views [12], because opportunities to post comments anonymously has also created an all-encompassing process of intolerant communications [13], [14]. This has often manifested itself as verbal aggression.

Verbal aggression can be described as an individual's desire to attack another individual, as opposed to the topic of the discussion [15]. This can be a form of argumentation or speak to the individual's emotions [16], [17]. In the computerized communications environment, it is important to ask whether the anonymity of users facilitates verbal aggression. Of importance is the idea that the psychological effect of online anonymity [18] encourages people to engage in self-disclosure at a far higher level than is the case with face-to-face communications.

III. METHODS

The research method was developed in several phases. In order to design the IIA platform (http://barometrs.korpuss.lv), 3,500 potentially "aggressive" word forms were selected from a sample comment corpus of 65,000 words, establishing a stock of 900 basic words in all forms and spelling variations. Text normalization [19] was conducted to handle transliteration and to obtain a more homogenous dataset. Keywords in the study were grouped into 11 categories: discriminatory words, swear words, injustice, calls of violence, aggressive activities, individuals symbolically associated with aggression, associations with aggressiveness, military terms related to aggression, denunciation, aggressiveness-related emotions, and treason. Each category was assigned with a specific weight depending on the level of aggressiveness: highly, moderately and less aggressive words. Next, a formula was devised to calculate the level of verbal aggressiveness on each news portal during any given period of time. The IIA formula takes into account the number of potentially aggressive keyword occurrences per day multiplied with the pre-calculated weights of keywords. The weighted sum of keyword occurrences is divided by the total number of words in user-generated comments per day.

In a later phase of development, a machine-learning experiment was conducted. First, a representative dataset of 10,000 comments was created, where each comment was human-annotated as aggressive or non-aggressive. Each comment was independently classified by at least two annotators; a third annotator intervened if the two made opposite choices. By using this dataset, an automatic binary classifier was trained. As the evaluation shows [19], the accuracy of the automatic classifier is 72.2% which is rather close to the inter-annotator agreement of 78%. The evaluation also shows that the whole-comment classifier produces a trendline that correlates to the trendline produced by analysing isolated aggressive keywords. This confirmed the hypothesis that the use of potentially aggressive words in a comment suggests that the entire comment is aggressive.

Further improvements to the IIA platform made it possible to identify the top news articles which attracted comments that led to the peaks of the IIA, determining the most aggressive comments as well.

To determine the average value of aggressiveness the data points of the trend graphs are calculated as follows. First, the total relative frequency of the potentially

aggressive keywords is calculated for each date by dividing the total count of keyword occurrences with the total word count for that date. This, however, results in a rather noisy graph with a lot of local peaks in both directions. Therefore, second, a smoothened trend graph is derived by calculating a moving average value for each date. The window for the moving average is 7 days, taking into account 3 days before the current date and 3 days after.

This research involved two methods – the IIA data, with 40 peaks (ten peaks within each study period both in the Latvian and the Russian language news), and content analysis of 400 news reports in Latvian and Russian. The study used IIA data on the level of aggressiveness, number of comments, and the keyword proportion under the most aggressively commented news during the COVID-19 pandemic in Latvia. Top 10 most aggressively commented news items in each peak were selected for the study according to IIA data in each of 10 peaks in the two stages of the research: from March 12, 2020 to June 10 (hereinafter stage I) and November 9, 2020 to February 9, 2021 (stage II).

Alongside IIA data, the study used content analysis following a codebook consisting of 10 code groups. News and comments were analysed using 45 categories through which topics of news in various portals and news sources, number of comments and the number of aggressive keywords were identified. Separate categories were created to evaluate COVID-19 related news.

IV. RESULTS

Stage I of the pandemic in Latvia covers the period from March 12, 2020, when the Latvian government announced the first emergency situation due to COVID-19, up to June 10, 2020, when the emergency was lifted, leaving certain restrictions in place. Stage II of the pandemic in Latvia is defined in this study as a three-month period starting November 9, 2020, when the Latvian government declared the second state of emergency due to deteriorating epidemiological situation, until February 8, 2021. Altogether ~ 663.5 thousand comments in Latvian and 5584.9 comments in Russian were analysed.

The IIA data show that the average aggressiveness increased in the second stage of the pandemic (see average aggressiveness value in Fig. 1) in comments in Latvian (from 3.4 to 3.6) while decreased slightly (from 1.9 to 1.8) in comments in Russian. IIA average value over more than a year, from January 2020 to February 2021, was similar: 3.5 in Latvian and 2.0 in Russian.

During stage I of the study (Fig. 1) the total level of aggressiveness in comments of both languages was similar dynamically, with a low level from mid-March to end of April, as well as end of May 2020, and increasing by beginning of May and June.
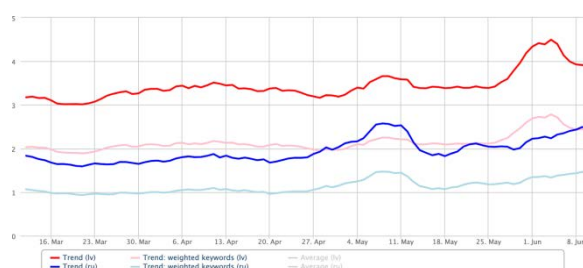
Fig. 1.IIA data in stage I (Latvian and Russian news channels)

During stage II of research (Fig. 2) the dynamics of aggressiveness are similar in both language environments. Lower aggressiveness levels were observed by the end of November 2020 and beginning of January 2021, short periods of higher aggressiveness were observed at the end of November, beginning of December, New Year period, second half of January and an upward tendency beginning of February.
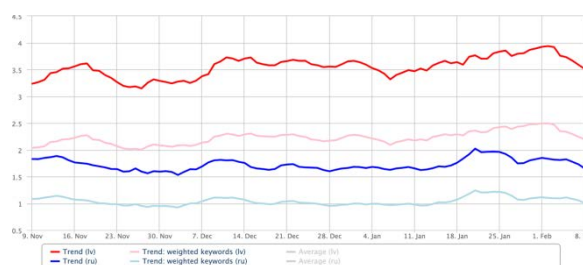
Fig. 2. IIA data in stage II (Latvian and Russian news channels)

Further data analysis reveals the proportion of aggressive keywords in each language and the number of keywords in comments on all news and news on COVID-19 in the specified period.

During stage I of the pandemic, 100 analysed news stories contained 14 381 aggressive comments in Latvian and 9819 comments in Russian (Table 1). In Latvian comments 10 068 keywords were identified, revealing aggressive communication according to IIA, whereas in Russian comments this figure was 5204. On average, each news story received comments, containing 101 aggressive keywords in Latvian and 52 in Russian. During the second state of emergency, a number of aggressive comments has increased. Under the 100 analysed news stories in Latvian, 16 380 comments were found, and in Russian the figure was 13 787. However, a number of aggressive keywords changed only slightly. In the Latvian comments, 10 699 keywords pertaining to IIA aggressive communication were found, and in Russian – 5541. An average of 106 keywords was found under each news story in Latvian and 55 aggressive keywords under each news story in Russian.

Comparing the level of aggressiveness related to COVID-19 pandemic and the aggressiveness expressed on other topics, it was observed that during stage I of the pandemic 3963 aggressive keywords (39% of all keywords) were included in the comments on COVID-19 directly or indirectly related news in Latvian and 1632 (31%) – in Russian (Table 1.).

TABLE 1. GENERAL DATA ON AGGRESSIVENESS LEVEL AND NEWS COMMENTS STRUCTURE (STAGES I AND II)

	Stage I		Stage II	
	LV	*RU*	*LV*	*RU*
Average value of aggressiveness	3.4	1.9	3.6	1.8
Total number of keywords (100 news pieces)	10 068	5204	10 699	5541
Total number of keywords (COVID-19 news)	3963	1632	5068	2176
Share of COVID-19 related keywords (%)	39%	31%	47%	39%
Average number of keywords (per news item)	101	52	106	55
Number of aggressive comments (10 days)	14 381	9819	16380	13787

At stage II of the pandemic the proportion of aggressive keywords related to COVID-19 news has increased: 5068 aggressive keywords (47%) were found on COVID-19 news in Latvian, and 2176 in Russian (39%). In both stages of the pandemic, a share of aggressive keywords in comments on COVID-19 news is 8% higher in comments in Latvian than in Russian.

Comparing COVID-19 related news and other news (Table 2) in the selected sample it was found that in Latvian slightly more than half of the news, while in Russian – less than half of the news was related to the COVID-19 pandemic. In stage I of the pandemic 52 news items in Latvian and 47 in Russian were related to the pandemic (accordingly, 11 and 18 of them indirectly). In stage II of the pandemic the same amount of news items in Latvian (52) and a slightly lesser amount of news in Russian (43) were related to the pandemic (accordingly, 12 and 2 of those related indirectly).

TABLE 2. STRUCTURE OF NEWS CONTENT (1ST AND 2ND PERIOD)

	Stage I		Stage II	
	LV	*RU*	*LV*	*RU*
News on COVID-19	41	29	40	41
News, indirectly related to Covid-19	11	18	12	2
Other news	48	53	48	57

Indirectly related news include such news where the pandemic is not the main focus of the journalist yet reveal its presence, for example, news on a State Security Service official explaining spy activity curbed by the pandemic or news on anti-racism solidarity protests in the shadow of COVID-19 restrictions on gathering.

Analysing the aggressively commented news in the Latvian language, three main topics emerge: international events, crime, and national politics (Table 3, 4). Other themes, like economic and social processes, war and conflict or culture, appear on the IIA peak less frequently. In stage I of the pandemic, international news in Latvian were predominantly related to the killing by police of George Floyd, a 46-year-old black man, in the United States (US) and the consequent anti-racism protests in the US and worldwide. In aggressively commented international news in Russian, anti-racism protests also emerge as a major topic though it is equally important to such topics as the criminal trial in the Netherlands on the crashed Malaysia Airlines Flight MH17 in the Eastern Ukraine and political persecution of anti-regime activists in Russia. International news in stage II of the pandemic (Table 4) were mostly concerned of former US President Donald Trump's pre-election events and Joe Biden's election as the US President. Many commenters' attention was drawn by news about protests in Belarus regarding the Lukashenko oppressive regime. Other aggressively commented news in this category is news related to events in Russia, especially revolving around the poisoning of Alexey Navalny. News in these two topics was commented aggressively twice as often in Russian as in Latvian – 35 news items in Russian and 18 in Latvian, respectively.

Among national politics news, in stage I of the pandemic the most aggressively commented topics in Latvian concerned the news on constructing the new State Security Service building. In Russian, aggressive comments evolved around news on Latvia's national day on the 4th of May and celebrations of the Victory Day on the 9th of May. The news on the controversial issue of the end of the Second World War was widely commented by both Latvian and Russian audiences under the topic of international conflicts and war. In stage II of the pandemic, the most aggressive comments on news about national politics were found under materials that regard a decision made by Constitutional Court on November 12 granting the rights to parental leave to a same-sex couple 9 (Table 4).

COVID-19 related news in the first period account for 52% all news in Latvian and 47% of news in Russian; in the second period they amount to the same 52% of all in Latvian and 43% in Russian (Table 3, 4). In stage I of the pandemic, most of the aggressively commented news in Latvian was related to the COVID-19 statistics in Latvia and abroad, and to the government's stance on the pandemic and combating of it. Slightly less aggressiveness was provoked by news describing COVID-19 restrictions.

TABLE 3. STRUCTURE OF NEWS TOPICS (STAGE I)

General news topics	LV	RU	COVID-19 news	LV	RU
National politics	5	12	COVID-19 statistics in Latvia	12	6
Economy	6	0	COVID-19 statistics in other countries	9	3
Social issues	0	0	Government stance	7	4

General news topics	LV	RU	COVID-19 news	LV	RU
Criminal news	6	14	Announcements of medical doctors, experts	1	3
Foreign policy	1	0	International events	4	5
International conflicts, war	6	8	Restrictions	5	10
International politics	28	27	Pandemic impact to economy	2	1
Culture	2	4	Opinions of politicians	4	3
Other	8	7	Social impact	1	1
			Individual experience	3	2
			Several mentioned topics	0	2
			Other	4	6
Total %	*48*	*53*	*Total %*	*52*	*47*

TABLE 4. STRUCTURE OF NEWS TOPICS (STAGE II)

General news topics	LV	RU	COVID-19 news	LV	RU
National politics	9	7	COVID-19 statistics in Latvia	6	7
Economy	1	1	COVID-19 statistics in other countries	2	1
Social issues	2	2	Government stance	11	10
Criminal news	12	7	Announcements of medical doctors, experts	2	2
Foreign policy	1	2	International events	3	2
International conflicts, war	4	2	Protests	0	6
International politics	18	35	Restrictions	10	2
Several mentioned topics	0	1	Pandemic impact to economy	0	1
Celebrities	1	0	Vaccines, vaccination	6	6
			Opinions of politicians	2	0
			Several mentioned topics	0	4
Total %	*48*	*57*	*Total %*	*52*	*43*

In Russian, the aggression was expressed towards news about restrictions, though in majority of cases restrictions were related to the topic of the news indirectly (for example, in news about 4th and 9th of May celebrations in Latvia involving a reference about COVID-19 restrictions on gathering). To a lesser extent, aggression evolved around news about COVID-19 statistics in Latvia and topics related to "other" themes such as Russian disinformation on Latvia as a COVID-19 failure story and comments of Bill Gates on his involvement in spread of COVID-19 and chipping.

In stage II of the pandemic, the most aggressively commented news in Latvian was similar to those in the first period: the news where government officials express their position on pandemic-related issues, news explaining restrictions and COVID-19 statistics. In addition, in stage II, vaccination emerges as an issue. News on protests against restrictions and the impact of the pandemic on Latvian economy have not been commented aggressively.

Data on aggressively commented COVID-19 news in Russian show that commenters' behaviour partly coincides with the Latvian commenters. Most frequently aggressive comments are addressed towards the government representatives' opinions and stance on the pandemic, and news on COVID-19 statistics in Latvia.

The biggest difference between Latvian and Russian-speaking users was in the attitude towards protests against the pandemic restrictions on December 12, 2020, in Riga. It is arguably related to the fact that one of the protests, held by the Freedom Monument, was organized by Aleksey Roslikov, a popular Russian-speaking politician in Latvia and a member of association 'Stability – Yes!'. Commenter aggressiveness was also observed by news related to disinformation, for example, on activist Valentin Jermeyev and Marina Kornatovska, physician assistant of Riga East University Hospital, spreading false news on COVID-19 patient treatment, and the news about them both being detained.

V. CONCLUSIONS

The study demonstrates that the fluctuations in the level of aggressiveness in Latvian and Russian language environments are directly linked to actual real-life events reported in the news. COVID-19 news published in both stages represented on average half of the level of aggression of internet commenters, but they have not significantly affected the overall level of aggressiveness of users of news portals. As the average level of aggression recorded by IIA in the rest of the year was similar in both languages, it can be concluded that while the pandemic determined the attitudes and difficulties expressed by internet commenters to a certain extent, the changes which the public faced had not raised the overall level of aggressiveness. Only during stage II of the study, the real-life events in Latvia and the news about them start showing signs of a slight increase in aggression in the Latvian comment environment, while the level of aggression has decreased slightly in the Russian comment environment. Overall, the highest level of aggression was provoked by news about events other than the pandemic – international politics, Latvian national politics and crime.

Analysing the number of aggressive comments, as well as the number of aggressive keywords in the comments of both language portals in both stages, the study concludes that the number of news comments is similar (with bigger difference between Latvian and Russian comments during stage I of the pandemic), but the number of aggressive keywords in Latvian and Russian comments differ.

Namely, Russian-published news commenters use fewer aggressive keywords. There are also fewer aggressive keywords in Russian compared to Latvian in the comments written on COVID-19 news. This implies that Latvian news commenters use more aggressive words in their comments, and, compared with Russian news commenters, have sharper attitudes towards COVID-19 news and have expressed more dissatisfaction and concern. In general, however, the level of aggressiveness of COVID-19 news comments has been lower than in other topics' news comments in both languages. In stage I of the pandemic, 39% of aggressive comments are expressed in 52% of COVID-19 related news in Latvian and 31% of comments go to 47% of COVID-19 news. In stage II of the pandemic, 47% of aggressive keywords are dedicated to COVID-19 in 52% of COVID-19 related news, whereas in Russian comments 39% of aggressive keywords are directed towards 43% of COVID-19 news.

Similar news themes have attracted the attention and aggressive comments in both Latvian and Russian-language portals. In each language, however, there were different actual topics that have caused higher aggressiveness. Although there is a linguistically divided information environment in Latvia and representatives of different ethnic groups use different media [20], [21], similar topics on COVID-19 cause aggression in the case of same portal users.

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Research of Approaches to Constructing Predictive Models of the Spread of Viral Diseases

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Abstract - **The article is devoted to the analysis of the available mathematical models in epidemiology and the possibility of their modification. We note that the situation with the COVID-19 virus pandemic is characterized by several features not comprehensively studied in the existing models. For a rational response to existing challenges, it is necessary to have a predictive and analytical apparatus in the complex (national and regional scale) mathematical models with a planning horizon of 2 years (the expected period of mass production of vaccines). The article discusses the existing approaches to predicting the spread of the COVID-19 virus in Russia based on mathematical models of epidemics. The possibilities and limitations of the proposed approaches are considered. In the conditions of the Russian Federation, transport connectivity at the interregional and intraregional levels plays an important role, and for megalopolises - transport flows within large agglomerations and the age structure of the population. In contrast to previous pandemics and epidemics, public policy plays a significant role. The approach, which consist in building multi-agent models that combine the advantages of compartment models and models based on the Monte Carlo method (individually oriented) is proposed by the authors. It is planned to use compartment models to assess the dynamics of the process and individually-oriented models - at the level of individual territories and districts.**

Keywords - prediction, predictive models, viral diseases, mathematical model.

I. INTRODUCTION

The SARS-COVID19 virus pandemic is an object of close study by both epidemiologists and specialists in data analysis and numerical modeling, since the high degree of informatization of developed countries allows to obtain open statistical information practically on the day of its registration.

An analysis of the spread of viral infections is important both from a scientific point of view and from a practical viewpoint, since the volume of sick people in the population determines the burden on the health care system, makes it possible to estimate the required number of beds in hospitals, the amount of drugs consumed, the number of ventilators and medical personnel, the nature and severity of the applied restrictive measures.

Mathematical modeling of these processes has been carried out since the 20s of the XX century, however, a modern highly mobile society, a developed healthcare system, the specificity of the COVID-19 virus as such sets the task of developing and verifying, if not completely new mathematical models in a significant way corrected model.

Thus, the work is relevant, and the proposed approaches can be used for prognostic by government agencies, the leadership of medical institutions and the business community.

II. MATERIALS AND METHODS

A. Base model
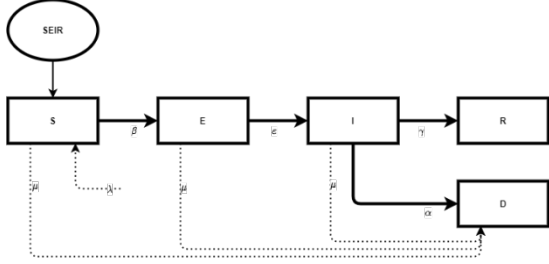
Fig. 1. Base SEIR model with populations dynamic (where S - susceptible, E - exposed, I- infectious, R - recovered), D – dead part of population, measured in a natual values).

Consider as a reference the SEIR model proposed by [1] and widely used at present [2, 3]. This is a modification that takes into account natural and additional mortality and population growth.

The population at each time is considered to consist of compartments, namely S (susceptible), E (exposed), I (infectious), R (recovered), and D (dead). S is the part of the population that can be infected, E is the carriers of infection in the incubation period, I is infected, R is cured. Deaths due to illness and natural attrition from all groups (D) are also included. The probability of transition from one compartment to another due to infection is given by coefficients (β, ε, γ, α), and the transition rules are represented by continuous lines. The natural loss of population is assumed to be the same and is given a coefficient μ, and the birth rate is λ. Note that the total number of living people in the population is N=S+E+I+R.

The model presented is deterministic and is described by the following system of differential equations (1):

$$\begin{cases} \frac{dS}{dt} = -\frac{\beta}{N}SI - \mu S + \lambda N \\ \frac{dE}{dt} = \frac{\beta}{N}SI - \varepsilon E - \mu E \\ \frac{dI}{dt} = \varepsilon E - \gamma I - \alpha I - \mu I \qquad (1) \\ \frac{dR}{dt} = \gamma I - \mu R \\ \frac{dD}{dt} = \alpha I \end{cases}$$

The first equation describes the probability of infection of immunocompromised individuals depending on the frequency of contact with the infected (SI) at the transmission rate β. Infected individuals become carriers of E infection, which in turn, become infected with I with a coefficient ε. Those infected can recover and become R, or die (D) with coefficients γ, α respectively.

A natural decrease with a μ coefficient is derived from all compounds except D and R for obvious reasons. The birth rate is proportional to the number of living population with a coefficient λ. We will then use these designations without further comment.

Everywhere S, E, I, R, D are functions of time (in days), and their initial values are given with the index 0 (S(0), E(0), I(0), R(0), D(0)). Several relative parameters are also

traditionally introduced, namely: R_0 - basic reproduction rate of virus, n_id - incubation period, $\beta = R\_0/n\_id$ - viral propagation rate, γ - withdrawal rate from infected state (see detailed description, e.g. [4-6]).

Option b) takes into account natural fertility and mortality, which is relevant for long-term epidemics with a cyclical pattern of about a year or more. The considered systems of differential equations are represented in the form of models Simulink (see https://github.com/Alex-Samarkin/Rezekne2021COVID).

B. MATLAB realization of the base model

MATLAB and Simulink are widely used for simulation modelling due to the high prototyping speed, an exceptionally convenient visual editor, stable and well-documented numerical modeling algorithms. Then applied: Runge-Kutte45 solver, variable integration step, relative error 1e-6. The consolidated block diagram of the model is presented in the Fig. 2. There is omitted documentation and info blocks, same as block of visual representation of results.
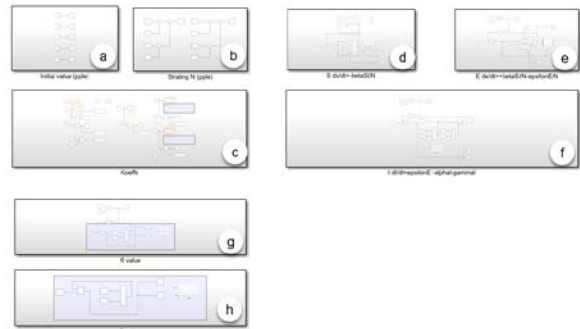
Fig. 2. Realisation of a base model SEIRD (where marked blocks is: a – initial value setup, b – calculator of population size, c – setup of coefficients, D-H – SEIRD calulators).

The following is the most important coefficient calculation block for further modelling.
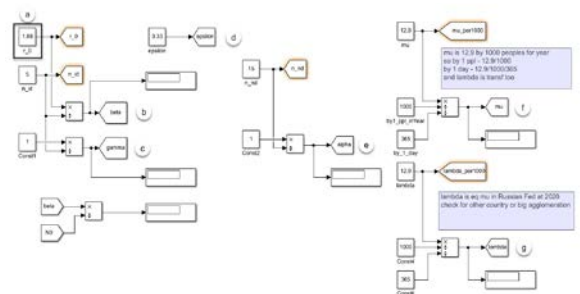
Fig. 3. Calculation of coefficients block (where a – transmission rate coefficient, b,c,d,e,f,g - $\beta, \gamma, \delta, \varepsilon, \mu, \nu$).

C. Criticism of the base model

There are several assumptions behind the integrated models: the compartments are homogeneous, the external effects have an instantaneous effect on the whole compartment, which obviously does not work under real-world conditions.

The stochastic nature of the processes (e.g., the likelihood of infection) is ignored.

It ignores not only the geographical extent of compacts, but also their length over time. Here, time refers to both the time of the simulation, for example, the year, and the time of the simulated processes: the time of the infected in the incubation period, the time of the disease. It is obvious, for example, that the probability of recovering or dying increases at the end of the disease term (n_nd).

Population responses and government action to halt the epidemic, and the socio-economic impact of the epidemic and the response to it, have been ignored, creating a system with multiple feedback loops. This makes it difficult to identify model parameters.

The way the model is described also has a major impact on the modelling procedures. For example, a system-based description of common computers allows the use of efficient computer mathematics systems. A description in the form of algorithms of transition from one complex to another - modeling in one programming language, multi-agent and individualized models may require implementation in hardware and software.

D. Ways to overcome the shortcomings of the standard model

One of the main drawbacks of the model is that its results are deterministic. It arises because of the deterministic nature of model parameters and deterministic rules of transition from one state to another. It can be shown ([7, pp. 384-388]) that transitions from one compartment to another in a stochastic interpretation of this process are subject to the law of exponential distribution. The same approach can be used in the analysis of time-long compounds (such as the E, I base model).

The SEIR model is well developed in the modelling of most viral infections [8, 9], so the authors have chosen an evolutionary modernization. The main idea is to introduce additional compartments into the model (for example, by geographical principle or by age groups). It also seems logical to model the process of the disease, as a transition from a compound with a period of illness i to a complex with a period of illness i+1.

Models based on the time distribution of patient groups are known, as the Erlang-SEIR model (Fig. 4).
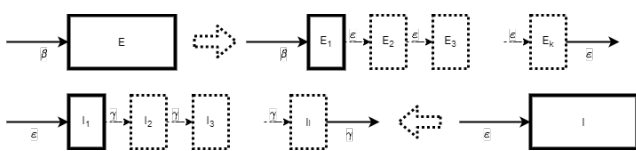
Fig. 4. The Erlang scheme in the incubation E and infeected I models.

From the authors' point of view (without detracting from the value of the approach itself), introducing such complexity on relatively small samples does not have a significant effect due to the effect of large numbers,

nevertheless the reader can find their implementation in ErlangSEIR1 - ErlangSEIR3_4 repository.

However, even the more complicated model [10] is actually deterministic. As the basis of her work are coefficients, the authors modelled their fluctuations over time, taking into account both cyclical temporary processes (daily, weekly, monthly, quarterly and annual) and purely random [11].

The determining parameter of the model is the transport factor, which measures the average number of new infected persons in a population made by one infected person per day.

At a value above 1, the epidemic increases, otherwise it fades. The coefficient is integral to an entire population and may vary significantly from one population group to another and is currently calculated in retrospect from the results of day-to-day infection statistics.

The diagram on a Fig. 5 shows the correction block for the reference value of the transport coefficient. The amendments are additive.
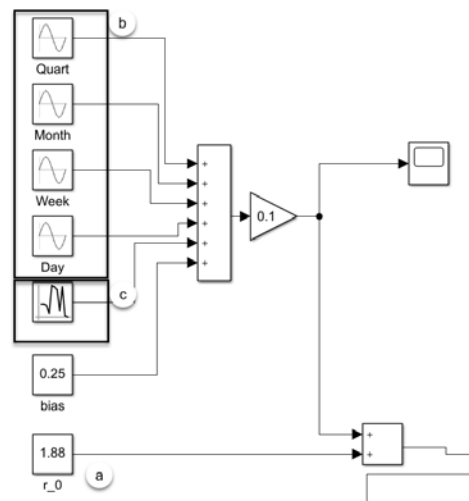
Fig. 5. Block diagram for generating a transport coefficient variable where a) is a base value, b) is a periodic oscillation, b) is a purely random component.

Similarly (the article does not show) the random variation of other model coefficients is considered.

The pandemic is accompanied by governmental action, and more or less significant effects of the containment situation. These effects may occur in different ways, but the main interest is their influence on the transport coefficient.

A typical response of different States to a pandemic (prior to mass vaccination) is the imposition of restrictive measures such as:

- wearing masks;
- restriction of movement;
- introduction of social distance standards.

It is easy to see they are aimed at lowering the transport coefficient and are multiplicative. The multiplicative corrections modelling unit is presented in the Fig. 6.
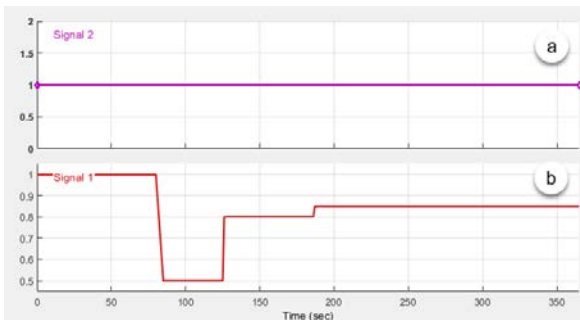
Fig. 6.   Multiplicative adjusters of the transport coefficient. Here: a) - no lockdown, b) - three-step restrictive measures.

Figure 6. b shows three stages of lockdown (Pskov region in 2020, reconstructed by authors):

- 80 days – no reaction or little effective action;
- 80-130 – hard lock-down with strict control;
- 130-180 – soft lock-down (some restrictions are lifted);
- 180-365 – ineffective lock-down (restrictions are formally observed, with little or no implementation by private businesses and the public).

As seen below, a step-by-step implementation of the lockdown may cause a second wave of the pandemic (but is not necessarily the cause of the wave).

At the regional level, in Pskov oblast it is possible not to consider the geographical length factor. At the Russian Federation level, however, this may be a determining factor in the relatively mild course of a pandemic.

Of particular interest is the age structure of the region's population. According to the authors, different age groups may have different contacts with the rest of the population, experience the disease differently and show different mortality rates. Based on data from Rosstat, the population of the Russian Federation and the Pskov region has an established age structure. We will present it in three age groups: children under the age of 15, the working-age population and pensioners over the age of 55.

We note that the first group (children) are almost asymptomatic but have the highest transport activity. Thus, children have a high transmission rate, but a low mortality rate. Note also this group is poorly covered by testing procedures. The able-bodied population has typical statistical indicators - base transport coefficient about 2, with moderate mortality (excluding persons at risk). As with children, this group has weekly and daily rhythms because of the need to go to work. The non-working part of population has the highest mortality, but this is combined with low transport activity.

TABLE 1 AGED GROUPS

	Proportion of aged groups (%)		
	Age 0-15	*Age 15-55*	*Age >55*
Value	20%	53%	27

An additional Simulink block library (SEIR_Lib file) was developed to implement the three-year model. The consolidated block diagram of the model is presented in Fig. 7.
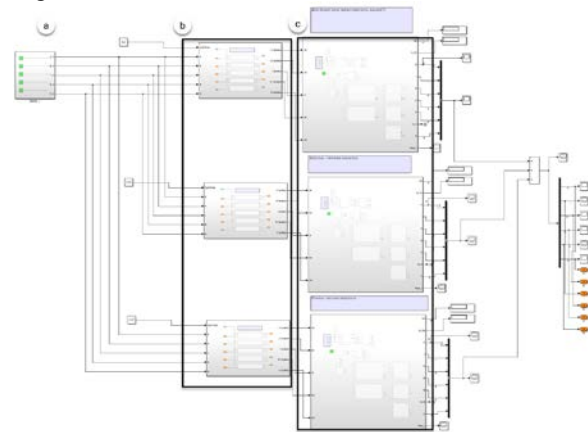
Fig. 7.   Model of epidemics by age structure of population. Here: a) - general population structure, b) - age separation blocks, c) - age-specific agents - private SEIR models.

III.   RESULTS AND DISCUSSION

The results of the simulation can be divided into groups – verifying correctness of the calculations (not mentioned here) obtained in the calculation of deterministic models, by models considering random factors and rhythms of the transport coefficient, Agency models that consider the age structure of the population.

The results are built by MATLAB using Scope blocks part of Simulink.
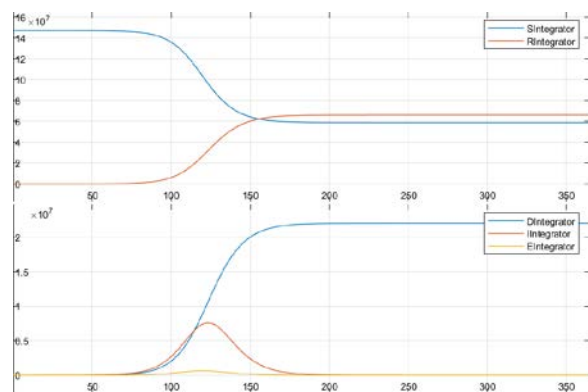
Fig. 8.   Classical SEIR model, fully determined by coefficients.

The results on Fig. 8 reflect the classic course of the epidemic – the increasing wave of infections, the formation of natural immunity and the end of the epidemic [13].

By many sources and as we have seen the model does not explain the emergence of a second wave of pandemics [14]. The figures also correlate with the dates of the first

wave of the pandemic in the Russian Federation and Pskov region, but are several times higher than the statistics.

The authors consider that: 1) The geographical extent of the State is significant, as in fact the first wave of the pandemic affected 2-3 major cities; 2) The population testing strategy affects only populations at risk, for which a potentially dangerous course of disease is possible [16]. The multiplicative effect of these factors can explain the deviation of the calculated results from the observed ones [15].
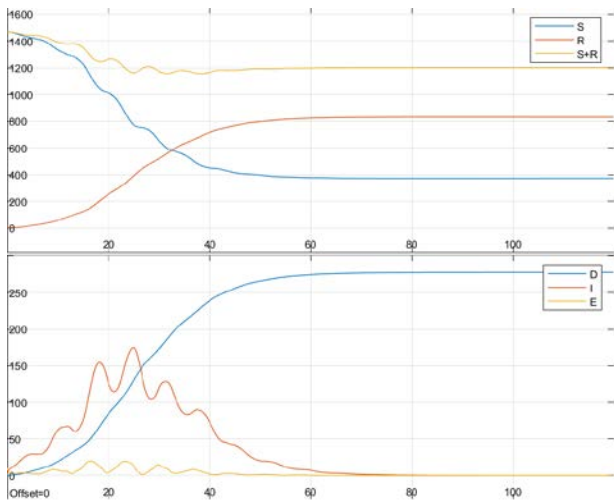
Fig. 9. Erlang-SEIR model considering fluctuations in transport coefficient values (120 days of a pandemic are simulated)

Sinusoidal rhythms that change the transport coefficient cause characteristic sawdust oscillations on the curves of the infected and the recovered. This result allows to simulate similar fluctuations, measured in the count of cured and infected.

However, these fluctuations do not result in a continuous fluctuation in the number of infected persons and therefore do not explain the waves of the pandemic.

a) Count of Infected by day (from https://datalens.yandex/Россия)
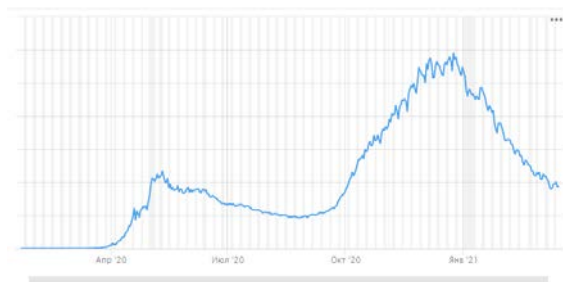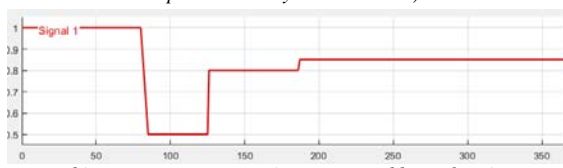
b) state restriction rate (reconstructed by authors)
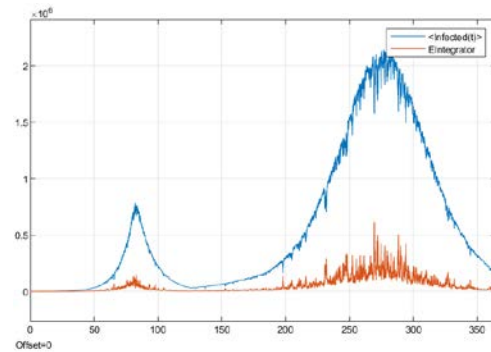
c) Count of infected by day - modeled data (from ErlangSEIRv3_2)

Fig. 10. Comparation of real-world data and modelled effect of restriction

The model demonstrates the emergence of a second pandemic due to the relaxation of restrictive measures by the State. The timing is relative good, but there is still a significant difference in the number of reported cases. The reason for the discrepancy is explained above.
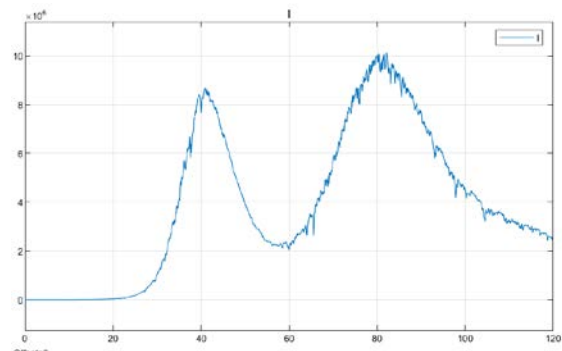
Fig. 11. The bimodal distribution of those infected by pandemic days is modelled considering the behaviour of three age groups, fluctuations in transport coefficient values and excluding restrictive measures (120 days of simulation).

IV. CONCLUSIONS

The presented paper demonstrates a wide range of results that can be obtained using several modified SEER models. The main directions of the modification are:

- The transition from constant coefficients in the system of differential equations (1) to certain functions, such as the sum of harmonic oscillations with periods corresponding to the characteristic rhythms of the population - from day to year);
- Introduction of elements of randomness (additive noise to coefficient values;
- Consideration of State and social control effects (with a multiplicative amendment taking into account the influence of lockdown on the transport factor, see also [17]);
- The formation of agent models in which the selected clusters interact with each other, and

the behavior of the cluster continues to be described by SEER models (the example is given of the division of the population into three clusters by age groups, [18, 19]).

In the continuation of the present work, geographical connectivity between the region and the State must be considered. The influence of mass vaccination processes should also be considered. The authors also propose to add economics-related models to the purely medical aspects.

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Theoretical and Practical Foundations of the Application and Use of the Telematics Solutions for the Development of the National Economy

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Abstract - **The authors' research is interconnected with the socio-economic policy of the Republic of Belarus. Structural components and metrics of economic efficiency in the scientific work are studied based on government demand, which is reflected in the National Strategies for Sustainable Socio-Economic Development of the Republic of Belarus until 2020 and 2030. In addition, statistical data on the activities in economic sectors allows us to identify the most vulnerable areas of business, where telematics solutions can be used as drivers of growth and development. Considering that in the Republic of Belarus there are no fundamental studies on the application of business solutions based on the telematics tools for socio-economic development, the relevance, and reasonableness of the study is subsequently substantiated by economic results obtained from the analysis of the implementation of telematics solutions in foreign practice and in Belarusian business, that's reflecting significant savings and cost reduction.**

Keywords - national economic development, telematics solutions.

I. Introduction

In a transitional economy, socio-economic systems are undergoing significant changes for sustainable development at the micro, meso and macro levels. At the same time, the strongest aspects of the system are considered as the main criteria and foundation for growth, which in the transition period is a driver of development and support for many areas of the economy. Considering the national economy of the Republic of Belarus, in analyzing and substantiating the ways of long-term development, we proceed from the goals and objectives of state program documents describing strategic steps to achieve the final result in the socio-economic sphere. Among these documents is the National Strategy for Sustainable Socio-Economic Development of the Republic of Belarus until 2030, in which the basis for sustainable development and ensuring socio-economic security is the basing of the Belarusian economy on innovative solutions, the effective use of national resources, as well as the country's comparative competitive advantages [1]. If to consider growth and development, which, in principle, are not interchangeable or equal categories, then for their balanced position it will be important to rely on the advanced development of science, the information technology sector, as structures for optimizing the production process, as well as drivers of sustainable development of the national socio-economic systems. In authors' opinion, telematics as a socio-economic category covering the field of informatics and telecommunications can have a significant impact on the long-term and proactive growth and development of the national economy. It was pointed out, that telematics and economic solutions designed on its basis are poorly studied in

Belarusian science. In the fund of the National Library of the Republic of Belarus, there were found only 3 Belarusian dissertations and only in the technical section: S.N. Kandybo considered analytical phototriangulation using the GPS method for determining the coordinates of the design centers of aerial photographs [2], O. V. Kravchenko presented automated systems processing of geodetic information based on the technology GPS-electronic tachometer [3], ON Pisetskaya studied the determination of the shape of the earth using GPS-measurements [4]. As can be seen, the above presented Belarusian fundamental works demonstrate the technical side of the issue of GPS service, which is a part of the structure of telematic solutions. Telematics in technical aspect from the perspective of geodesy and mapping was considered by such researchers as O. Gruber, E. Merrita, F. Acherman (F. F.), L. E. Blankerberg (LE), H. Burman (H. Burman), K. Torlegard K., A. Lobanova, V. I. Pavlov, I. D. Kargopolova, I. T. Antipova, Sh. E. Kuznetsova, S. A. Khmelevsky, S. I Belikov; issues of designing geodetic networks are presented in the studies of Yu. I. Markuze, V. D. Bolshakov, V. A. Kougiy, M. M. Mashimov, A. A. Solomonov, A. S. Yarmolenko, etc. In fundamental research of the Russian school the most relevant works are the following: M. Yu. Ozherelyev, who studied improving the quality of information support for transport and telematic systems in cities and regions using the example of dispatch control of passenger transport [5]; B. Shamsi, who investigated the integration of INS / GPS-GLONASS in order to correct the orientation angles of a moving object [6]; S. I. Dolganiuk presented methods and algorithms for information processing for positioning mobile industrial facilities based on GLONASS / GPS [7]; P.V. Artamonov assessed the durability of load-bearing metal structures of dump trucks using a GPS satellite monitoring system [8]; GV Kiselevich substantiated the structure of information support for monitoring and controlling the movement of vessels using GLONASS / GPS [9]. The above dissertations are valuable in terms of the structural construction of a telematic solution, using it in various areas of socio-economic relationships. Furthermore, as per authors' research, both "telematics" and "telematics solutions" do not have an appropriate definition in socio-economic aspect in Belarusians studies. Therefore, using foreign experience is a valuable opportunity to formulate authors' definition vision. The economic view of "telematics solutions" was presented in the researches of the following foreign scientists: G. Waksman, M. Harkin, O. Tettero, D. J. Out, H. M. Franken, J. Schot, M. Duplaga, M. Leszczuk, K. Zielinski, E. A. de Castro, C. Rodrigues, C. Esteves, A. da Rosa Pires, Shu-Hao, Chin-Yuan Fan, A. Sachez-Macian, J. E. Lopez de Vergara, E. Pastor, L. Bellido, R. Janecki, S. Kraviec, G. Sierpinski, K. Schilling, H. Roth, M. Pajak, L. Muslewski, M. Woropay, Z. Smalko,

II. Materials and Methods

The authors put forward the assumption that telematic solutions can have a positive impact on the socio-economic development of the national economy, thereby being the drivers of growth and development of the national economic system. Research methods include analysis, synthesis, generalization, induction, deduction. The novelty of the research lies in the authors' study of telematics solutions as drivers of the development of the national economy. The exclusivity of the research is emphasized by the lack of existing fundamental works in the Belarusian science on the topic of telematics, considered in the socio-economic aspect.

III. Results and Discussion

At the beginning, it was important to define the main investigation categories: "telematics" and "telematics solutions". It's noted that telematics consists of two interrelated concepts, such as telecommunications and informatics (information technologies). At the same time, telematics is inextricably linked with a GPS tracking technology, which was originated in the 1960s, when the US Department of Defense and the Applied Physics Laboratory of Johns Hopkins University began developing a global positioning system (GPS) [10]. GPS used satellites in the sky and a receiver on the ground to help the US military track military personnel, installations, facilities and equipment. GPS has also improved American missiles, making them more accurate in targeting and airborne control. Basically, telematics is a new concept, and for the first time it was mentioned in 1978 in the work of French scientists Simon Nora and Alain Minc. When writing a report for the French government, they described telematics as the process of transmitting information using telecommunications [11]. In the process of development, the terminology underwent changes, and subsequent formulations were relative to the scope. Analysis of the existing approaches in defining the category of "telematics" showed that in many respects the conceptual apparatus of scientists and researchers is similar in structure, and, at least, means a technology, a set of technological tools or a field of technology. Further, this fundamental approach covers the structure of the telematic complex, considering scope and a type of monitoring objects. At the same time, as a result of the study of the concept of "telematics" as a socio-economic category, the authors come to the conclusion that the definition does not have a universal character and for the topic of the research, should be clarified in the direction of commercialization and business, which is important for the formation of telematic solutions as drivers of the development of the national economy at the micro, meso, macro levels. The authors' definition has not only theoretical value, but also practice-oriented significance in the development, creation and implementation of telematic solutions in the domestic and international markets. Thus, the category "telematics" in the authors'

opinion is presented as follows. Telematics is a related area of socio-economic and information-technological relationships on the matter of creation, development and promotion, as well as the implementation of telematic solutions to meet the various needs of the national economy, taking into account the specifics of market supply and consumers demand. As it can be seen, the above terminology covers the area of related telematics applications. At the same time, for the process of creating telematics products that are interesting to the market and the consumer, an in-depth study of the theoretical and structural components of telematic solutions is essential, among which there is a telematic complex that forms the structure of a telematic solution. The theory and methodology of the formation of economic solutions based on telematic services are interrelated components in the creation, promotion and implementation of a telematics product. Today, there are many approaches to building, managing and marketing a product. The authors share the opinion of O. V. Ilyina on the organization of product marketing management; the concept of life cycle management is among the key components of the researchers' methodology. The model focuses the business on forecasting short and long-term trends in supply and demand, as well as conducting a comprehensive and systematic work to assess the competitiveness of each service and developing control actions to increase its level, planning and developing new services, using an integrated approach to the formation of marketing activities at all stages of production [12, p. 4]. O. V. Ilyina's research is valuable in constructing the structure of marketing problems that arise at the stages of the life cycle of high-tech products. This concept allows to timely respond to changing market conditions, track supply and demand to increase the demand for the product, as well as to improve the tools for its promotion to the market. We understand that with an increase in the quantitative and qualitative level of supply in the telematic services market, the life cycle of a telematic product decreases due to increased competition and decreased demand from the consumer. In studying the parameters of demand and factors influencing it in the process of forming a telematic solution, we consider it valuable to consider the position of A.M. Levin, who represented demand and price factors through the prism of mathematical measurements. According to the scientist, if we analyze the demand curves and supply curves from the point of view of the manifestation of the vector properties of the price, then these properties do not appear, since the price functionally depends on the quantity of goods that is not a vector quantity. At the same time, the economic meaning of A. M. Levin's model is as follows: if a tendency towards an increase in prices is assumed, the buyer will strive to purchase the next quantity of goods or the next batch of goods. The same applies to the situation in the market, when only a downward trend in prices is expected. In this case, the buyer delays the next purchase

of the product, expecting a larger actual decline. The presence of a vector characteristic of the price of a product is manifested everywhere, for example, thanks to advertising, which creates a more favorable direction of the vector towards an increase in the general utility function [13, p. 70]. Among the models of interaction of A.M. Levin, it's suggested to explore his assumption that when considering the free movement of a point-product, it is worth considering the absence of any connections that rigidly restrict its movement in any direction. Using the time axis of the quantity of goods, the scientist represents the nature of the manifestation of dependencies associated with the general utility of the goods and the total costs of its supply in the market [13, p. 84]. We believe that the value of this opinion lies in identifying an additional criterion for the formation of an economic solution based on telematic services, namely the criterion of the value of the product for the consumer, which, in conjunction with price and quantitative factors, determines consumer behavior and subsequent choice. The similarity of A. M. Levin's model can be traced to the studies of such authors as: J. Hicks, who performed a four-dimensional model of interaction between the price of two goods and their quantity [14, p. 106]; A. Marshal, who presented the elasticity of supply and demand; J. Stewart, A. Smith, who identified the relationship between supply and demand in the market [15], etc. It's also been found interesting for the research to overview the concept of the relationship between price and product marketing and the potential benefit to the consumer. The concept structure includes the process of collecting, analyzing, introducing and promotion of a product to the market, seeing changes in market conditions, demand and supply. F.K Kotler, in his concept of a four-level product model, imagined that each element of the aggregate product increases the consumer value of the product - all together they form a hierarchy of consumer value. The purpose of the product is to demonstrate benefits through satisfying a need. Thus, through the formation of an economic solution based on telematic services, the business creator determines what will be valuable components for the consumer in the product structure, what added utility each component will bring individually or in batch use [16]. Another model of F. Kotler, the theory of the "Black box" [17], allows to correctly determine the final composition of the telematic solution. This theory was originally applied to define consumer behavior. An imaginary black box - consumer thinking and behavior at the time of analysis and purchase of goods, works and services. In the telematic business, the "black box", according to the authors, is a space of consumer requirements and needs that must be satisfied by a telematic product or service. Thus, at the entrance, the telematics company analyzes the demand from a potential buyer, identifies his needs and weaknesses of his existing solution, in order to further present a unique offer suitable for a specific client. At this point, we conclude that the final service or product of the telematic business

is directly related to the level of demand and competition among companies offering similar services to consumers. In this regard, the more detailed we approach the analysis of the components of the "black box", the greater our chances of meeting the approval of a potential buyer and making a sale.

Based on the studied existing research and scientific works in the field of formation, marketing and product management, the authors enclosed that, in general, experts focus on the theoretical component of the issue, since it is the foundation for building and promoting a product to the market. Just like in business or in negotiations with a large partner, the creator of a telematics solution must be sure that he has made the necessary preparation for presenting his product, work or service to the market. However, the analyzed models cannot fully represent the necessary steps for the formation of economic solutions based on telematic services, since the telematics field and the components that are included in the structure of telematic solutions require an individual approach in analysis and selection. Our model of the formation of economic solutions based on telematic services is aimed at applied application. The value of the model lies in the detailed and deep study of the issues that arise at each stage of the formation of a telematic solution and the model of its sale and promotion in the telematic market. The advantages of the model:

1. Versatility. It is focused both on existing users / integrators of economic solutions based on telematic services, and on beginners (startups).
2. Fundamentality. Allows you to carry out the necessary preparatory research and study the issues of forming, collecting and implementing decisions based on existing experience, which reduces the risks of making incorrect administrative decisions and increases the chances of project success.
3. Proactivity. The author's model is focused on the prospects for the development of a telematic solution, considering the current situation and future changes, which allows timely monitoring of the competitive supply and socio-economic situation in the region of implementation, and, as a result, to respond to dynamic market conditions to maintain / increase consumer demand.

To form the structure of future telematic solutions, suitable for the needs of the national economy, the authors analyzed the dynamics of the composition and structure of the Belarusian telematics market. It was found out that among the main components of telematics solutions are telecom and IT products, which form the ICT sector in the Republic of Belarus. It is noteworthy that in 2017, in the ranking of the global Index of Information and Communication Technologies (hereinafter referred to as ICT), the Republic of Belarus ranks 32nd out of 176 countries, ahead of neighboring countries Lithuania (41st), Latvia (35th), Russia (45th), Poland (49th place) [18]. This indicator demonstrates the competitiveness of the Belarusian ICT sector. According to the current data, there are 12 Internet providers [19] and 3 mobile operators in the Republic of Belarus, including A1 (owned by Telecom Austria), MTS (part of MTS Group), life :) (part of Turkcell) [20]. Since in the structure of the telematics complex there is a telematics unit, which includes telematics equipment and a SIM card, it is important for us to analyze the mobile communications and Internet market in the Republic of Belarus. The leader in terms of the number of connected subscribers is MTS, which has demonstrated a growth rate of 104% over a four-year period. According to the reporting information from three mobile operators A1, MTS, life :) for the period of 2018-2020, the leadership is held by MTS as a provider of mobile services, which generates a larger volume of revenue in the Republic of Belarus. In our opinion, to understand the reasons for the positive financial and subscriber growth of a mobile operator, it is worth paying attention to the pricing policy, which is one of the important factors when choosing mobile communication services. In general, the analysis demonstrated the price leadership (relatively lower price) of life :), where the average cost of mobile services and Internet services is lower than that of competitors. Nevertheless, it was noticed less demand for this mobile operator among connected subscribers. The reason for this dissonance, in our opinion, lies in the coverage volume (zone of reliable reception) in various settlements of the Republic of Belarus. As of 2021, the maximum coverage is provided by MTS [21], whose zone of reliable 2G, 3G, 4G reception covers almost the entire territory of the Republic of Belarus (all regions), in comparison with the coverage map life :) and A1, which have a zone confident reception will apply only to individual regions and settlements.

Considering that the software is an integral part of the telematics solution, the researches draw attention to the current trend and dynamics in the field of IT in the Republic of Belarus, which will determine the development of the information technology market, including in the development of GPS monitoring systems. As of 2018, the IT sector formed 5.7% of the GDP of the Republic of Belarus (3.1 billion US dollars), for comparison, agriculture and forestry 6.4%, construction 5.4%, transport 5.8%. The volume of exports of IT products and services in 2018 amounted to US $ 3.1 billion [22]. In 2019, the share of the IT sector in the GDP of the Republic of Belarus was 6.5%, demonstrating the largest contribution to GDP growth - 0.5 pp [23]. In 2019, there were detected more than 50 thousand IT specialists in the IT sector. At the same time, the Belarusian IT sector has more companies offering outsourcing services (60%). Considering labor productivity in the HTP as an export per employee, Belarusian experts note that this indicator has grown 4 times since the creation of the High-Tech Park. It is also worth noting that Belarusian IT products and services are in demand in 50+ countries around the world, 91.9% of the software produced is exported [24].

Turning to the analysis of the Belarusian market of GPS monitoring, it is worth noting its low saturation, since according to the authors' calculations using the Google search engine, only 50+ companies with Belarusian and international capital provide GPS monitoring services in the Republic of Belarus, which is slightly more than 1% of all Belarusian IT companies. Among the key market players, it is worth highlighting Gurtam, BelTransSputnik, VISSEN, Unified Navigation System, Omnicomm, Resurskontrol Group of Companies, Lektum Prof. Separately, we note the Belarusian IT company with 18 years of experience in the industry - Gurtam and its commercial platform for GPS monitoring Wialon [25]. Wialon provides a wide range of functions, including fuel consumption control, driver identification, passenger monitoring, notifications, geofences, etc. As of today, 2.8+ million monitoring units are connected to Wialon, the platform supports 2300+ GPS devices from 600+ equipment manufacturers. The number of Wialon partners in 130+ countries around the world has already reached 1900+ [26]. Plus, Gurtam also offers Ruhavik, a non-commercial GPS tracking solution, which is targeted at the end-user segment for monitoring small fleets. Ruhavik has already connected 150,000+ objects in 70+ countries around the world, the number of platform users is 130,000+ [27]. The Ruhavik application is installed on an Android or iOS smartphone and allows a private user or small business to track the location of a car, family members, employees, etc. in real time, receive notifications about the movement and status of the monitored object, as well as analyze reports generated on the basis of data about the monitored object. For a full-fledged GPS monitoring process, a GPS device must be connected to the object, which serves as an intermediary between the satellite and the software, subsequently transmitting data about the state and location of the object for analysis on software (for example, object speed, location, fuel consumption, etc.).

Based on the above data, we established that the telematics market of the Republic of Belarus, formed by telecom and IT sector companies, demonstrates high development indicators, including financial ones, which has a positive effect on the macroeconomic result of the Republic of Belarus. In turn, the Belarusian IT sector can rightfully be called the driver of the national economy, which forms a significant share of GDP and demonstrates high export rates. Thus, solutions based on the interaction of the IT sector and other sectors of the economy contribute to optimizing production processes, reducing costs, as well as rational allocation of resources. The authors' idea is based on the desire to "collect" the existing experience of using telematic solutions that can optimize business processes in companies, as well as help reduce / minimize costs, which is very important for a long-term development perspective. The existing international experience in the use of telematic solutions shows the variety of their application: in the transport,

logistics areas, personal monitoring, control over the state of property or personnel in the service sector, etc. By the way, in 2017 London Economics, a leading independent European consulting company, conducted a large-scale study to calculate and estimate possible losses in the absence of satellite monitoring systems, which are used to determine the location of an object on the ground. By means of a GPS tracker, the data can be received and subsequently transferred to the platform (software), where the user can control and analyze the data received about the object. The agency's study found that the benefits of, for example, GPS-based applications and telematics solutions in the UK rail system are estimated at 11 million pounds per year. And a five-day non-use or shutdown of the system will cause problems for railway infrastructure managers, railroad and freight companies, which is equivalent to direct and indirect losses of 110 million pounds. The most obvious problem is the lack of a centralized system that allows to control routes and rail transport, thereby causing losses due to downtime, delays, etc. [28]. In our opinion, the experience of introducing telematics solutions into the trade, transport and logistics sector could become more relevant for the Belarusian economy. Among the most promising is the experience of using telematic solutions for transport companies in Africa, which made it possible to achieve the following results [29]:

- Savings of $ 45,000 per month as the solution reduced fuel consumption by 40% by controlling speed while driving and reducing theft.
- The business owner / C-level managers got the opportunity to control the transportation chain of valuable and at the same time dangerous cargo in real time, as well as to determine the driving behavior and respond in time to violations of drivers.

The experience of the Russian business in refrigerated transportation focuses on the effectiveness of telematics solutions due to the ability to control temperature conditions, which is a key factor in the successful transportation of goods requiring special temperature conditions, for example, ice cream, medicines, flowers, etc. In this case, the problem of damage or loss of cargo is eliminated by notifications about violation of the temperature regime. As a result of the introduction of a telematic system, the company reduced fuel costs by 18%, reduced operating costs, and also reduced the cost of expensive regular temperature recorders by 1.3 million Russian rubles due to the expert installation of high-quality equipment by a system integrator [30].

In the meantime, according to analysts in May 2020, the Belarusian consumer also prioritized food delivery services, which were second in the top 5 list. Bookmakers are in the lead. At the same time, Belarusians paid for food delivery during April 2020 by 31-37% more often than last year. The coronavirus situation and the general lockdown / self-isolation have played into the hands of the

delivery services [31]. Along with the arrival of greater consumer demand, uncertainty and delays also appear due to the unwillingness of the business to instantly re-profile from offline to online modes, as well as to organize competently the service, while controlling the process of transporting orders, as well as the quality of their work by couriers. Thus, according to the authors, the use of telematic solutions in services for the delivery of goods or food is a tool for optimizing operating costs, increasing control over the delivery of goods, as well as reducing costs. An example is the experience of Papa John's pizza chain, which, in addition to a telematics solution, also uses the iiko restaurant business automation system to control production facilities and finances. The integration of the fleet management system with the iiko platform allowed reducing the time spent on processing customer addresses, as well as creating routes for order delivery and their distribution between drivers. In addition, the integrated solution allows you to track the status of the vehicle fleet of the delivery service (busy / free) with the aim of optimal and timely distribution of cars to couriers for subsequent transportation of the order to the client [32]. It should be noted that the above telematics solution can be applied not only to the pizza delivery service, but also in any restaurant services, or it can be adjusted to the needs of e-commerce delivery.

IV. Conclusions

As a result of the research carried out within the framework of the dissertation work, the author concluded that the structural and comprehensive study of the issue of the application and use of telematic solutions in the national economy is not only relevant, but also important in the Republic of Belarus both at the macro and micro levels. In the process of studying the field of telematics and solutions based on it for socio-economic development, we solved the following tasks:

1. In the process of researching existing approaches to defining the category of telematics, the author formulated a complex definition that reflects the whole essence of telematics as a component of the socio-economic system.
2. As the results of studying the structure of a telematic solution have shown, it is multifaceted and involves many components, each of which has its own functional and value load in the process of collecting, processing, transferring data about an object. At the same time, the Belarusian scientific school does not define the category of a telematic solution, and therefore, the author's approach is one of the provisions put forward for defense.
3. The choice of an effective methodology for the formation of economic decisions based on telematic products and services is one of the key factors in obtaining a positive result from the application.

4. The structural component of the telematic market of the Republic of Belarus includes IT and telecom companies. Based on the authors' analysis, it was revealed that the activity of the data forms a significant positive contribution to the development of the national economy through an increase in the macroeconomic indicator. Thus, being the drivers of socio-economic development, IT, telecom and solutions based on the interaction of these areas can be a tool for the development of various areas of Belarusian business in the long term.
5. The study of indicators of sustainable development of the national economy showed that the Belarusian model of socio-economic growth provides for an emphasis on the introduction of innovative technologies in traditional sectors of the economy in order to increase their competitiveness.
6. The current state of some Belarusian economic spheres and the analysis of their activity at the macro level showed negative changes that affected the spheres of logistics, transport and trade. Considering the negative growth rates of these areas, we propose to consider telematic solutions that contribute to the optimization of business processes, as well as to reduce / minimize costs.
7. Analysis of the international practice of introducing telematic solutions into the activities of various business areas showed a significant reduction in costs, as well as opportunities for optimizing business processes and interaction in the organization. Ready-made cases of using GPS monitoring systems and a telematics unit allow you to proactively assess the possibilities of using similar solutions to minimize costs and optimize transport / logistics or business in the field of trade with a delivery service.
8. Theoretical and practical analysis of drawing up a telematic solution for specific sectors of the economy showed that with a high-quality setting of all system components, as well as using the necessary set of options and equipment, the organization saves up to 14% on reducing costs from the quality of driving drivers and fuel costs.

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COVID-19 and Education Management: the Case of Silesian Region - Poland

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Abstract - **COVID-19 outbreak has changed the economic and social relations and caused a critical impact on the higher education system. The closure of University campuses to prevent community transmission of the Coronavirus SARS-CoV-2 has shifted face-to-face classes to online learning, distance learning, e-learning, mobile learning, and social learning. E-Learning and virtual education may become an essential component of the higher education system in the next years. Accordingly, teaching staff had to adapt their teaching methodology and tools to eLearning tools and platforms for effective student engagement.**
This paper reports on a first study conducted from December 2020 to January 2021, involving one hundred Higher Schools teachers of Management in the Silesia Region.
The study showed many serious problems related to the emergency teaching-learning experience since it was essentially based on the translation of face-to-face approach in the online environment.

Keywords - Remote teaching-learning, e-learning, Information Technology in education, Social media.

I. INTRODUCTION

When COVID-19 became a global pandemic in March 2020, most school systems began closing down. Since March, universities worldwide have postponed or cancelled all campus events such as workshops, conferences, sports, and other activities. They raced to transition their courses and other educational programs from face-to-face to remote teaching.

In April, UNESCO estimated 1.5 billion students were no longer attending lessons in a physical classroom [1].

The remote teaching modality was addressed as *emergency remote teaching* (ERT) to underline that it was extemporary, adopted under necessity [2], and different compared to e-learning in normal circumstances.

Due to the lockdown, the situation at higher education institutions appeared immediately critical. Although quite a few of them have had already introduced Learning Management System (LMS) platforms, such as Backboard and Moodle, they were not ready to start with a massive remote teaching experience.

Accordingly, the transition to online learning created several problems forcing most of institutions to upgrade their information technology (IT) infrastructure quickly, train and support teaching staff in using software tools, and deal with new modalities for exams.

It was challenging to define suitable new procedures for administrating online courses as well as monitor students

when they were online and ensure they do not cheat during online tests. Moreover, laboratory activities were not possible to conduct remotely, and not all students necessarily got a fast internet connection. Finally, while universities closed campuses, many students do not have any other alternative accommodation facilities.

In general, the experience of ERT showed several issues. It demonstrated that adopting an online learning environment is not just a technical question but poses pedagogical and instructional challenges [3, 4, 5].

In the last few months, many surveys and case studies have been carried out to evaluate the impact of ERT on educational systems [6, 7, 8]. They mostly focused on the teaching staff and students' evaluation of ERT experience as well as the assessment of online teaching-learning practices.

The desk research carried out for this paper shows that:

- Teachers adopted in remote teaching the same modality they used in normal face-to-face modality.
- Students and teachers generally agree to continue with remote teaching-learning, but they pointed out on the disadvantage of the loss of interaction.
- Many teachers complained that students were passive, and often they switched off the webcam, claiming it slowed down the internet speed.

Data from surveys indicates that there is a general consensus that ERT has been a unique and significant experience, although the organization of remote classes and virtual exams, as well as of the various bureaucratic activities proved very challenging [9, 10, 11, 12, 13, 14, 15]
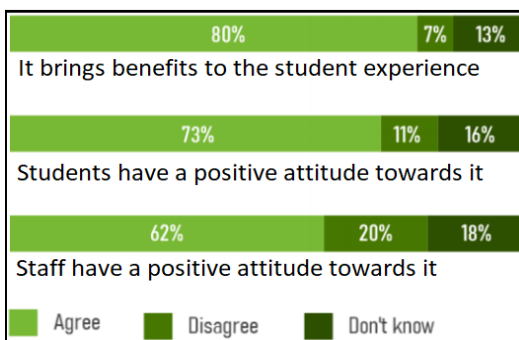
Fig 1. Position of higher education institutions towards digitally enhanced learning and teaching (source: Gaebel, Zhang, Stoeber, & Morrisroe, 2021, p. 44)

A survey conducted from April to June 2020 by DIGI-HE, a European Union co-funded project, shows (Figure

1) that, in general, acceptance by higher education institutions on digitally enhanced learning and teaching has grown, and they widely acknowledge the benefits it brings to the student experience [16].

However, ERT also brought out discrimination and psychological health issues.

A recent survey conducted by McKinsey on school teachers in several countries (Australia, Canada, China, France, Germany, Japan, the United Kingdom, and the United States) shows that teachers agree on the high cost of remote learning, especially for vulnerable students [17].

It has also been argued that remote teaching-learning caused a tremendous stress level among students with unfavourable effects on their learning and psychological health [18].

II. METHODOLOGY

A survey was conducted from December 2020 to January 2021, involving 100 teachers of Management in various Universities in the Silesia Region.

The questionnaire analyses the institutional support in the learning process during the early months of the Higher schools lockdown to assess and evaluate the current situation caused by COVID-19. The Google forms tool has been used to create an online questionnaire providing a hyperlink to teachers interested in participating in the survey.

The results available through Google sheets have been transferred to Statistica 13, a software developed by StatSoft, Inc.

The survey's questionnaire used both single and multiple-choice questions, while the χ^2 test was used to compare observed and expected frequencies from the survey results.

III. RESULTS AND DISCUSSION

The teaching staff and adult educator trainers who responded to the questionnaire confirm using their PC or laptop to provide lectures and workshops during the pandemic time. Nearly all of them [87%] affirm that they had only access to their PC for preparing their teaching materials. While 80% reportedly used their PC or Laptop for delivering the content of their lessons, only 14% used smartphones. The main reason for this low score is the difficulty of presenting the PowerPoints and other materials without using a touchpad and mouse.

87% of respondents claimed they would like to use their laptop or PC for lessons and training, only 4% would be interested in using a business PC, and 6% smartphones.
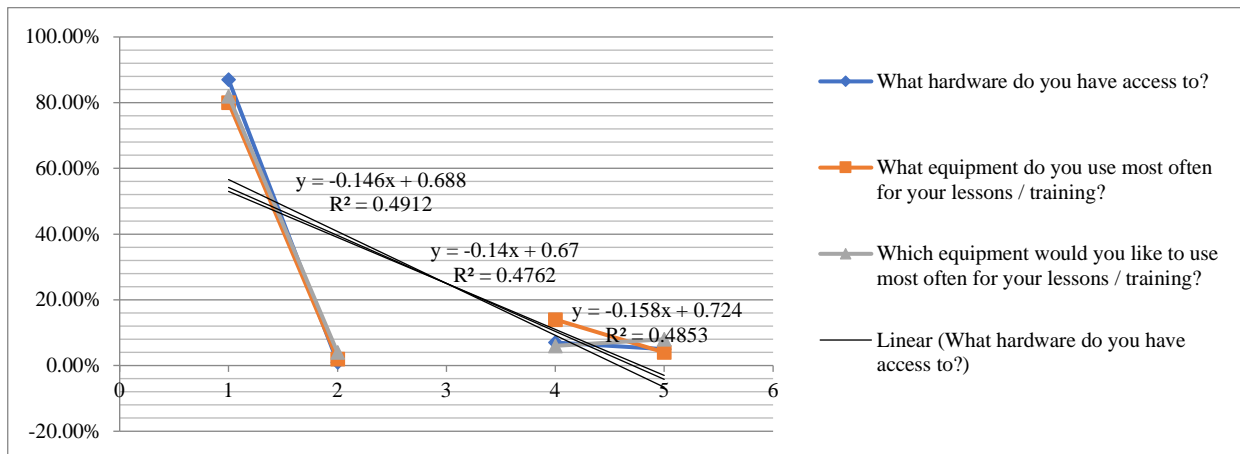
Fig 2. Tech devices used by teachers

In order to check the respondents' online behaviour, a chi2 test was carried out.

Most respondents used online libraries (91%) for internet searches (95%). This answer was followed by social media portals and video channels. Other digital education tools such as cloud-based software, social conferences, were not preferred as much as the other favoured options focusing on search engines, social media portals and video channels.
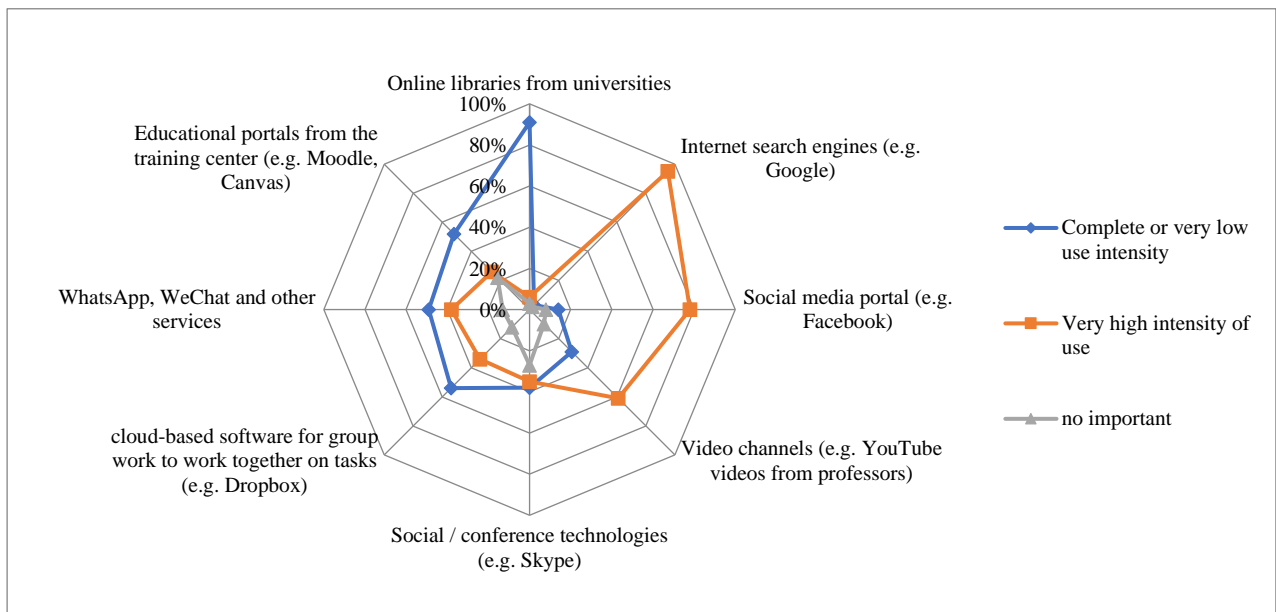
Fig 3. Digital Education Tools for Teachers

In order to communicate with the student teacher, applications such as zoom are most often used (100%), the instructors also use social media in about (50%), the classic form of communication such as E-mail is still often used about 60% of the time, and it is definitely more often than a phone call (20%). For communication, teachers still use text messaging such as We chat (30%) of the respondents.
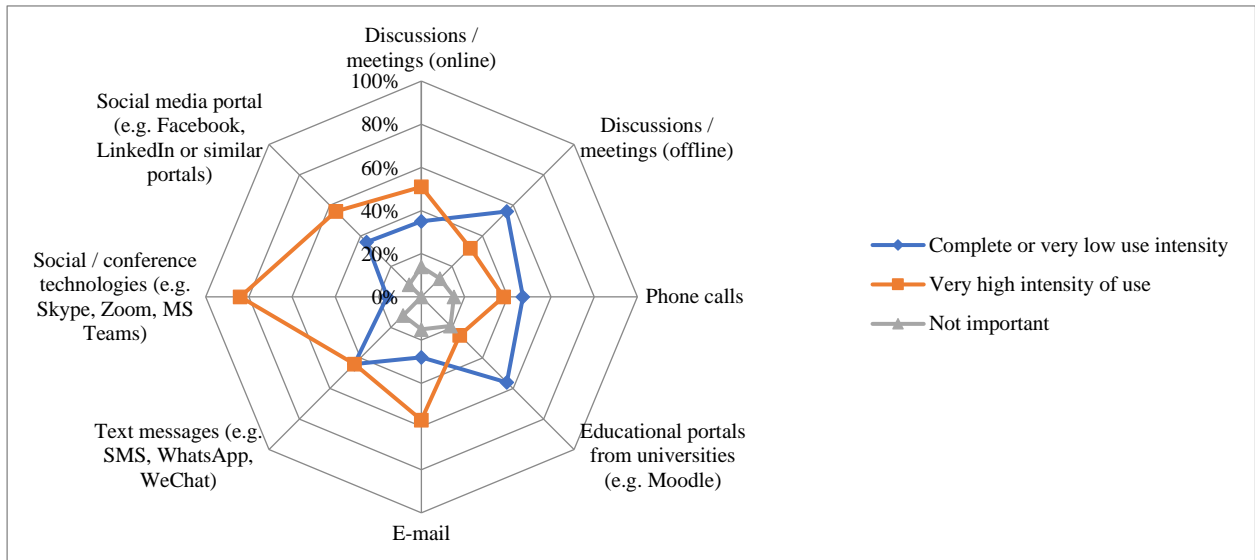
Fig 4. Technology teachers use to communicate with their course participants / students

The questionnaire also aimed to identify the institutional support in the learning process. More than half of the participants were found to be very satisfied about the possibility of using selected technologies in studies / project and communication (59%) and their own level of competence when using technology.

Almost half of participants also found the lecturers' use of technologies that support the learning process (47%); however, for 31%, the lecturers' use of technologies is not satisfactory.

With 44% and 42% of dissatisfaction ratios respectively, availability of university support services (e.g. IT Support Centre) and availability of information technology in an educational institution (e.g. computer lab) indicated low levels of satisfaction among the participants.
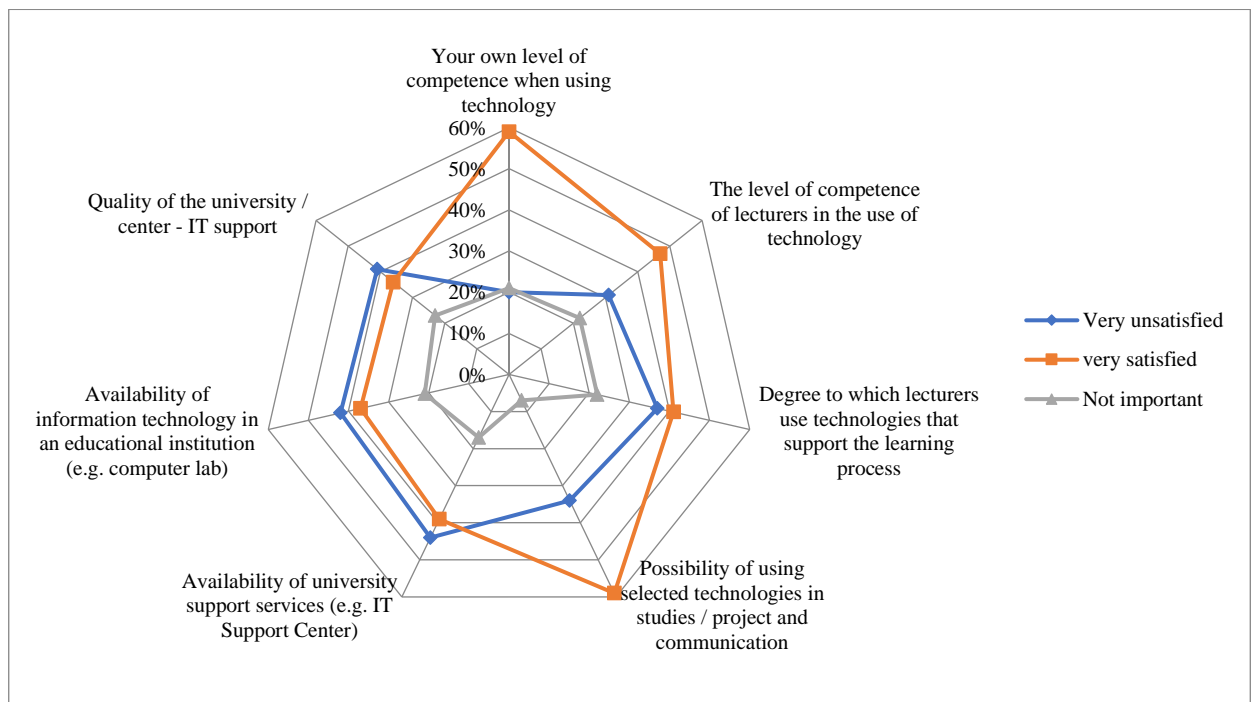
Fig 5. Institutional support in learning process

Analysing the results, it can be concluded that the dominant social networking site is Facebook – 90% most often people use it for every application. Another website is Instagram, most often people upload their photos 35%, interestingly, when commenting on content, twitter 11% is used more often than Instagram 7%. Summarizing the results, it can be said that the most favourite medium is the Facebook, it is the most used in each case. Then Instagram, but twitter is used for commenting.

	Viewing and reading content	Like content	Commenting on content	Content sharing	Posting photos	Posting a message	Networking
Facebook	90%	90%	90%	85%	84%	90%	83%
Snapchat	19%	11%	7%	21%	35%	18%	8%
Twitter	20%	11%	11%	9%	4%	7%	5%
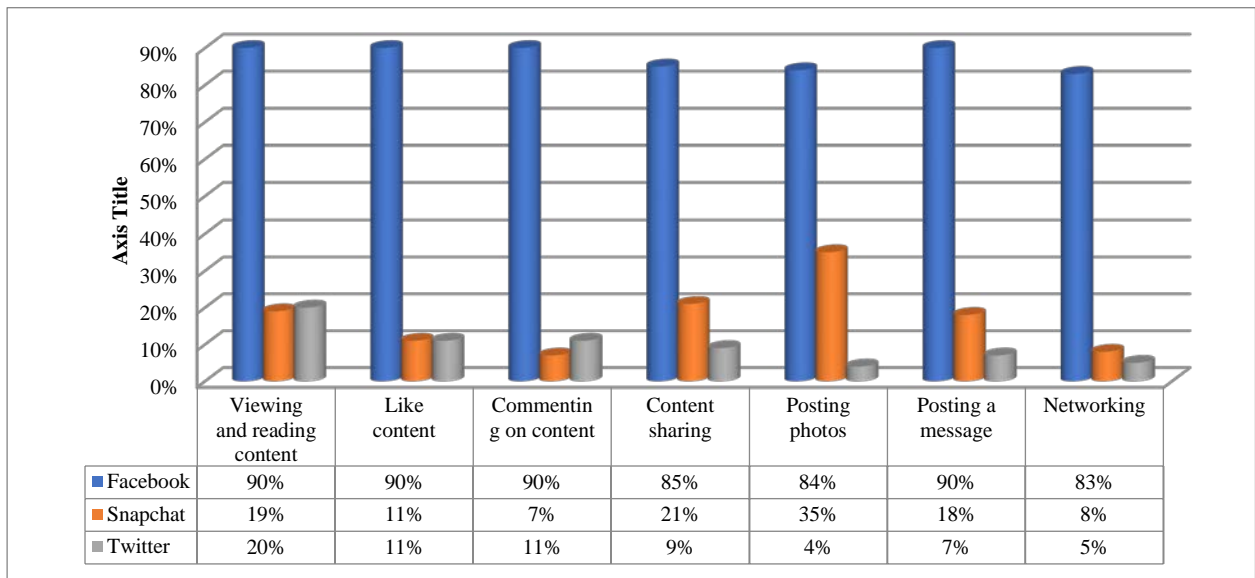
Fig 6. Social Media channels' use

The majority of respondents did not provide any information about the workplace 92% of respondents, only 8% of respondents can observe such a phenomenon. In order to learn more about the impact of corona virus on education, we recommend repeating the study after completing the pandemic. As a result, the impact on teachers and education can be better identified.
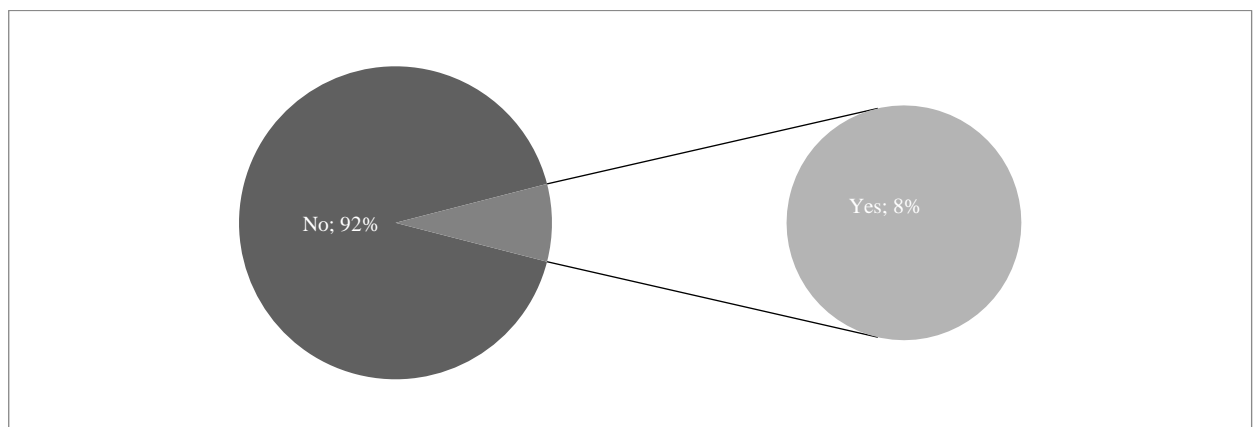
Fig 7. Placing information about the place of employment on a private profiles

IV.   CONCLUSIONS

In the current epidemiological situation, one should be particularly careful and remember sanitary and epidemiological requirements. Safety and quality of teaching must be given priority by every university; while improving the quality of educational services.

Summing up, it should be added how a vital role in teaching is played by establishing a relationship with the student - the social aspect of entering a relationship and learning.

This article showed the difficulty of establishing a relationship with students and encouraging them to participate in classes actively.

Lack of direct contact with the teacher hinders the learning process; because classes at universities should be carried out synchronously and involve both lecturers and students. The pandemic's time had the potential to revolutionize higher education, but it failed, and faculty failed to transfer the lecture and practice model to the internet. No cameras are turned on. Students are reluctant to enter into discussions. Anonymity and one-sided broadcasting of messages lower the level of higher education.

Research shows that teachers do not receive the expected support, both technical and psychological, and are left alone with the choice of tools, channels, and educational platforms. From the presented results, it emerged that students "join", for example, to the zoom platform or teams; however, they are reluctant to use contact, e.g., by phone - to establish a direct conversation with the lecturer. Despite the diagnosed and identified challenges, the COVID-19 pandemic could provide students with an impetus to exponentially develop their self-study skills.

The academic staff of universities should actively encourage students to remain resilient and able to adapt in the face of a pandemic, as this may inculcate in students the necessary attributes on the labour market, e.g. working in remote teams in organizations or virtual organizations [19]. Acquiring these traits can enable students to deal with uncertainty and continue their lifelong learning process more effectively. Greater support for students can increase their learning ability and academic performance as students receive advice on strategies to better cope with academic stress [20, 21].

A new survey has been planned for the next months on the same group of people. It aims to analyse the changes that occurred in their teaching-learning experience.

Indeed, the COVID-19 pandemic caused a profound, structural change in higher education. There is the opportunity to improve online teaching-learning.

However, a research effort is needed to create effective online environments in which teachers and students can enter into a relationship.

Moreover, what will higher education be after the epidemic?

This question is an exciting research theme for the near future.

V. ACKNOWLEDGEMENTS

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Event-Driven Management of Economics and the Exit of Economics from Stagnation

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Abstract - **The work describes the developed cortege and mathematical model for managing the quality of development and exit of the system from stagnation. The scientific problem of economics development is formulated on the basis of artificial intelligence, algebra of logic and logical-probabilistic calculus.**

Keywords - Development, stagnation, model, system, economics, event-driven management, cortege, quality criterion.

1. Introduction

Academician A. G. Aganbegyan indicate that the way out of stagnation is the most difficult process of the country's economics crisis [1]. The country's economics has been stagnating for over 20 years. Scientists-economists offer different approaches based on the successful experience of other countries. But agreement and a single solution are no found, and stagnation continues.

The theory of managing economics and the state is unsatisfactory. She has no fundamental achievements. In recent years, Nobel Prizes in economics have been awarded to papers that have not made a significant contribution in economics science. Management in the modern economics is carried out without mathematical methods and models, on the basis of adjustment and regulation, "by concepts", "manual control", "give more money", advice, promises and measures. Management of economics and the state is carried out exclusively "from above" which leads to corruption. We can say: "Faith served us as a shield for the mind. But then we need the science of granite". This work is devoted to solving this problem.

Event-driven management of economics is proposed, focused on improving the quality of economics, the state and human life [2]. Event-driven management is the artificial intelligence technique. Event-driven management is based on the algebra of logic and logical-probabilistic calculus (LP-calculus).

The scientific novelty of the work is as follows:

- The definition of Boolean event-propositions has been expanded and the measure of invalidation is defined as the probability of failure. We use estimates of the probabilities of events on based of invalidity, non-numerical inaccurate and incomplete expert information [3], identifying a logical-probabilistic model of failure on statistical data [4].
- Developed the cortege to describe the system of event-driven management of the quality of economics. Created a unified set of tools for managing the quality of economics and the state in the digital economics.
- A mathematical model for managing the quality of development and exit of a economics from stagnation has been developed.

II. Event-Driven Management of the Economics Quality

Event-driven management is a method of artificial intelligence [5]. Management objects are structurally complex systems and processes in economics. Event-driven management based on logic algebra and LP-calculus. The event-driven management of real systems and processes is considered. Management components are subjects (who solves the problem), objects (what tasks are being solved) and infrastructure. In event-driven

management, arithmetic and logical calculations have great complexity are performed. Therefore, a computer and special software are used. Event-driven management is carried out any L-complexity of the system.

The formulation of a new scientific direction required a transition to a qualitatively new level of outlook and the introduction of new knowledge and new tasks for managing the quality of economics and the state. Proposed event-driven management of the quality of economics and the state "from above" and "from below" based on artificial intelligence.

In event-driven management, the management of the quality of human life considered for the first time. The quality of a person's life is presented in the form of L-addition of the quality of his life processes. Quality management of life processes (treatment, education, decision-making) and the construction of appropriate models is carried out with the participation of the person himself. Models give results for management from below, which are at the same time feedback for management from above.

Event-driven management of the quality of the state and economics (systems and processes) is based on events. We consider invalid events, meaning the deviation of the system parameters from the requirements and norms. Different systems and processes can have common triggering events and this ensures their connection. LP-risk models of different systems can simply be logically combined into one common LP-risk model, on which to solve the problems of assessment, analysis, forecasting and management of the state and development of a large system. The characteristics of event-driven management of quality are as follows:

- The event-driven management system is described by the proposed cortege.
- Event-driven management of systems and processes is carried out on the LP-model according to the quality criterion.
- Problems are solved for any complexity of the logical model of the system.
- Event-driven management allows to obtain quantitative estimates of the quality and contributions of initiating events to the values of the criterion.
- Operations of logical-probabilistic calculus are performed with both logical variables and logical functions.
- The logical functions of risk (failure) have neither coefficients nor degrees.
- The dynamism of LP-models of safety and quality is ensured by correcting the probabilities of initiating events in response to signaling events.
- The dependence and connection of various systems (models) ensures the correct accounting of repeated events in the systems that are included in a large system.

III. THE CORTEGE OF THE SYSTEM OF EVENT-DRIVEN MANAGEMENT OF THE QUALITY OF ECONOMICS

The cortege of the quality management system of economics and the state includes the following components:

– $S = \{S_1, S_2, S_3, S_4, S_5\}$ – Objects, Criteria, Knowledge, Tasks, Provisions;

– $S_1 = \{S_{31}, S_{32}, S_{33}, S_{34}, S_{35}, S_{36}, S_{37}, S_{38}, S_{39}\}$ – New management objects: Ministries, Social-economics systems, Enterprises and companies, Safe living space, Quality of human life;

– $S_2 = \{S_{21}, S_{22}, S_{23}\}$ – Criteria for quality, safety, efficiency;

– $S_3 = \{S_{31}, S_{32}, S_{33}, S_{34}, S_{35}, S_{36}, S_{37}, S_{38}, S_{39}\}$ – Subjects (who decides): President, State Duma, Federation Council, Government, Banks, Business, Scientists, Public Opinion, Person;

– $S_4 = \{S_{41}, S_{42}, S_{43}, S_{44}, S_{45}, S_{46}, S_{47}, S_{48}, S_{49}\}$ – New knowledge: Methodological foundations, New Boolean events-propositions, LP-models, Public opinion, Special Software, Technology, Probabilities of Events, Continuing Education Course;

– $S_5 = \{S_{51}, ... S_{5i}, ... S_{5n}\}$ – New tasks;

– $S_6 = \{S_{61}, S_{62}\}$ – Provisions: LP-calculus, Unified set of tools for the Digital Economics.

Let write components of the cortege in more details:

– $S_{15} = \{S_{151}, S_{152}, S_{153}, ... \}$ – Quality of human life: processes of treatment, learning, decision-making;

– $S_{43} = \{S_{431}, S_{432}, S_{433}, ...\}$ – New Boolean events-propositions in management: about the failure of subjects, about the failure of objects, about signaling events in economics and politics, about invalidity, about conceptual forecasting, about danger and legitimacy, about groups of incompatible events;

– $S_{44} = \{S_{441}, S_{442}, S_{443}, ... \}$ – New risk models: structural and logical, according to statistical data, hybrid, invalid, conceptual, indicative, development management, quality of management systems, living space, human life, exit from stagnation;

– $S_{45} = \{S_{451}, S_{452}\}$ – Public opinion: Management "from above", Management "from below";

– $S_{46} = \{S_{461}, S_{462}\}$ – Special software: *Arbiter, Expa;*

– $S_{47} = \{S_{471}, S_{472}, S_{473}, S_{474}\}$ – Risk technologies: procedures for constructing risk LP-models, model analysis, forecasting on a risk model, risk management;

– $S_{48} = \{S_{481}, S_{482}, S_{483}\}$ – Estimation of the probabilities of events by: the invalidity of indicators, identification of the risk model using statistics, non-numerical, inaccurate and incomplete expert information;

– $S_{49} = \{S_{491}, S_{492}\}$ – Additional education course: lectures and laboratory work.

In [6 - 10], the components of the cortege of the quality management system of economics and the state, new knowledge and new tasks to be solved are considered in detail. For the quality management system of economics and a government of a region and an enterprise, a similar map should be used with components and tasks of the appropriate level.

IV. MANAGEMENT OF THE DEVELOPMENT OF A SYSTEM TO EXIT FROM STAGNATION

The list of new effective problems in economics (see the cortege) is as follows [2, 11]:

1. Modeling, analysis and quality management of one and several logically integrated systems.
2. Taking into account the effect of repeated events on the quality assessment of the integrated system.
3. Analysis of different outcomes of quality management of subsystems in a complex system.
4. Monitoring and management of the bank lending process.
5. Counteracting bribes and corruption.
6. Safety management of the living space.
7. Managing the quality of human life (processes of treatment, education, decision making).
8. Event-driven management of the economy's exit from stagnation, etc.

These tasks are not formulated either in the plans of the government of the country, or in the national projects "Digital Economy" and "Artificial Intelligence", or in the priority fundamental scientific research areas of the Russian Federation and the Russian Academy of Sciences.

The formation of a new scientific direction in the management of the quality of economics and the state required a transition to a new level of worldview and the introduction of new knowledge and new tasks.

Below we consider in detail only one new important task of economics "Event-driven management of the system to get out from position of stagnation".

Stagnation (Latin stagnatio – immobility, from stagnum – stagnant water) is a state of the economics characterized by stagnation of production and trade for a long period of time. Stagnation accompanied by an increase in the number of unemployed, a decline in wages and living standards of the population. It is expressed in zero or insignificant growth rates, unchanged structure of economics, its immunity to innovations, scientific and technological progress [1].

Stagnation occurs during the transition from a command-administrative to a mixed economics and is a consequence of the economic mistakes of governments, ignorance of economic laws. In particular, in economics of the post-Soviet states in the 1990s, stagnation manifested itself in a sharp decline in production and

investment activity, physical destruction of productive forces, primarily in the scientific, technical and intellectual potential of society, as well as a devaluation of motivational incentives for productive work. The crisis has engulfed the sphere of finance and money circulation. The crisis of non-payments was especially acute. Due to the lack of competitive goods, the post-Soviet countries were unable to quickly integrate into the international market system. At the same time, the national economic complex of the country and economic ties between industries were destroyed.

In fact, the author first developed a stagnation management system in 1982 in his doctoral dissertation (Institute of Cybernetics, Kiev). In the work "Fundamentals of building systems for automated debugging of complex technical systems", the author studied systems of debugging tests of free-piston engines, which were destroyed within up to 1 min after starting. To establish the factors that led to the destruction, it was necessary to have time to measure several parameters. For this, the test bench was equipped with artificial systems in order to implement a significantly less intense thermal and dynamic mode of starting and operating the engine. So it was possible to measure the parameters and build a model of the heat-stressed state of the engine. At the subsequent stages of testing, artificial systems at the stand were gradually removed.

Engineering test management is the management of stagnation in economics. Fig. 1 "Stagnation management scheme" taken from the thesis. Economists who are solely concerned with profits, not the quality of life of the population, and without knowing the algebra of logic, have not noticed the widely published results. Economic science has become smaller in the country - there are many institutes, research centers, experts and consultants. The problem of managing the quality of economics and the state is complex at the intersection of technology, economics, management and artificial intelligence. Complex problems are not solved in the country. Academician V. M. Glushkov would say now: with such an economics and economists one can live to the Stone Age.

The scheme of economic quality management during the process of overcoming stagnation. In fig. 1 the X-axis is the time (months) of the economic development process, the Y-axis – the values of the R criterion of economic failure, *A–B* – the planned trajectory of changing the economic failure criterion, stages of development *j=1, 2, …, n*.

Let us use the following variables for the construction of models: Z_j – the factors denoting the state of economics, U_j –controls, W_j – infrastructure of the country. Variables *Z, U, W* and their components are presented by events and logical variables.

R criterion is calculated at each stage; the contributions of events-factors and controls into

economic failure are analyzed. Values Z at stages n are determined in the management of the process of economic development. Controls U, W are realized while resources are spent.

The state of economy can be treated as an event of validity (success) with probability P, as well as an event of non-validity (failure) with probability $R = 1 - P$. Below, in order to make manual calculations simpler we use system validity, although *the Arbiter* software complex uses the non-validity of a system (factor) more often.

The system which controls the process of overcoming economic stagnation includes the following components: objects of management (economy, systems, industries), subjects of management (state officials, specialists, scientists), factors of economic quality, natural management factors (investments, taxes), artificial management factors (loans, R&D agreements), infrastructure (connections and functions of ministries in the government).

Let us use the following logical model (function) of the success of controlling the process of overcoming economic stagnation:

where:

Z is the model of the validity of the state of economics,

U is the model of the success of controls for overcoming economic stagnation,

W is the model of the success of infrastructure needed for overcoming economic stagnation.

The model of the validity of the state of economy. Let us use the following notation of the factors of the quality of economy:

1) the initial state of economy A is described by the following factors: $Z_{1\,beg}$ – the number of unemployed, $Z_{2\,beg}$ – average salary, $Z_{3\,beg}$ – standard of living, $Z_{4\,beg}$ – rates of industrial growth;

2) the final state of economics B is described by the values of factors: $Z_{1\,end}$, $Z_{2\,end}$, $Z_{3\,end}$, $Z_{4\,end}$.

3) minimum values of factors $Z_{1\,min}$, $Z_{2\,min}$, $Z_{3\,min}$, $Z_{4\,min}$.

4) maximum values of factors: $Z_{1\,max}$, $Z_{2\,max}$, $Z_{3\,max}$, $Z_{4\,max}$.

Let us denote Boolean events-propositions about validity of factors by logical variables Y_1, Y_2, Y_3, Y_4. Normalized values of variables, taking into account the nature of their monotonicity in relation to the quality of economy, equal:

The value of variables Y_1, Y_2, Y_3, Y_4 are treated as

$$Y_1 = (Z_{1\,init} - Z_{1\,final}) / (Z_{1\,init} - Z_{1\,min});$$

$$Y_2 = (Z_{2\,final} - Z_{2\,init}) / (Z_{2\,final} - Z_{2\,min});$$

$$Y_3 = (Z_{3\,final} - Z_{3\,init}) / (Z_{3\,final} - Z_{3\,min});$$

$$Y_4 = (Z_{4\,final} - Z_{4\,init}) / (Z_{4\,конх} - Z_{4\,min}).$$

probabilities of their validity P_1, P_2, P_3, P_4.
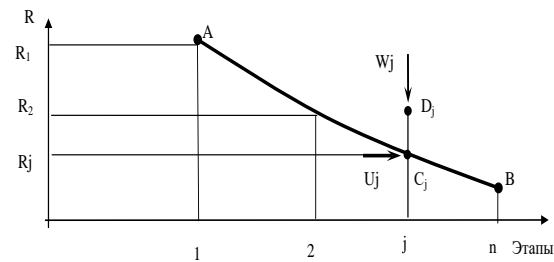
Fig. 1. The scheme of economic development management with the aim of overcoming stagnation

The scenario of economic validity: the event-validity of a system happens due to any single factor, any two factors, or events-validity of all factors. The scenario is written down as a logical function of economic validity at the stage:

$$Y = Y_1 \wedge Y_2 \wedge Y_3 \wedge Y_4.$$

The probabilistic function (criterion) of economic validity at the stage:

$$P_Y = P_1 P_2 P_3 P_4.$$

The criterion of economic non-validity at the stage:

$$Ry = 1 - Py.$$

Non-validity of an economic factor is the deviation of its value from the set one. Non-validity characterizes a loss of quality. The values of criteria of validity and non-validity of economy at any values of probabilities P_1, P_2, P_3, P_4 belong to the interval $\{0, 1\}$. During analysis we calculate quantitative contributions of factors Z_1, Z_2, Z_3, Z_4 into the criteria of validity P_Y or non-validity R_y of economy. They depend on probabilities P_1, P_2, P_3, P_4.

The model of the success of controls for overcoming economic stagnation. Natural controls include:

U_1 – investments,

U_2 – taxes,

U_3 – involvement of state officials, specialists, scientists and public opinion.

Artificial controls include:

U_4 – loans,

U_5 – R&D agreements about the development of the program for overcoming stagnation and analysis of results.

The author does not possess information about the structure of the government and the connections within it , therefore, a single parameter W_1 – the influence of infrastructure is used.

Let us denote controls U_1, ..., U_5 and the influence of infrastructure W_1 by events and logical variables Y_5, Y_6, Y_7, Y_8, Y_9, Y_{10}. Their probabilities P_5, P_6, ..., P_{10} of overcoming stagnation successfully will be assessed by non-numerical, inexact and incomplete expert information [11].

In this case the logical model of the success of controlling the process of overcoming economic

stagnation, using the model (19) obtained previously at the stage will be written down:

$$Y = Y_1 \wedge Y_2 \wedge Y_3 \wedge Y_4 \wedge Y_5 \wedge Y_6 \wedge Y_7 \wedge Y_8 \wedge Y_9 \wedge Y_{10}. \quad (1)$$

The probabilistic model of overcoming stagnation successfully by a system at the stage:

$$P = P_1 \ P_2 \ P_3 \ P_4 \ P_5 \ P_6 \ P_7 \ P_8 \ P_9 \ P_{10}. \quad (2)$$

The process of overcoming stagnation. Let us describe the process of the management of overcoming stagnation.

At stage 1 the logical model of success Y of the system overcoming stagnation is built:

$$Y^1 = Z^1 \wedge U^1 \wedge W^1.$$

Success criteria P^1 and failure criteria R^1, as well as the contributions of components Z, U and W into criteria are calculated. After we select and apply new controls U and W in order to make a transition to stage 2 and obtain new values of factors Z.

At stage 2 we build a new logical model:

$$Y^2 = Z^2 \wedge U^2 \wedge W^2,$$

and calculate success criteria P^1 and failure criteria R^1, as well as the contributions of components Z, U and W into the criteria. If the values of criteria P^2 and R^2 do not satisfy us, we make a transition to stage 3, using the above algorithm, etc.

After every stage of analysing the contributions of components of vectors Y, U and W a decision is also made about a partial or complete exclusion of certain artificial controls.

Example. In accordance with the previously introduced notation of events and logical variables let us set the following probabilities of validity of events: $P_1 = P_2 = P_3 = P_4 = 0.8$; $P_5 = P_6 = P_7 = P_8 = P_9 = 0.9$; $P_{10} = 0.7$. In this case the probability of the validity of economic stagnation according to formula (2) $P = 0.1693$, and the probability of non-validity of economics stagnation equals: $R = 1 - P = 1 - 0,1693 = 0,8307$. It should be pointed out that the calculation of validity (success) of overcoming economic stagnation by arithmetic addition of the probabilities of events or by their averaging would yield an incorrect or even an absurd result. Logical functions have no coefficients and exponents of logical variables. The values of the criteria of validiy and invalidity with any probabilities of factors belong to the interval {0, 1}. The quantitative assessment of significance and contributions of events Y_1, Y_2 ,..., Y_{10} into criteria P and R are proportionate to their probabilities. The contribution of non-validity of events-factors into system non-validity for minus and for plus is calculated algorithmically on the P-model of system validity (20 for every event-factor. The contribution for the minus is

calculated as the difference of criterion P values with the value P_i and the value of criterion P with $P_i = 0$. The contribution for the plus is calculated as the difference of criterion P value with the value P_i and criterion P when $P_i = 1$.

Based on the value of the system validity criterion and contributions of events-factors controls U and W are used, investments are made, structural changes and innovations are introduced in technology and management, taxes are changed. During the next stage (month) of system development the real changes in the values of system factors are assessed, according to the described technique the new LP-model of system validity is built, analysis is conducted, controls are used, etc.

The students of the four groups of Institute of Business Technologies from St. Petersburg State University of Aerospace Instrumentation experience no difficulties doing such research during laboratory works done on *Arbiter и Expa* software complexes.

V. Conclusion

The paper describes mathematical model for managing the quality of condition, development and exit of economic system from the condition of stagnation on the basis of event-driven management of the quality of economics.

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Digital Data Processing Based on Wavelet Transforms

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Abstract - **The paper focuses on the main theoretical principles and properties of wavelet transforms. The problem of digital data processing based on wavelet transforms is considered. The analysis and processing of signals and functions that are non-stationary in time and inhomogeneous in space are presented. The authors propose methods of progressive coefficients' values that combine wavelet decomposition and quantization, the main purpose of which is to convey the most important piece of information about a signal.**

Keywords - basic wavelet function, discrete (DWT) and continuous (CWT) wavelet transform, scaling function, wavelet transform.

I. Introduction

Currently, information systems and technologies are actively used in almost all spheres of human life. In this regard, the constant growth of the volume of digital information is characteristic, the increasing requirements for the quality of its processing, transmission and storage [1, 2]. The results of research in the field of digital information processing have found application: in mechanical engineering and instrument making, in the military field, in medicine and ecology, in geographic information systems and cartography, in scientific research and other areas.

As a rule, various compression methods are often used to reduce the amount of information during its storage and processing. At the same time, it is necessary that the compressed data contain only the most significant and unique part of it, according to which it is possible to restore all the original information.

There are a large number of data compression methods that are used to achieve different purposes and, as a result, have their own characteristics. Relatively new, but at the same time popular due to the extensive field of application of this mathematical apparatus, is the scientific direction associated with the theory of wavelets.

II. Defining a Wavelet Transform

Wavelet is a generalized name for a family of mathematical functions local in time and in frequency, which have the form of a small wave with nonzero values in the central region and decrease to zero with distance from the center. Wavelets include functions that are constructed from one parent wavelet $\psi(t)$ by time shift operations *(b)* and time scale changes *(a)*:

$$\psi_{ab}(t) = \frac{1}{\sqrt{|a|}} \cdot \psi\left(\frac{t-b}{a}\right),$$

$$(a,b) \in R, \ \psi(t) \in L^2(R) \tag{1}$$

Wavelet transform is a transform that transforms a signal from a temporal representation into a time-frequency representation and is a convolution of a wavelet function with a signal [3]. The results of the wavelet transform contain combined information about the analyzed signal and the wavelet itself, and also allow you to isolate the low-frequency and high-frequency components of the signal.

In digital data processing, it is necessary to comply with some requirements related to scaling and orientation of objects, as well as spatial localization. Data transformation should allow analyzing the image of an object simultaneously at different scales. Spatial localization of transformation is usually resorted to when information about the location of object details is necessary.

III.   DISCRETE (DWT) AND CONTINUOUS (CWT) WAVELET TRANSFORMS

For signal processing and transformation, as a rule, discrete (DWT) and continuous (CWT) wavelet transforms are used.

Let the functions $s(t)$ with finite energy (norm) in space $L^2(R)$, be defined along the whole real axis $R(-\infty, \infty)$.

Continuous wavelet transform or wavelet image function $s(t) \in L^2(R)$ is a function of two variables:

$$C(a,b) = \left(\frac{1}{\sqrt{|a|}}\right) \int_{-\infty}^{\infty} s(t) \cdot \psi\left(\frac{t-b}{a}\right) dt, \tag{2}$$

$$(a,b) \in R, \ a \neq 0$$

where $s(t)$ – original function, $\psi(t)$ – mother wavelet function, a – wavelet timescale parameter, b – wavelet time offset.

Analysis by continuous wavelet transform starts at high frequencies and is carried out in the direction of their reduction. The first value of the scaling parameter corresponds to the most compressed wavelet, then the value is increased and the wavelet is expanded. The wavelet is placed at the beginning of the signal, multiplied with it, integrated and normalized. The result of the calculation is placed at the point of the time scale of the transformation spectrum corresponding to the unit time parameter and the zero time offset of the wavelet. At the next step, the unit scale wavelet is shifted to the right by the value b and the calculations are repeated. The procedure is repeated until the wavelet reaches the end of the signal. The result is a row of points on a time scale for a unit scale. To calculate the next scale row, the time scale value is increased by some value.

Thus, the continuous wavelet transform is the decomposition of the signal in terms of all possible shifts and contractions / stretches of some localized finite function - a wavelet. In this case, the variable '*a*' determines the wavelet scale and is equivalent to the frequency in Fourier transforms, and the variable '*b*' is the wavelet shift from the initial point in the domain of its definition, the scale of which completely repeats the time scale of the analyzed signal. Hence it follows that wavelet analysis is a frequency-spatial analysis of signals.

Continuous wavelet transform is poorly suited for numerical calculations. Also, this transformation gives wavelet spectra with an excessive amount of information, that is, it is possible to completely restore the signal with a smaller number of spectral components. Continuous wavelet transform uses the entire range of variation of the values of a and b, which in practice is impossible to achieve. A choice of samples with respect to a and b is required, or sampling of the phase space [4], which would eliminate this redundancy.

Therefore, in practice, discrete wavelet transform is most often used.

Discrete wavelet transform provides enough information for both signal analysis and synthesis, while being economical in terms of the number of operations and the required memory. DWT operates with discrete parameter values a and b, which are set, as a rule, in the form of power functions:

$$a = a_0^{-m}, b = k \cdot a_0^{-m},$$

$$a_0 > 1, m, k \in Z \tag{3}$$

where m – scale parameter, k – shift parameter [5].

The direct transform wavelet coefficients are described by the following relation:

$$C_{mk} = |a_0|^{\frac{m}{2}} \int_{-\infty}^{\infty} s(t) \cdot \psi(a_0^m t - k) dt \tag{4}$$

The inverse discrete transformation for continuous signals with a normalized orthogonal wavelet basis of space is represented in the following form:

$$s(t) = \sum_{m=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} C_{mk} \cdot |a_0|^{\frac{m}{2}} \cdot \psi(a_0^m t - k) \tag{5}$$

When processing data arrays, discrete wavelets are used in a pair with their associated discrete scaling or scaling functions $\varphi_{mk}(t)$. If wavelets are considered as analogs of high-frequency filters of a signal, then the scaling functions are analogs of low-frequency filters, with which the components that have not passed the wavelet filtering are extracted from the signal. The sum of the wavelet coefficients and the scaling coefficients of the signals' decomposition provides the ability to perform accurate signals' reconstruction:

$$s(t) = \sum_{k=-\infty}^{\infty} C_{a_k} \cdot \varphi_k(t) +$$
$$+ \sum_{m=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} C_{d_{mk}} \cdot |a_0|^{\frac{m}{2}} \cdot \psi(a_0^m t - k) \quad , \quad (6)$$

where C_{a_k} – scaling factors, or signal approximation factors, $C_{d_{mk}}$ – wavelet coefficients, or detail coefficients [5].

In matrix representation, low- and high-frequency filters are interconnected vectors of coefficients: a high-frequency filter is obtained from a low-frequency filter by writing its coefficients in reverse order and changing the sign of each even coefficient. Thus, if we denote the coefficients of the low-frequency filter as a vector *c* of length *2n*, then the wavelet transform of the signal will consist in multiplying the corresponding column vector by a matrix of the following form:

$$\begin{pmatrix} c_1 & c_2 & c_3 & ... & c_{2n-1} & c_{2n} & 0 & 0 & 0 & ... \\ -c_{2n} & c_{2n-1} & -c_{2n-2} & ... & -c_2 & c_1 & 0 & 0 & 0 & ... \\ 0 & 0 & c_1 & c_2 & c_3 & ... & c_{2n-1} & c_{2n} & 0 & ... \\ 0 & 0 & -c_{2n} & c_{2n-1} & -c_{2n-2} & ... & -c_2 & c_1 & 0 & ... \\ ... & ... & ... & ... & ... & ... & ... & ... & ... & ... \end{pmatrix} \quad (7)$$

To carry out the inverse transformation, it is necessary to multiply the vector of signal coefficients by the inverse matrix:

$$\begin{pmatrix} c_1 & -c_{2n} & 0 & 0 & ... \\ c_2 & c_{2n-1} & 0 & 0 & ... \\ c_3 & -c_{2n-2} & c_1 & -c_{2n} & ... \\ ... & ... & c_2 & c_{2n-1} & ... \\ c_{2n-1} & -c_2 & c_3 & -c_{2n-2} & ... \\ c_{2n} & c_1 & ... & ... & ... \\ 0 & 0 & c_{2n-1} & -c_2 & ... \\ 0 & 0 & c_{2n} & c_1 & ... \\ 0 & 0 & 0 & 0 & ... \\ ... & ... & ... & ... & ... \end{pmatrix} \quad (8)$$

From the point of view of using a set of filters, discrete wavelet transform of a signal *x* according to Malla's scheme are obtained by decomposing the signal through a low-frequency filter with an impulse response *g* and a high-frequency filter *h* as a result, the coefficients of approximation and detail are obtained, respectively (Fig. 1).
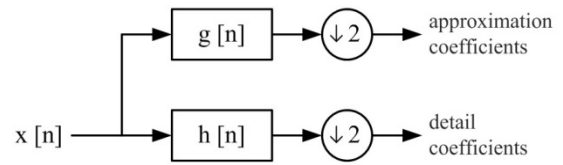
Fig. 1. Signal decomposition scheme for fast discrete wavelet transform (according to Malla's scheme)

IV. HAAR AND DAUBECHIES WAVELETS

The simplest and most widespread wavelets are the Haar and Daubechies wavelets.

Haar wavelets (HAAR wavelets) are orthogonal and well localized in space, but they are not smooth, symmetric in shape and do not have good localization in the frequency domain [6]. The basic wavelet function has the form of rectangular pulses and is set as follows:

$$\psi(t) = \begin{cases} 1, 0 \le t < \dfrac{1}{2} \\ -1, \dfrac{1}{2} \le t < 1 \\ 0, t \notin [0,1) \end{cases} \quad (9)$$

or in discrete representation:

$$\psi_{m,k} = 2^{m/2} \psi(2^m t - k), \quad (10)$$

where *m* – scale parameter, and *k* – shift parameter [7].

The scaling function that determines the approximation of the signal is constant and described by the following expression:

$$\varphi(t) = \begin{cases} 1, 0 \le t < 1 \\ 0, t \notin [0,1) \end{cases} \quad (11)$$

or discretely:

$$\varphi_{j,k} = 2^{j/2} \varphi(2^j t - k) \quad (12)$$

The Haar transform is a pair of filters that separate the signal into low-frequency and high-frequency components [8]. That is, each pair of adjacent elements of a one-dimensional signal is assigned two new signals: the approximating signal a_i, which is calculated as the half-sum of the elements, and the detail signal b_i – half difference of adjacent elements.

The Haar transformation matrix has the following form:

$$H = \begin{pmatrix} \dfrac{1}{\sqrt{2}} & \dfrac{1}{\sqrt{2}} \\ \dfrac{1}{\sqrt{2}} & -\dfrac{1}{\sqrt{2}} \end{pmatrix} \qquad (13)$$

It has the property of orthogonality, so its inverse matrix can be obtained by transposition:

$$H^{-1} = H^{T} = \begin{pmatrix} \dfrac{1}{\sqrt{2}} & \dfrac{1}{\sqrt{2}} \\ \dfrac{1}{\sqrt{2}} & -\dfrac{1}{\sqrt{2}} \end{pmatrix}^{T} = \begin{pmatrix} \dfrac{1}{\sqrt{2}} & \dfrac{1}{\sqrt{2}} \\ \dfrac{1}{\sqrt{2}} & -\dfrac{1}{\sqrt{2}} \end{pmatrix} \quad (14)$$

The two-dimensional Haar transform in accordance with the Malla scheme is reduced to a composition of one-dimensional transformations: a one-dimensional wavelet transform is applied to each row and subsequently column of the two-dimensional matrix, as a result of which four matrices are obtained: approximating the original signal, as well as vertical, horizontal and diagonal detailing signals [3].

Since the Haar wavelet is not smooth, Ingrid Daubechies suggested using functions that are calculated iteratively. Such wavelets do not have an explicit analytical representation of a function by a single formula; they have orthogonality, compact support, and are asymmetric. The widespread use of these wavelets in digital signal processing has led to the possibility of using them to implement fast discrete wavelet transform.

One of the characteristics of Daubechies wavelets is the order n, which is defined as half the number of coefficients [9]. There are two variants of notation for Daubechies wavelets:

- *DN*, where N – number of wavelet filter coefficients;
- *dbn*, where n – wavelet order.

With an increase in the order, the "smoothness" of the wavelets and the steepness of the cutoff of their frequency characteristics increase, therefore, the quality of signal decomposition and their reconstruction.

The coefficients of the Daubechies transformation matrix are found using the system of equations, which for the Daubechies wavelet *DN* will contain N equations: $\dfrac{N}{2}$ equations following from the orthonormality condition, $\dfrac{N}{2}$ and zero moment equations. For example, to find the values of the coefficients of the Daubechies transformation matrix *D4*, the system of equations looks as follows:

$$\begin{cases} c_1^2 + c_2^2 + c_3^2 + c_4^2 = 1 \\ c_3 c_1 + c_4 c_2 = 0 \\ c_4 - c_3 + c_2 - c_1 = 0 \\ c_4 - 2c_3 + 3c_2 - 4c_1 = 0 \end{cases} \qquad (15)$$

To perform one-level two-dimensional wavelet decomposition with respect to a specific wavelet, the MATLAB Wavelet Toolbox provides the 'dwt2' command. The results of performing a two-dimensional wavelet transform in the MATLAB system are shown in Fig. 2.

a)   b)
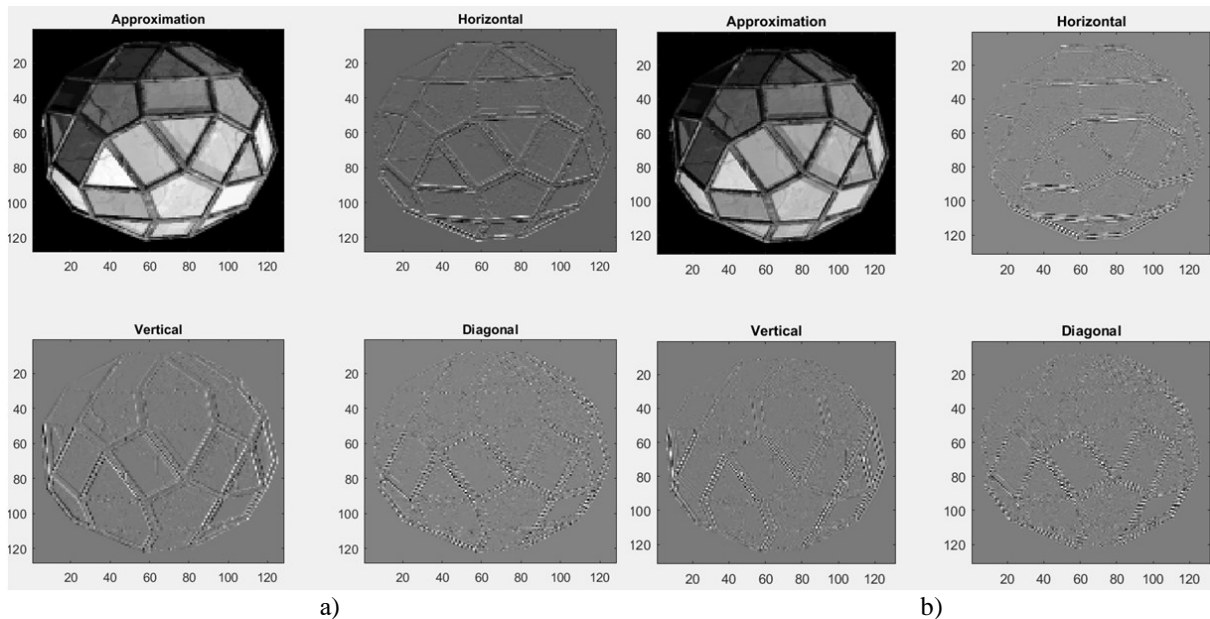
Fig. 2. Two-dimensional transformation in the MATLAB system:
a - with basic Haar wavelet, b - with basic Daubechies wavelet db4

V. APPLICATION OF METHODS OF PROGRESSIVE COEFFICIENTS' VALUES (PCSM) IN INFORMATION COMPRESSION

Wavelet transforms provide an efficient solution to the compression problem. However, in addition to this, the complete cascade sequence of two-dimensional signals' compression, or true compression, includes the iterative phases of quantization, encoding and decoding (Fig. 3) [10].

There are progressive coefficients' values (PCSM) techniques that combine wavelet decomposition and quantization. The main purpose of such methods is to transmit as soon as possible the most important piece of information about the signal, which gives the largest reduction in the discrepancy between the original and reconstructed signals [11]. Such methods are based on the following ideas:

- receiving an image with an increased resolution during decoding;
- obtaining a set of compression coefficients based on the length of the stored code;
- use in aggregate of wavelet decomposition to ensure sparsity and classical coding methods;
- using a tree structure for wavelet decomposition [12] – [14].

Some of the methods for progressive coefficients' values in MATLAB Wavelet Toolbox terminology are as follows:

- *'ezw'* - the Shapiro method, or the Embedded Zerotree Wavelet method - combines stepwise thresholding and progressive quantization, focused on efficient coding in order to minimize the compression coefficient;
- *'spiht'*, *'spiht_3d'* - the method of partitioning a set in hierarchical trees (Set Partitioning In Hierarchical Trees) - an improved version of the original *EZW* algorithm, which uses nested encoding, and also provides the best quality of a two-dimensional signal at any stage of decoding;
- *'stw'* - Spatial-orientation Tree Wavelet method;
- *'wdr'* - Wavelet Difference Reduction method;
- *'aswdr'* - Adaptively Scanned Wavelet Difference Reduction method [10, 15].
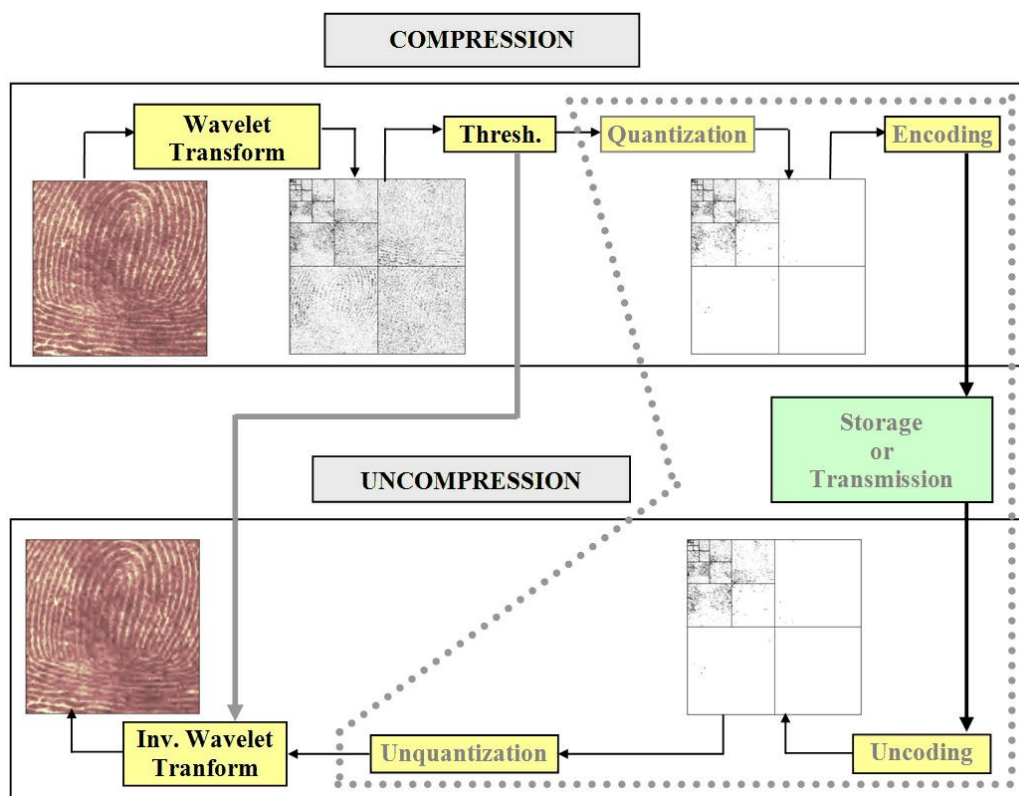
Fig. 3. Genuine compression scheme

The quality of data compression in the aggregate depends on the compression method, the selected wavelet and the number of iterations [16]. Fig. 4-7 show the compression results for the 'ezw' and 'spiht' methods using the Haar and Daubechies db4 wavelets in various combinations [17, 18].
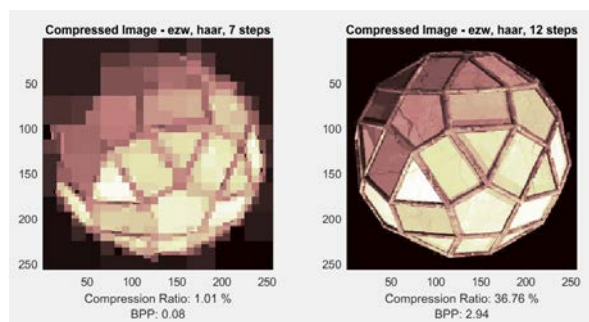
Fig. 4. Results of compression of a two-dimensional signal by the EZW method using the Haar wavelet
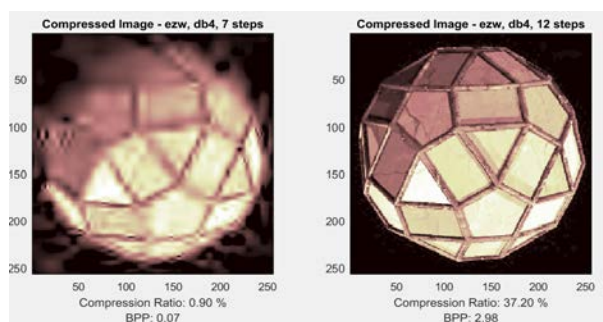
Fig. 5. Results of compression of a two-dimensional signal by the EZW method using the Daubechies wavelet db4
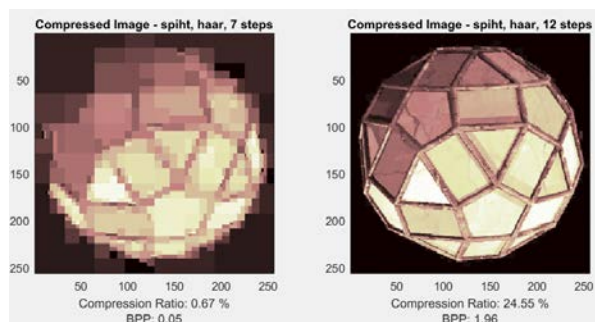
Fig. 6. Results of compression of a two-dimensional signal by the SPIHT method using the Haar wavelet
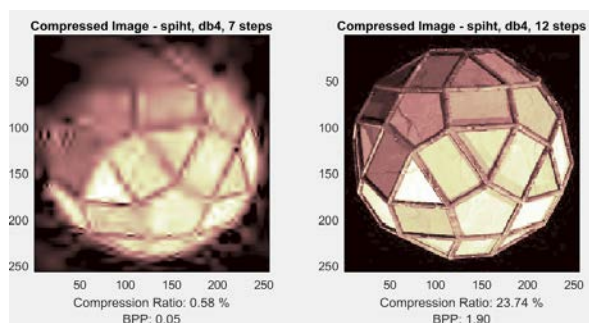
Fig. 7. Results of compression of a two-dimensional signal by the SPIHT method using the Daubechies wavelet db4

VI. CONCLUSION

The use of wavelet transforms in data compression has a number of advantages: information redundancy is eliminated, data is restored with the same filters, and lossy compression is implemented simply by discarding unimportant details [19]. Although wavelet analysis is already the basis of some compression technologies, this direction of research remains relevant, because there is no single method for choosing a transformation algorithm and a basic wavelet [20, 21].

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Fuzzy Robust Estimates of Location and Scale Parameters of a Fuzzy Random Variable

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Abstract - **A random variable is a variable whose components are random values. To characterise a random variable, the arithmetic mean is widely used as an estimate of the location parameter, and variation as an estimate of the scale parameter. The disadvantage of the arithmetic mean is that it is sensitive to extreme values,** *outliers* **in the data. Due to that, to characterise random variables, robust estimates of the location and scale parameters are widely used: the median and median absolute deviation from the median. In real situations, the components of a random variable cannot always be estimated in a deterministic way. One way to model the initial data uncertainty is to use fuzzy estimates of the components of a random variable. Such variables are called** *fuzzy random variables*. **In this paper, we examine fuzzy robust estimates of location and scale parameters of a fuzzy random variable: fuzzy median and fuzzy median of the deviations of fuzzy component values from the fuzzy median.**

Keywords - fuzzy median, fuzzy median of absolute deviations from the fuzzy median, fuzzy random variable, random variable.

I. Introduction

Let there be a population or sample containing *n* objects. These objects are characterised by multiple values of the estimating attribute $\mathbf{X} = \{x_1, ..., x_n\}$. Then the set of values $\mathbf{X}$ can be correctly considered as a random variable, whose elements are values $x_i \in X$.

In standard statistics, a random variable $\mathbf{X}$ can be characterised (or described) by two parameters:

- location parameter $E(\mathbf{X})$, which is the arithmetic mean of components

$$E(X) = \frac{1}{n} \sum_{i=1}^{n} x_i \qquad (1)$$

- scale parameter (variation) $V(\mathbf{X})$ that describes deviations of components $x_i \in \mathbf{X}$ from the mean value, $E(\mathbf{X})$

$$V(\mathbf{X}) = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - E(\mathbf{X}))^2 \qquad (2)$$

The disadvantage of the location parameter (1) is that its value is greatly influenced by extreme data values, *outliers*. To mitigate such unwanted influences, various robust estimates of location and scale parameters have been proposed that are insensitive to the presence of outliers in the data.

The simplest robust estimator of the location parameter of a random variable is its median. The median value is determined as follows. Let us have a random variable $X = \{x_1, ..., x_n\}$.

Let us order the values $x_i \in X$ in non-decreasing order: $x_{(1)} \leq x_{(2)} \leq ... \leq x_{(n-1)} \leq x_{(n)}$ where the subscript in parentheses represents the component number in their ordered sequence. Then the median of the relevant random variable is defined as

$$\operatorname{med}(\mathbf{X}) = x_{(n+1)/2}, \quad n \text{ - even;} \qquad (3a)$$

$$\mathrm{med}(X) = \frac{1}{2}\left(x_{(k)} + x_{(k+1)}\right), \; n = 2k \; \text{-odd.} \quad (3b)$$

In this case, the median of absolute deviations from the median is used as a robust estimator of the scale parameter

$$\mathrm{mad}(\mathbf{X}) = \mathrm{med}\left|x_{(i)} - \mathrm{med}(\mathbf{X})\right|, \; i = 1, ..., n . \; (4)$$

Let us consider a simple illustrative example. Let there be $X = \{3, 7, 14, 32\}$. Using expression (3b), we can calculate the median value for these data

$$\mathrm{med}(\mathbf{X}) = \frac{1}{2}\left(x_{(2)} + x_{(3)}\right) = \frac{1}{2}(7 + 14) = 10.50 .$$

For comparison, using expression (1), let us calculate the arithmetic mean value for a given random variable

$$E(\mathbf{X}) = \frac{1}{4}(3 + 7 + 14 + 32) = 14.00 .$$

Obviously, the mean is affected by the extreme value $x_{(4)} = 32$, which could potentially be an outlier in these data.

Let us calculate the values of the absolute deviations of the initial data from the median. We have the following expression:

$\left\{x_{(i)} - \mathrm{med}(X)\right\} = \{7.50, 3.50, 3.50, 21.50\}$. Let us arrange these values in non-decreasing order: $3.50, 3.50, 7.50, 21.50$. By expression (4), we have

$$\mathrm{mad}(\mathbf{X}) = \mathrm{med}\{3.50, 3.50, 7.50, 21.50\} = \frac{1}{2}(3.50 + 7.50) = 5.50$$

In many real-world situations, it is impossible to specify precise numerical values for the relevant attribute for a population or sample. Therefore, there is a natural need to set the attribute values in some suitable uncertain form. One of the widely used options for modelling uncertainties in the initial data is to use fuzzy numbers as estimates of attribute values.

In the general case, a fuzzy number represents a fuzzy set on the scale of real numbers. To set a fuzzy number, it is necessary to determine its support (interval) on a certain measurement scale x. For each point x inside the support, the value of the function of membership $\mu(x)$ of the value x at this point to a fuzzy number $\tilde{\mathbf{X}}$ must be known. The value x for which $\mu(x) = 1$, is called the core of the fuzzy number $\tilde{\mathbf{X}}$. If the maximum value of the membership function of a fuzzy number is 1, such a number is called a *normal* fuzzy number.

The membership function of a fuzzy number $\tilde{\mathbf{X}}$ can be set analytically, graphically, or in the form of calculated values for intervals at any of its α-levels. In this paper, we will use normal fuzzy numbers in the simplest form,

namely, triangular fuzzy numbers. Fig. 1 shows a graph of the membership function of a conditional normal triangular fuzzy number.
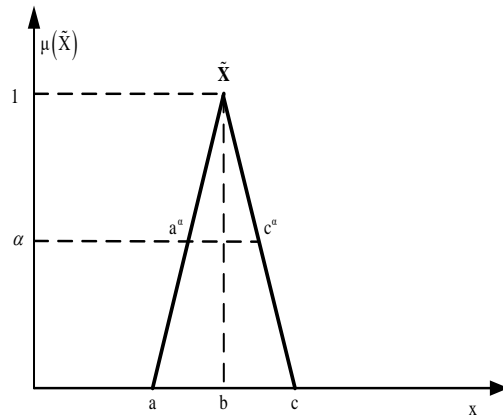
Fig.1. Graphic representation of a normal triangular fuzzy number $\tilde{X}$.

The support of a fuzzy number $\tilde{\mathbf{X}}$ is an interval $[a, c]$, point b corresponds to its core, for which $\mu(\tilde{\mathbf{X}}) = 1$. If we set some value α of the membership function, to this number corresponds an interval (the interval $\left[a^\alpha, c^\alpha\right]$ in Fig. 1). This interval is called the α-cut of the fuzzy number $\tilde{\mathbf{X}}$. Evidently, when $\alpha = 0$, the α-cut is the support of the fuzzy number $\tilde{\mathbf{X}}$, and the value $\alpha = 1$ corresponds to the core of this fuzzy number.

Using the notation shown in Fig. 1, a fuzzy number $\tilde{\mathbf{X}}$ can be given in the form of a triplet of numbers $\tilde{\mathbf{X}} = (a, b, c)$, where a and c are the boundaries of the support $\tilde{\mathbf{X}}$, b is the value x that corresponds to the core $\tilde{\mathbf{X}}$. We will use this notation in the subsequent sections of the paper.

A random variable whose components are fuzzy numbers is called a *fuzzy random variable*. There are two alternative formal definitions of the concept of a fuzzy random variable. The first definition is presented in [4, 5]. The second definition is presented in [6]. The difference between these definitions is only in the interpretation of the components of a fuzzy random variable. A detailed analysis of these differences is provided in [7]. Various aspects of the theory and practice of fuzzy random variables can be found in [8- 12]. According to the authors of formal definitions, the first type of such variables is called fuzzy random variables in Kwakernaak's sense, the second type is called fuzzy random variables in Puri /Ralescu's sense.

In the context of fuzzy statistics, alternative definitions of a fuzzy random variable lead to different definitions of the variation of such a variable.

For the purposes of representing and analysing fuzzy robust parameters of the location and scale of a fuzzy

random variable, it does not matter in this article how this variable is formally defined.

II. CALCULATION OF FUZZY PARAMETERS OF A FUZZY RANDOM VARIABLE

For the purposes of comparative analysis, we first present an expression that allows us to calculate the interval of the fuzzy mean value of a fuzzy random variable at the level α

$$E(X)_\alpha = \left[E(\inf x_\alpha), E(\sup x_\alpha) \right] \qquad (5)$$

It follows from this expression that the lower limit of the interval of the fuzzy number $\tilde{E}(X)$ at the level α is calculated as the average value $\inf X_\alpha$, i.e., as the average value of the corresponding values on the ascending parts of the membership functions of fuzzy numbers $\tilde{X}_i$, $i = 1,...,n$. In its turn, the upper limit of the interval a fuzzy number $\tilde{E}(X)$ at the level α is calculated as the average value $\sup X_\alpha$, that is, as the average value of the corresponding values on the falling parts of the membership functions of fuzzy numbers $\tilde{X}_i$, $i = 1,...,n$.

The fuzzy mean $\tilde{E}(\tilde{X})$ has the same disadvantage as its crisp counterpart $E(X)$, namely, it is sensitive to outliers in the data. The fuzzy median is devoid of this synonym drawback and can be used as a fuzzy robust estimator of the location parameter of a fuzzy random variable. The theoretical foundations of fuzzy medians are discussed in [12, 13].

Let us introduce the following definitions.

Definition 1 [13]. Mapping $F_C(R) \times F_C(R) \to [0, \infty)$, such that, for $\tilde{U}, \tilde{V} \in F_C(R)$

$$\rho_1(\tilde{U}, \tilde{V}) = \left\| s_{\tilde{U}} - s_{\tilde{V}} \right\| = \frac{1}{2} \int_{(0,1]} \left| \inf \tilde{U}_\alpha - \inf \tilde{V}_\alpha \right| + \quad (6)$$
$$+ \left| \sup \tilde{U}_\alpha = \sup \tilde{V}_\alpha \right| d\alpha$$

is called *the distance of norm-1 between fuzzy numbers*. In this definition, $F_C(R)$ is a set of fuzzy sets (numbers) defined on a real scale R.

Definition 2 [13]. For a given probability space (Ω, A, P) and associated fuzzy random variable $\tilde{X}$, *the median* (or medians) of the distribution X is a fuzzy number (or fuzzy numbers).

$$E\left(\rho_1, M\tilde{e}(\tilde{X})\right) = \min_{\tilde{U} \in F_C(R)} E\left(\rho_1(\tilde{X}, \tilde{U})\right), \quad (7)$$

whenever such an expectation exists. In Definition (2), $F_C(R)$ is a set of all fuzzy sets defined on a real scale R, ρ_1 is a metric of norm-1 – from Definition (1).

The following definition is presented in [15] in the form of a theorem with a strong proof.

Definition 3. For a given probability space (Ω, A, P) and a fuzzy random variable $\mathbf{X}$ associated with it, for any value $\alpha \in [0,1]$, we have a fuzzy number $M\tilde{e}(\mathbf{X}) \in F_C(R)$ such that

$$M\tilde{e}(\mathbf{X})_\alpha = \left[Me(\inf X_\alpha), Me(\sup X_\alpha) \right] (8)$$

where, if $Me(\inf X_\alpha)$ and $Me(\sup X_\alpha)$ are not unique and following customary agreements, $Me(\inf X_\alpha)$ is selected as the midpoint of the median interval from $\inf X_\alpha$; $Me(\inf X_\alpha)$ is selected as the midpoint of the median interval from $\inf X_\alpha$; $Me(\sup X_\alpha)$ is selected as the midpoint of the median interval from $\sup X_\alpha$.

Note that the scheme for calculating the fuzzy median $M\tilde{e}(\tilde{X})$ is similar to that for calculating the fuzzy mean $\tilde{E}(\tilde{X})$. The difference is that values $\inf E(X)_\alpha$ and $\sup E(X)_\alpha$ are calculated as averages of values $\inf X_{i\alpha}$, $\sup X_{i\alpha}$ $i = 1,...,n$, but values $\inf(Me(X_\alpha))$ and $\sup(Me(X_\alpha))$, are calculated as medians of values $\inf X_\alpha$, $\sup X_\alpha$.

In the previous section, expressions were presented for calculating the median value on the set of real-valued initial data (expressions (3, a, b). Let us modify these expressions so that they can be used to calculate the fuzzy median $M\tilde{e}(\tilde{X})$.

Let a fuzzy random variable $\tilde{X} = (\tilde{X}_1,...,\tilde{X}_i,...\tilde{X}_n)$ be given. First, sets of values $\{\inf X_{i\alpha} / i = 1,...,n\}$, $\{\sup X_{i\alpha} / i = 1,...,n\}$. Then the values $\inf X_{i\alpha}$, $\sup X_{i\alpha}$ must be ordered in order of increasing their values. The value $Me(\inf X_\alpha)$ is defined as

$$Me(\inf X_\alpha) = \inf X_{\left(\frac{n+1}{2}\right)}, \qquad (9a)$$

where n is an odd number.

$$Me(\inf X_\alpha) = \frac{1}{2}\left(\inf X_{\left(\frac{n}{2}\right)} + \inf X_{\left(\frac{n+1}{2}\right)} \right), (9b)$$

where n is an even number.

Similarly,

$$Me\left(\sup X_{\alpha}\right) = \sup X_{\left(\frac{n+1}{2}\right)}, \quad (10a)$$

where n is an odd number.

$$Me\left(\sup X_{\alpha}\right) = \frac{1}{2}\left(\sup X_{\left(\frac{n}{2}\right)} + \sup X_{\left(\frac{n+1}{2}\right)}\right) (10b)$$

where n - is an even number.

Expressions (9a, 9b) and (10a, 10b) are formal representations of the conventions in Definition (3).

Let us consider a simple illustrative example. A fuzzy random variable $\tilde{\mathbf{X}} = \left(\tilde{\mathbf{X}}_1, \tilde{\mathbf{X}}_2, \tilde{\mathbf{X}}_3, \tilde{\mathbf{X}}_4\right)$ is given, where, $\tilde{\mathbf{X}}_1 = (1,3,5)$, $\tilde{\mathbf{X}}_2 = (4,7,10)$, $\tilde{\mathbf{X}}_3 = (9,14,19)$, $\tilde{\mathbf{X}}_4 = (30,32,34)$. It is necessary to determine the fuzzy median of this fuzzy random variable.

Let us derive calculation expressions for determining the intervals of fuzzy components $\tilde{\mathbf{X}}_1$, $\tilde{\mathbf{X}}_2$, $\tilde{\mathbf{X}}_3$, and $\tilde{\mathbf{X}}_4$ at levels α.

- fuzzy component $\tilde{\mathbf{X}}_1$:
$$\inf X_{1\alpha} = 1 + (3-1)\alpha = 1 + 2\alpha$$
$$\sup X_{1\alpha} = 5 - (5-3)\alpha = 5 - 2\alpha ;$$
- fuzzy component $\tilde{\mathbf{X}}_2$:
$$\inf X_{2\alpha} = 4 + (7-4)\alpha = 4 + 3\alpha$$
$$\sup X_{2\alpha} = 10 - (10-7)\alpha = 10 - 3\alpha ;$$
- fuzzy component $\tilde{\mathbf{X}}_3$:
$$\inf X_{3\alpha} = 9 + (19-14)\alpha = 9 + 5\alpha$$
$$\sup X_{3\alpha} = 19 - (19-14)\alpha = 19 - 5\alpha ;$$
- fuzzy component $\tilde{\mathbf{X}}_4$:
$$\inf X_{4\alpha} = 30 + (32-30)\alpha = 30 + 2\alpha$$
$$\sup X_{4\alpha} = 34 - (34-32)\alpha = 34 - 2\alpha .$$

Given the nature of the relevant fuzzy numbers, there is no need to perform calculations at intermediate α levels. It is enough to perform calculations at the levels $\alpha = 0$ and $\alpha = 1$.

$\alpha = 0$: $\left\{\inf X_{i0}\right\} = \{1,4,9,30\}$. By expression (9b), $Me\left(\inf X_0\right) = \frac{1}{2}(4+9) = 6.50$ $\left\{\sup X_{i0}\right\} = \{5,10,19,34\}$.

By expression (10b), $Me\left(\sup X_0\right) = \frac{1}{2}(10+19) = 14.50$.

$\alpha = 1 : Me\left(X_1\right) = \frac{1}{2}(7+14) = 10.5$.

Thus, the fuzzy median in our example is $M\tilde{e}\left(\tilde{\mathbf{X}}\right) = (6.50, 10.50, 14.50)$. The graph of the membership function together with the graphs of the membership functions of the original fuzzy numbers $\tilde{\mathbf{X}}_i$, $i = 1, 2, 3, 4$ is shown in Fig. 2. For comparison, this figure shows a graph of the fuzzy average value $E(\mathbf{X})$ calculated by expression (5).
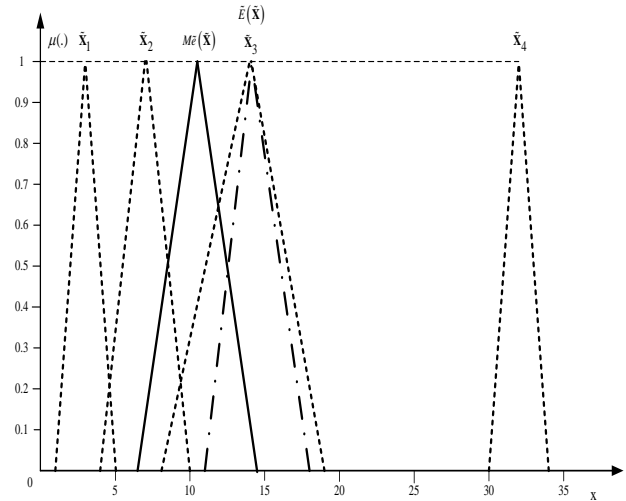
Fig.2. Graphs of membership functions of fuzzy components $\tilde{\mathbf{X}}_i$, $i = 1, 2, 3, 4$, fuzzy median $M\tilde{e}\left(\tilde{\mathbf{X}}\right)$ and fuzzy mean $\tilde{E}\left(\tilde{\mathbf{X}}\right)$.

By analogy with the median of absolute deviations from the median of a deterministic random variable, we define the fuzzy median of fuzzy deviations from the fuzzy median.

$$ma(X)_{\alpha} = \left[\inf\left\{\left|X_{(i)\alpha} - me(X)_{\alpha}\right|\right\}, \sup\left\{\left|X_{(i)\alpha} - me(X)_{\alpha}\right|\right\}\right],$$
$$i = 1, ..., n \quad (11)$$

Let us define a fuzzy value $m\tilde{a}\left(\tilde{\mathbf{X}}\right)$ for the fuzzy random variable $\tilde{\mathbf{X}}$ presented above. The calculations will be performed at the levels $\alpha = 0$ and $\alpha = 1$.

$\alpha = 0$:

$$\left|X_{10} - me(X)_0\right| = \left|[1.00, 5.00] - [6.50, 14, 50]\right| =$$
$$= [5.50, 9.50]$$;

$$\left|X_{20} - me(X)_0\right| = \left|[4.00, 10.00] - [6.50, 14, 50]\right| =$$
$$= [2.50, 4.50]$$;

$$\left|X_{30} - me(X)_0\right| = \left|[9.00, 19.00] - [6.50, 14, 50]\right| =$$
$$= [2.50, 4.50]$$;

$$\left|X_{40} - me(X)_0\right| = \left\|[30.00, 34.00] - [6.50, 14, 50]\right\| =$$
$$= [19.50, 23.50]$$

Let us arrange the lower bounds of the resulting intervals in non-decreasing order: $2.50, 2.50, 5.50, 19.50$. The median of these values is:

$$med = \frac{1}{2}(2.50 + 5.50) = 4.00.$$

Let us arrange the upper bounds of the resulting intervals in non-decreasing order: $4.50, 4.50, 9.50, 23.50$. The median of these values is

$$med = \frac{1}{2}(4.50 + 9.50) = 7.00.$$

It follows that the support of the desired fuzzy number $M\tilde{a}(\tilde{\mathbf{X}})$ is $ma(X)_0 = [4.00, 7.00]$

$\alpha = 1$:

At this level, we are dealing with deterministic numbers. The absolute values of the differences between the point values of the components and the point value of the median form the following sequence: $7.50, 3.50, 3.50, 21.50$. Let us sort these numbers in a non-decreasing sequence: $3.50, 3.50, 7.50, 21.50$. The median of this sequence is $med = \frac{1}{2}(3.50 + 7.50) = 5.50$. Thus, we have the following fuzzy number representing the fuzzy median of the absolute deviations of fuzzy components from the fuzzy median $M\tilde{a}(\tilde{\mathbf{X}}) = (4.00, 5.50, 7.00)$. The graph of the membership function of this fuzzy number, together with the initial and previous resulting data, is shown in Fig. 3.
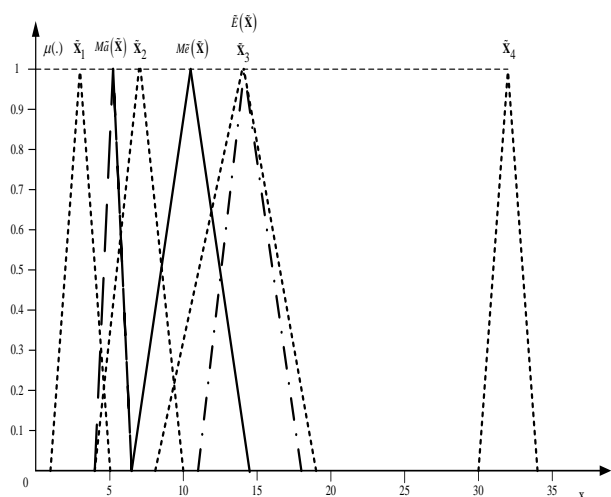
Fig.3. Graphs of membership functions of fuzzy components $\tilde{\mathbf{X}}_i$, $i = 1, 2, 3, 4$, fuzzy median $M\tilde{e}(\tilde{\mathbf{X}})$, fuzzy median of deviations from fuzzy median $M\tilde{a}(\tilde{\mathbf{X}})$ and fuzzy mean $\tilde{E}(\tilde{\mathbf{X}})$.

III. RESULTS AND CONCLUSIONS

In this paper we consider extensions of the concept of median and median of absolute deviations from the median as robust estimators of parameters of a random variable to fuzzy initial data. In standard statistics, the mean and variation of the values of a random variable are widely used as parameters for location and scale. However, the mean has a significant drawback as an estimator of the location parameter :it is sensitive to extreme values in the data. Extreme values in the data can cause the estimated mean to shift towards large or small data values. In other words ,in such situations, the average value cannot serve as an adequate estimator of the location parameter.

To reduce or completely avoid the impact of outliers in the data on the estimation of random variable parameters, an estimator is desirable whose values are not affected by large or small extreme values in the data. In other words, a robust estimator of location parameter is needed. Nowadays, different variants of such estimators are available. One of the most common options is to use the median of a random variable as an estimator of the placement parameter of this random variable.

The use of the median makes it necessary to use the corresponding estimator of the scale parameter. The median of absolute deviations from the median is used as such an estimator.

This paper presents an extension of the concepts of the median and median of absolute deviations from the median to the case of fuzzy random variables, that is, random variables whose components are given in a fuzzy form. The theoretical part of the work is supplemented with an illustrative example. Based on this example, an unambiguous conclusion can be made that the introduced fuzzy estimator of location parameters has a high degree of robustness. The corresponding fuzzy scale parameter has the advantage of simplicity of calculation. Calculations of the fuzzy median of absolute deviations from the fuzzy median are significantly simplified for normal triangular fuzzy numbers, which was demonstrated by the example in this work. With more complex forms of membership functions, calculations must be performed at a larger number of α levels. This only increases the volume of the calculations performed, but not their complexity. Calculating the fuzzy value of the variation is much more complicated and requires a lot of computational costs.

Summarizing, we can make a reasonable conclusion that the use of the fuzzy analogues of robust estimators of location and scale parameters presented in this work can be confidently recommended for processing fuzzy initial data.

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Enterprise Management in the Context of Expanding the Scope of Blockchain Technology

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Abstract - **The method of creating an automated enterprise management system is considered. The method is based on the ideas of the imitation approach and fuzzy mathematics. Real-time enterprise planning is the goal. The method is relevant in the context of setting up the market for goods and services with the expansion of e-commerce. The model of the formation of the plan of the enterprise for the execution of the orders received is considered.**

Keywords - Blockchain, smart contract, automated system, prompt enterprise management, efficiency indicators, constructive-simulation model, planning randomization.

Introduction

On the modern market of goods and services, the manufacturer should not only have and offer a certain product. One of the trends of the modern market is the desire of the enterprise to find a client and lead to a significant negotiation with him, including remotely in real time. Customization of the goods and services market occurs [1]. At the same time, a potential customer is trying to provide itself with more favorable conditions: the price of goods, deadlines and delivery scheme, as well as other components of the services. The interests of the buyer are becoming increasingly important argument in the conditions of exceeding the proposal on the need. The introduction of e-commerce [2], as well as the emergence and development of the technology of the blockchain [3], contributes to solving these tasks

Blockchain is a tool for transferring and storing data. For business cooperation, partners use databases. The process of interaction between business partners is associated with operations in the database, that is, with transactions. All transaction can be performed using Blockchain technology.

Bitcoin, Ethereum, NXT, Side Chans are the most popular platforms operating on the Blockchain principle. They are created mainly for the financial sector. However, Ethereum is a good platform for creating smart contracts [4].

Blockchain and smart contracts technology allow modern enterprises to switch to small-scale production. Such possibilities are very convenient for buyers. However, they create a number of business difficulties. The fact is that each order requires the development of its own unique technology. The company must simultaneously perform a large number of small orders. This requires qualitative changes in the operational planning of the enterprise.

Any enterprise is an open system. Streams of matter, energy and information flow through it. This makes him dependent on the external environment and makes him adapt. A modern enterprise operates in a single economic space. Its dependence on the environment is constantly growing. The success of activities in such conditions depends on an adequate reaction of the enterprise to the market situation, as well as on the ability to predict the development of the situation.

Each new order must take into account the technological capabilities of the enterprise and the availability of resources. There are many orders, they come at a random time. The company needs up-to-date databases for all production components. Databases should contain changing information about all orders, equipment utilization, the maximum allowable lead time for each order, and the availability of financial and other resources at the enterprise. When new orders arrive, tools for adjusting production plans are required.

Currently, work is underway to create specialized enterprise management systems from a variety of positions. In this aspect, the most interesting is the MES (Manufacturing Execution System) [5]. This is an information and communication system of the enterprise, focused on the management of current production activities in accordance with incoming orders, the requirements of design and technological documentation, the current state of the equipment and pursuing the goal of maximum production efficiency. .. It can be viewed as a link between ERP-systems focused on financial and economic tasks [6] and the operational production activities of an enterprise at the site or production line level. Despite significant advantages, MES systems actively use the calendar planning toolkit, thereby not being suitable for solving the entire complex of online management tasks.

To implement the mechanism of enterprise management in extreme situations, situational centers began to form. The main purpose of their purpose is as follows:

1. Monitoring the status of the management object and its environment;

2. Support for the process of solutions (including on the basis of information and analytical systems and mathematical planning models);

3. Support for operational management in crisis situations.

Undoubtedly, many tasks of situational centers are related to the functioning of an enterprise and online management. However, online control mode becomes the norm. Apply the actions intended for serious critical situations (as a rule, force majeure circumstances) is inappropriate.

The emergence of new and new controls causes the need for further improvement and adaptation. At the same time, the active development of new approaches and methods of their creation are made.

Thus, the central task for online management is to form solutions and plans based on current information. In this regard, the effective solution of the problem under consideration, as well as progress in automatic control in general, can be obtained by a common information field, which is updated by the continuous monitoring system of the control object [7].

Ontology is used to describe a subject area or a specific task (Ontology in the theory of objects and their ties) [8]. The ontological approach makes it possible to describe the structure of an enterprise and its components. It is a good tool for creating a database and building a real-time control system [9], [10].

In the conditions under consideration, real-time control is necessary for an enterprise (plant, factory). However, it is also necessary for other areas of activity: service [1], trade [11], energy supply [12], transport [13], vocational education [14] and others.

Problems of the formation of continuous monitoring systems of processes occurring both in the system and in its environment were practically freed from technical and technological restrictions. Now it is basically a decision of organizational issues. Search for answers to these questions occurs when the information system of the enterprise is introduced. At the same time, complex economic, social and psychological problems arise. This is the need for a partial or complete reorganization of the enterprise structure and the need to change business technologies. The resistance of the company's employees and a number of other problems can also arise.

Because of the above, the following task is of interest to solve. The company implements an existing set of orders. At some point in time, the company receives a new proposal (order) for the supply of products described by a number of parameters: assortment, quantities, price, execution time and others. It is necessary to form a plan that is provided with resources, technology and can be implemented (permissible plan). Such a plan takes into account the interests of the enterprise, its condition and opportunities, the entire set of orders that have been taken earlier. The plan should be supplemented with performance indicators (we denote them through W) to quickly take a reasonable solution.

The features of this task is as follows: 1) there are a large number of factors; 2) high degree of uncertainty in the development of the situation; 3) It is impossible to use averaged indicators and traditional planning methods (mathematical programming, probability theory).

For the sake of convenience in presenting the essence of the proposed solution to this problem, we will restrict ourselves to a number of simplifications:

- during this period, only one application for the production of one type of product is being considered;

- production is characterized by integral productivity;

- for the manufacture of a unit of production, material is used as a generalized concept;

- for each present and subsequent time intervals there is information about the available amount of material and the financial capabilities of the enterprise.

As the analysis shows, the expansion of these conditions leads to a complication of the description and to an increase in the dimension of the problem, but does not affect the essence of the proposed approaches.

CONSTRUCTIVE-SIMULATION METHOD OF PLANNING

In the theory of decision-making, a prominent place is occupied by the tasks of modeling the activities of various kinds of organizational systems, where so-called weakly structured problems often arise. An essential feature of these problems is ignorance of the object of modeling and, as a consequence, the presence of various kinds of uncertainties that prevent the construction of formal models for describing possible trajectories of the functioning of these systems. The problems that arise when solving problems of the type formulated above are also weakly structured.

In the field of management of organizational systems, an important place belongs to the concept formulated by management, presented, as a rule, in verbal form. The idea usually includes: the main goal of the control object, a possible way to achieve it is schematically indicated, some recommendations for solving specific problems are described, and the main performance indicators are formulated. Obviously, this only determines the scheme of subsequent management actions and requires the development of a complete detailed plan for translating the idea into reality. It is desirable to accumulate such information in the knowledge base of each enterprise [15].

When planning (in the traditional sense), various mathematical models can be used, which are based on hypotheses about a specific variant of the development of situations with certain values of parameters and schemes for performing individual actions [16]. While the use of traditional mathematical methods justifies itself for forecasting and developing plans for a sufficiently long term, the situation is different for operational planning tasks. The scheme for the formation of operational decisions is usually not fixed, since it significantly depends on the developing situation. So, given the possibility of fulfilling the request, we can fulfill some part of it at the expense of stocks of finished products in the warehouse (the question is in what part?). Then the rest will need to be done specifically for this order (in what time frame, with what resources?). Since the volume of the order for the manufacture of products changes over time, you can form a large number of options for the potential activities of the production itself. The situation is similar with the expenditure of material, financial and other resources. This means a dramatic increase in the variability of production support situations.

When faced with such obstacles, very primitive balancing methods are usually used in practice. Schemes of actions of the control object, its subsystems and elements are considered fixed (guided by pre-written rules and instructions) In another case, planning is transferred to lower levels of management (departments and services) without assessing the real possibilities of production. In this case, the boss considers such tasks to be unconditionally completed (action on the principle: they must perform). Obviously, for organizational systems, this approach leads to the construction of low-quality plans, which, as the processes of interaction between business entities accelerate, become an ever greater obstacle to their successful activity. As a result, the urgency of solving the problem of providing control bodies with the possibility of operational development of detailed resource and technologically feasible plans increases, which implies a transition to fundamentally new schemes of mathematical modeling.

In practice, the manager analyzes the situation at the present time (so to speak "for tomorrow") and formulates, as a rule, very rational private solutions. This fact was adopted as a basis for the design and modeling method under consideration (CSM-method) [17].

It consists of the following cycle: 1) a description of the situation (the state of the object and the environment); 2) the formation of a complete set of potentially possible so-called private solutions; 3) the choice of one of the solutions as a fragment of the future plan; 4) modeling the execution of this particular solution as the process of transitting the modeling object to a new state. Thus, from an ordered, interconnected and interdependent set of private solutions, a general plan for achieving goals is created. Please note that the space-time process of the enterprise under consideration is the object of modeling. There are various options for modeling the activity of the enterprise. However, most of them are not suitable for online management of the production process [18].

Thus, a two-stage scheme is implemented step by step: in a given specific situation, a resource and technologically possible private solution is created and the process of its implementation is modeled. The system model is transferred to a new state. Then the cycle of forming another frequent solution and its modeling is repeated. That is why the method is called by us the constructive-simulation method (.the CSM method).

Thus, the main steps of the CSM method are as follows.

1. For the current time interval, the system generates a complete set of possible particular solutions (a set of permissible plans) for each functional component of the modeling object. If the set of permissible plans is empty, the System switches to the next time interval. The initiative to form a particular solution belongs either to another component or is contained in the conditions of the order. For example, send a finished product to a customer on a specified date.

2. Otherwise, each of the permissible plans is weighed. Weight, as usual, is designed to account for all "for" and "against" this solution. The weight G_j of each j-alternative is formed by the formula that we usually apply and recommend:

$$G_j = \sum_{\forall h}(c_h \, g_{jh}) / \sum_{\forall r}(c_r \, q_{jr}) \qquad (1)$$

g_{jh} is the value of the h-parameter, the increase in which as a whole corresponds to the objectives set in front of the object. This, for example, profits, product quality, company quality and much more;

q_{jr} is the value of the r-parameter, the decrease in which in general corresponds to the objectives set for the system. These are the indicators: the time, the cost of the operation or product, the number of waste and the other;

c_h, c_r - model setup coefficients.

For the formation of the weight $\{G_j\}$ of a private solution, corresponding cognitive cards can be used [19].

3. On the set of scales $\{gj\}$ as a fragment of the formable plan, one particular solution is selected. This choice is advisable to carry out the method of a randomized draw, the scheme of which is widely used [20]. Let ξ be the generated value that is equally distributed on the segment [0, 1] of a random variable. Then the same alternative to the alternative j* which is the first (as j) satisfies the condition

$$j^* = min \ [\ k \ / \ \frac{\Sigma_{j=1}^{k} G_j}{\Sigma_{j=1}^{j_0} G_j} > \xi \ ], \qquad (2)$$

where k is the number of alternatives already considered, j_0 is the total number of alternatives formed.

The possible critics of using such, in general, "blind" procedures explain that at least at the stage of building a model randomized draw in full alternatives are fundamentally necessary, since the elimination of any resource and technologically possible private solutions can lead (by the way, that we And we see when using other mechanisms) to an inefficient solution of the problem as a whole (a special solution with a small weight can sometimes lead to the best general solution of the task). The model setup coefficients c_h, c_r serve for a finer account of the features of the systems under consideration or the conditions of their functioning at the operation stage.

4. The procedure for implementing a private solution is carried out after its choice. All the actions of the plan are carried out with all the components of the system. In addition, it is very important, changes to the object state are recorded at all subsequent time intervals, for example, spending and the acquisition of resources is fixed.

The solutions obtained in the considered time interval are implemented only in subsequent time intervals. This rule is practically not difficult (since the time interval can be chosen very small). This ensures the creation of private solutions that do not contradict each other. In addition, since only admissible particular solutions are formed, the decision that is selected from them can be performed unconditionally. The duration of the implementation of this solution can cover several subsequent time intervals, which is also fixed.

5. The model of the object goes into the final state (in this case, the action plan of all enterprise components for execution of the order is formed). A set of all selected private solutions forms an enterprise plan to fulfill the order. So, one of the permissible plans of the enterprise is formed. It is supplemented by the values of all indicators of the effectiveness of the enterprise. In other words, we form and implement one of the possible options for solving the problem. If the procedure for forming a plan has repeatedly repeated, then from the received set of plans you can choose the most appropriate option in the sense of the selected criterion

The longer a series of tests, the greater the likelihood of receiving the best plan. However, since in practice the number of possible options for plans is very large, significantly increased the number of tests of the model is not recommended. The so-called setting according to the criterion increases the likelihood of obtaining the best plan.

Since the operation of the randomized draw is implemented in the process of forming a plan, the production plan with a certain indicator of its effectiveness W is an event random. After conducting a series of tests, you can build a histogram describing the distribution of the frequency of generating a plan with different values of the criterion. This allows you to estimate the likelihood of obtaining a plan with an efficiency indicator at the specified value interval.

In the process of studying the model, it was shown that due to the selection of settings, you can deform the histogram of the distribution of plans. In this case, the probability of obtaining the optimal plan can be significantly increased.

ENTERPRISE PLAN MODEL FOR ORDER EXECUTION

We describe a simplified scheme for the formation of a permissible plan of execution by the enterprise received the order Z [21]. Let the order for the production of products (in the most simplified form) is the following vector:

$$Z = (m, T_z), \qquad (3)$$

where m is the volume of ordered products, T_z is the time execution of the order.

It is assumed that the company is working on the fulfillment of its portfolio of orders already existing. In addition, predicting the development of the situation, the enterprise can produce products regardless of the presence of orders (work for the warehouse). For its activities, the enterprise acquires the necessary consumables, produces products, contains a certain stock of materials and finished products. All relevant information for each current day (or selected time interval) and perspectives (which are already scheduled and approved) are contained in a corporate database. For further presentation, references will be required:

n(t) - the volume of unallocated finished products in the warehouse per day t;

h(t) - the volume of products that can make an enterprise per day t (characterizes the free power of production itself);

s(t) - the volume of unallocated consumables, which has an enterprise for the day t;

l(t) - the amount of unallocated financial resources that can be consumed by the enterprise to purchase consumables and other needs for the day t.

Managers formulate the rules for holding a client dialogue and the rules for developing an order plan.

Their actions are based on the results of work experience, on the analysis and forecasting of the development of the situation, as well as based on the set of goals. First of all, this desire to keep some resources. It is advisable to formulate the rules in accordance with which not all order is performed at the expense of products in stock; production is not used in full force; Not all materials are taken from the relevant warehouse (some of them can be purchased); Not all currently available financial resources can be spent.

Such rules can be formulated in a mild form using elements of fuzzy mathematics. For example, we can use linguistic variables and functions..

For example, $\mu_i(x)$ is the function of the belonging that can describe the ability to take parts from the warehouse of finished products, guided by the following rules: if I = 1, then you can take a small part of the reserve; if i = 2, then you can take half of the reserve; if i = 3, you can take most of the reserve. The selection of one of these three rules can be performed in advance when setting up the model. In

essence, each value of $\mu_i(x)$ is a measure of expediency for accepting an i-version of actions for which the corresponding part of the finished product or consumables is taken from the warehouse ($0 \leq x \leq 1$).

Such functions are entered for all other subsystems:

$\upsilon_i(x)$ - the function of the belonging, which describes the feasibility of using a part of the production capacity to execute the order;

$\phi_i(x)$ - the function of the belonging, which describes the feasibility to ensure the production of existing stocks of consumables;

$\varphi_i(x)$ - the function of the belonging, which describes the feasibility of partial financing of the purchase of necessary materials from borrowed funds.

The choice of each next private solution is implemented on the basis of such function of the belonging.

Naturally, the formation of an order execution plan must be started with the definition of a potential opportunity to satisfy the conditions of the order. It is necessary to check the condition:

$$\max_{t \leq \tau \leq T_z} n(\tau) + \sum_{\tau=t}^{T_z-1} h(\tau) \geq m \quad (4)$$

If the condition is not fulfilled, it means that the company does not have the ability to fulfill this order. In this case, the order is rejected. Changing the stated conditions can be coordinated. This can be viewed as a formulation of a new task. The formation of the plan continues if this condition is performed. In fig. 1 is a scheme of the order execution plan.
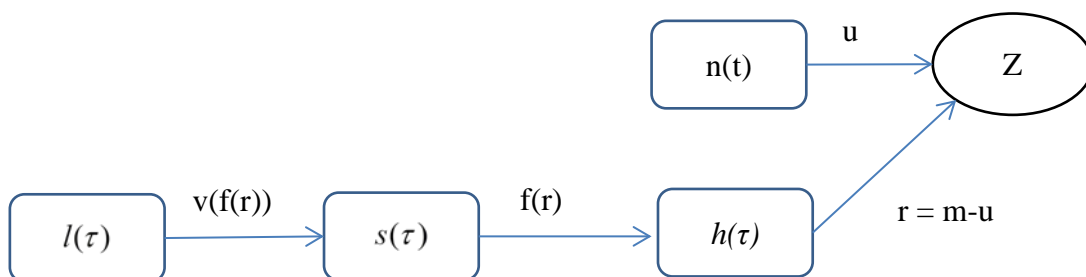
Fig. 1. Scheme of the order execution plan

Let us describe the logic for calculating the feasible plan. To do this, we will use the following idea of the CSM method: at each stage of creating a plan, we will consider a solution for only one subsystem. For example, it is necessary to decide how much of the resources can be taken

from the finished goods warehouse. For these purposes, a randomized test is performed on the set of all values of the membership function $\mu_i(x_k)$. This allows you to form a decision on the issue of finished products in the amount of $U = \min\{n(t)x_k, m\}$ units. from the warehouse. Such

calculations can be carried out not only for the day the order is received, but also for all days in the interval. [t+1, T_z -1].

When choosing a specific solution,

$$u = \min \{n (t) x_k, m\}, \qquad (5)$$

the rest of the order in the amount of r = (m-u) units should be performed due to the production itself. Obviously, this can be implemented, for example, for several days of production. What and how many products do in each of them? It is clear that the extraction days should be placed in the interval [t+1, T_z-1], where the condition is recorded that the results of production can be issued to the client, for example, the day after their production. Determining how many units of products and what day should be done to execute an order is carried out at two stages. Initially, one of the arguments of the function of the belonging $\upsilon_i(x_k)$ is selected, which determines which part of the free power can be used, that is, x_k. Previously received orders remain in the plan of the enterprise. Then day τ is selected from the interval [t+1, T_z-1]. For the selected day, the production volume is recorded, which is designed to perform orders, in the amount of r_τ = min {h (τ) x_k, r} units. After that, the solution must be fixed:

$$P(\tau)=r_\tau \, ; \, h(\tau)=h(\tau)-r_\tau. \qquad (6)$$

Then R = R-R_τ and the procedure described continues, and until the condition R_τ = 0 is executed. In the end, we get many plans for production in the interests of the order under consideration:

$$P (\tau) \, \forall \tau \in [t + 1, T_z -1] \qquad (7)$$

Consumables are needed for planned production. The determination of which volume of materials take from the warehouse of materials, and which is purchased on the market, it is proposed to be carried out according to a similar scheme, but taking into account the time required to deliver purchased materials. Similarly, the question of financing can be solved.

The procedure described forms an enterprise action plan (its main divisions) to fulfill the order::

$$P_z = \{u (T_z), P(\tau), P_s(\tau-1), P_l(\tau-\alpha)\} \qquad (8)$$

for all $\tau \in [t + 1, T_z-1]$.

Here $P_s(\tau-1)$ and $P_l(\tau-\alpha)$ are fragments of the plan for the activities of the warehouse of materials and financial bodies, respectively, α is the time interval necessary for the procurement of materials.

It should be noted that the formed plan is always a permissible plan, therefore the procedure for its formation occupies a central place in the decisions on the management of the enterprise from the point of view of orders.

CONCLUSION

New business technologies require fast planning and enterprise management tools. The considered method uses a production model. This allows you to take into account the resources of the enterprise, the orders received and the possible time frame for the fulfillment of these orders. The changing database of the enterprise provides the ability to quickly get a permissible plan, that is, a plan that is provided with resources, technologies and can be implemented. Such plans are the basis for fulfilling contractual obligations. The method described in the article allows us to hope for the practical effectiveness of such a control technology.

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Structural Management Paradigm in the Models of Network Organizations

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Abstract - **Development problem of network organizations' modelling methods is considered in this article. It is characterized with two fundamental directions that are the basis of the scientific approach. The authors offer one more aspect of modelling – taking into account the influence on the object's structure and the produced products of external messages that carry structural rules, i. e. the rules needed for similar objects modelling.**

Keywords - database, knowledge base, management paradigm, modelling, network organization

I. INTRODUCTION

Developing and researching modelling potential for doing practical tasks of any organizations within society digitalization is rather significant. This kind of the modelling problem has some features [1, 2]. To start with, the modern stage of modelling development is characterized with two main directions that are the basis of scientific approach to modelling.

Firstly, this is a traditional fundamental approach that is based on deep mathematical study of the object, the aim of which is to define object domain, initial and boundary conditions, to set a modelling scenario and to analyze its results. This scientific field is characterized by research papers of A.A. Samarsky [3] and other scientists including studies of optimal control theory by N. N. Krasovsky [4].

Secondly, this is a well-known user-driven approach (G. S. Pospelov's school). The model appears when a set of predeveloped standardized modules of the future model are used as the representation of the non-programming practitioner, as the representation in the situational dependence. This set gives the opportunity to develop automated procedures of constructing the finite mathematical model. In addition, special attention can be paid to N.N. Moiseyev's studies on tasks of system analysis [5]. All approaches have their advantages, but, in fact, do not cover all possible ways to organize modelling processes.

For instance, V.V. Ivanishev school [6] indicates the importance of comprehending internal essence of the program part of the model for every particular application, without which serious mistakes of modelling are possible, because the structure and principles of modelling programs are not accessible to the authors of the mathematic models.

The paper describes the approach's development as another aspect of modelling taking into account the influence of external prescriptions on the object's structure and on the products generated in it. These input messages can carry structural rules, i. e. the external rules strictly needed for modelling similar objects [7] – [9].

Thus, it seems to be very important to develop a modelling method of network organizations' management process.

The paper describes the methodology of defining an organization as a network one. The article also examines how input messages that carry structural rules and solutions to management tasks of network organizations affect its structure and its products.

II. THE NOTION OF NETWORK ORGANISATION MODEL

Network organization stands out from others because it uses mostly input messages specifically for the arrangement of management that is connected with maintaining its internal structure, management, leading to provision of output product due to preassigned structure of skills, knowledge and relations.

It is possible to say that the organization can be completely regarded as network if there is a process of structuring its network interactions in the chain from the command (structuring) input message to the formation on its basis of the finite product of a predetermined structure. This external structuring is considered to be the management process although somewhat different from its generally accepted signal variant.

It can be written as the following model of a network organization using the case of a university. To avoid confusion, it is necessary to note that this is a model of the prescribed organization of the educational process. No optimization of this structure is possible simply due to its purpose. However, research on minimizing the costs of technical equipment supporting this structure and of communication channels is essential.

Assume that S_{FSES} is an integral prescription for the organization of the entire educational process in all universities throughout the country set by the federal state educational standards (FSES).

Then $S_{FSES} = \bigcup_{n=1}^{N} S_{n\_EMA}$, i.e. the general standard contains its differentiation for the organization of training in N educational programs at the level of education and methodics associations (EMA).

It follows that structure S_n of the prescribed organization of the educational process in n educational program is described with the expression modelling it, containing the foundations of specified generalized prescription:

$$S_n \subseteq \left(\sum_{k=1}^{K} p_k^n, \sum_{k=1}^{K} T_k^{p^n}, \sum_{k=1}^{K} M_k^{p^n} \right), \qquad (1)$$

where:

$P_k - k$ is a discipline from K disciplines provided for the study in S_n structure of n educational program;

p^n – is an index for the constituent parts of the model in relation to each particular discipline P of n educational program;

T_k – is semester time provided in each individual discipline P of n educational program for the study of k-discipline.

M_k – is the prescription for the study of K disciplines in n educational program ("private structure" task of mutual provision of the studied disciplines).

III. INFORMATION AND INTELLIGENT DATABASES AS THE BASIS OF MANAGEMENT ARRANGEMENT

Considering the term "structural (data) management", we point out that it is tautological in the information field because according to N. Wiener information is management in terms of mathematical optimization. Therefore, as we take this term to underline the difference between this kind of management and signal (structural-operator) one, we regard it as structural management (management based on analyzing changes in data links) as it is given in scientific literature [10, 11].

First, it is necessary to clarify a few terms related to this technology of management. We assume the obvious fact that we need to define knowledge as data relation as it enables to understand an input message as "structuring signal of control".

The authors in [10] aim to develop information processes structurally and determine that *the term "data" includes the description of objects, their environment, phenomena, facts, whereas knowledge, in its general sense is a variable in time and context named characteristic of the relations between pieces of data.*

According to this definition, structural management (management at the knowledge level) implies that two or more systems understand equally (and perceive in the same context) interrelated information given in a language that carries and transmits data and knowledge about the subject domain [12]. It is quite clear that the concept "knowledge" always expressed in the language of relations (predicates) is complex as it can be implemented in numerous ways and is always linked to the concept "data" [13].

These ideas are supported by G.S. and D.A. Pospelov [14] who were the first to suppose that it is possible to manage unimaginable objects using natural human language. It is quite clear that in modern terminology everything said above repeats and specifies this hypothesis, indicates the need to organize management based on using context-sensitive languages [15]. This is the required non-computable thing that is mentioned in the works [16, 17].

It is shown [10, 18] that the offered definition of knowledge as a data link structure that can be observed, studied and changed, leads to an engineering approach of work with knowledge, to systems "with management on structures". This management, with some restrictions, is quite applicable in modern computers. In addition, this definition puts everything in order when we compare the terms "database" and "knowledge base" and, ultimately, enables to construct a non-signal paradigm of

management – a management paradigm which requires structural changes of the object carried by input messages.

At the logical level of representation (Fig. 1) the system which stores both data and knowledge understood as described above consists of a related database (DB) and a knowledge base (KB), which can be together named just as an information base and a tool (system) of its development and maintenance (IBMS). In [10] this construction is considered as a "template" for the relational construction of an intelligent system. This paper examines it only as "a half" of the system with its own structure, changing under the influence of external messages in a language close to natural. Let us consider this question.
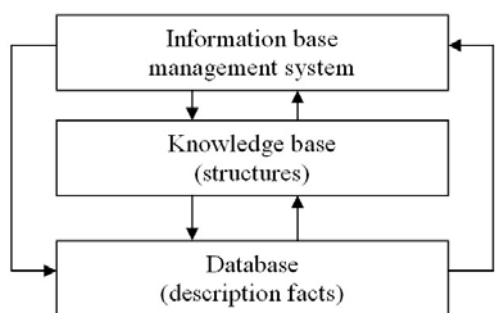
Fig. 1. Logical level of information base representation

One of the most successful approaches to representing a natural language saving its basic semantic constructions is the use of predicate constructions over it. The simplest thing here seems to replace full-length sentences of natural language with simple ones, which ideally consist of a subject, a predicate and an object. Theoretically it is possible only with a loss of the semantic part which is common for complex expressions. It is known [19] that for the simplest situations, partially formalized constructions with a limited thesaurus, such losses are negligible.

The above mentioned simple sentences are "templates" for constructing sentences of the predicate type, which have the form data–relation–data, i.e. completely appropriate for being written in the standard predicate form ARB. As shown in [19], verbs that represent relations are subject to the same formal logic as logical operators (the laws of commutativity, transitivity and others are executed with some special additions corresponding to the "internal logic of thinking in the terminology of this area").

Consequently, in Fig. 1 we have not only a relational base, but also a construction that separately stores pieces of data and the relations between them, called knowledge. It hardly needs to be explained that it ensures the storage of the structure described by a set of data and relations, and if this is a description of an organization (for example, the relations of academic disciplines among themselves M, the names and content of academic subjects P, the correspondence of the academic discipline and hours of the corresponding lectures and practical lessons T), then this is a description not only of the organization itself, but of its current state.

From this description, that is an updated model at the core, one can make automatic selections and comparisons with standard prescriptions for organizing the structure of an organization (in our case, a university). It is possible to update the model continuously simply changing the links between pieces of data or entering new data based on the results of external messages analysis.

As given in a number of works [10, 20, 21, etc.], for the practical implementation of this update method of the database content, two-component construction shown in Fig. 2 is needed.

The given construction has the ability to store necessary information in relational (predicative) form – pieces of data (including numeric and text) and the links between them. We assume (see Fig. 2) that Base 1 contains the last known variant of links. At the same time, Base 2 contains the same variant of data links through the same relations. After some time Δt, Base 2 receives a new message about the desired new structure of links in connection with either a directive instruction about the change in the structure, or with a research of the possible consequences that occur after the introduction of a new structure.
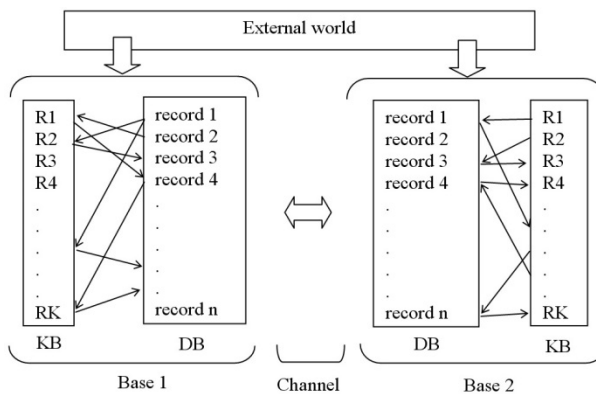
Fig. 2. Two-base variant of updating stored structures

In the latter case, it is also possible to organize the check of the failure consequences of some technical means (or the impossibility of conducting any discipline) for the entire situation connected with the preparation of the finite product. We have already had the criteria for such an assessment based on the changed structures of the object (the teaching process at the university).

In any case, the two-base construction saves the existing variant of the structure and makes it possible to assess the consequences of a disturbing situation without practical experiment.

For example, after making the plan of studies at university, it is possible to compare it with the

requirements of the federal state educational standard (FSES) and other similar possibilities.

In case of purposeful work with data structures (providing the process with constant update of links due to subject-object communication or external messages), a base consisting of several information bases can be considered intelligent and controlling, generating a control message "from changing the structure" (Fig. 3) [10].

We can give the following comment about this system, i.e. the system of automatic communication. Terminologically, the "property of intelligence" of the system is synonymous with management and can be used only as a characteristic of the system complexity, as the requirement's indicator of precisely this kind of management. In addition, according to N. Wiener, "management is nothing more than sending messages that effectively influence the behavior of their recipient".
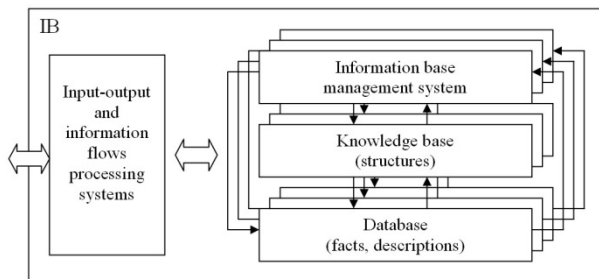
Fig. 3. Intelligent base as a set of information bases

Efficiency here means that we are initially talking about an active system of two-way interaction of these bases in Fig. 3. It can be considered that, the above given definitions in the aggregate, the information and even intelligent base receive their normal logical meaning - the basis for the representation of time-dependent updating knowledge. Thus, the logical level shown in Fig. 1 of the information base representation is the main block for constructing a management system, consisting of numerous blocks that have different purposes and interact with different data flows. In the terminology of the network organization Fig. 3 reflects the process of changing the structure under the influence of external messages.

IV. STRUCTURAL MANAGEMENT PARADIGM

The introduced term of an intelligent base as a part of interacting data and knowledge bases is constructive, because in this context a new management paradigm is constructed [10, 11].

The classical management paradigm ("signal" or "transfer" paradigm) comes from the concept of a control signal expressed in analog or digital form, control of the achieved management result and its correction for deviation by changing the transfer characteristics of the feedback control system [22, 23].

This kind of paradigm is natural and acceptable for systems which descriptive complexity allows their cybernetic representation or functional modelling. In this case, we assume that in a certain area of admissible control the transfer functions of the system have at least continuity, i.e. we assume that the concept of "control signal quantity" or "measurement" of a deviation in deviation range makes sense.

Saving this paradigm for system-complex objects automatically refers us to the level of their cybernetic model (a model that does not create an individual information image of a system with a variable structure of links). This modelling causes pointlessness of any attempts to organize management in high-level languages (not programming languages, but natural, context-sensitive languages), the transition to which, specifically for the purpose of managing public institutions (the universities belong to), was recommended in work [14].

The system view indicates [10, 11, 24] that in order to resolve this contradiction, it is necessary to move to a different management paradigm. It comes from the concept of managing the changes in the links' structures of a certain system by changing the relations between pieces of data and the coordinating procedure of this structure between separate parts (object and subject) in an intelligent system. Consequently, it is proposed to name this paradigm the *data paradigm of structures' coordination* or the *structural management paradigm.*

Let us consider this question in details. Feedback, as a way to correct the subordinate function, does not exist in intelligent systems with "image accumulation" because of the absence of the evident subordinate function in its classical view. Its place is taken by the data structure and the apparatus for coordinating data structures. This process is not recursive and, perhaps, not even partially recursive [16].

A fundamentally important conclusion follows about other management mechanisms in system-complex situations (in particular, in the "network organizations" [25]) and about the limitation of modelling such situations not only by the inconsistency of the languages' description with the context-independent approach, but also by the management mechanism.

V. CONCLUSION

Thus, as it follows from the work [10], modelling "complex according to K. Boulding" object [24] with the help of even an intellectualized automatic control system, we admit that its observability is limited not only by the possibilities of its representation, but also by the fundamental replacement of the acceptance mechanism of management decisions. As it is known [26], in the theory of automatic control, observability is a dual concept of controllability if all its state variables can be directly or indirectly determined from the output (measured) vector of the system.

From a systemic point of view, observability is determined, first of all, by the system's language of representation, its communicative power. Observability

is maximum when the language is the system's own language, in situation when this language is adequately perceived by the observing system. In other cases, the system is observable with restrictions. The problem of stability of these systems is generally adequately considered only at the level of the homeokinetic plateau mechanism [10, 16, 27].

This work does not aim to use completely the new management paradigm for restructuring the network organization under external information flows. Today, the full implementation mechanism of such management is still extremely expensive to implement, and it is not needed in full under the realities of modern requirements for the arrangement of management at the level of the "educational doctrine" of federal state educational standards [28].

In compliance with the objectives of the research:

Work has been done to form the concept of a network organization as an organization in which the process of creating and transforming the internal structure of relations is required and carried out.

It is determined that network organization is an integral part of the external network that manages it and manufactures products reflecting the main content features of the components that form the structure of this network.

It is indicated that Pospelov's hypothesis about working with a textual representation of the organizational structure of an organization is necessary.

Conceptual models of the network organization are formed. They are focused on the representation of the university's technical means comparing their real structure and the structure required by the federal state educational standard.

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Apple and Pear Scab Ontology

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Abstract - **An important issue in horticulture is ensuring plant disease, such as scab, prevention and treatment. Apple and pear are among the most widely grown (approximately 43% of all fruit tree area [1]) and economically important fruit crops specified worldwide and in Latvia. Scab diseases caused by ascomycetous fungi *Venturia inaequalis* and *V.pyrina* are economically the most important diseases worldwide. Research projects have produced research data covering various aspects of plant-pathogen interactions, but there is no internal linkage analysis, as well as implementation of other types of data (such as environmental and meteorological data, etc.). Establishing such a data integration system would allow the identification of new regularities in plant-pathogen interactions, and provide mechanisms for disease control decisions. Semantic analysis is one of information technology approaches to finding relationships in data. The product of analysis is ontology. There are plant disease ontologies which provide classification of diseases and describe their reasons. However, there is no ontology which describes a specific plant and relations among its farming parameters and disease probability. Such an ontology for apple and pear scab is presented in this paper. The constructed ontology can be applied to develop guidelines or digital expert systems.**

Keywords - ontology, pathogens, scab

I. INTRODUCTION

Apple scab caused by *Venturia inaequalis* (Cooke) G. Winter and European pear scab caused by *Venturia pyrina* Aderh are one of the most important diseases of the apple and European pear growing regions worldwide [2]

especially in regions with cool and wet spring and early summer [3]. Scab is considered as one of the most serious threats to commercial apple and pear production especially in organic orchards, causing severe reduction in the quality and size of fruits, premature fruit drop, defoliation and reduction of tree vigor over time [4].

Venturia inaequalis and *V. pyrina* are Ascomycetes fungus with the life cycle of them comprised of one sexual and multiple asexual reproductions annually, which causes significant variations in the fungus population. Annual sexual reproduction leads to recombination and high variation in fungal genome and changes in population genetic structure.

Species of *Venturia* are mostly identified based on morphology and host [5] and on the basis of ribosomal internal transcribed spacer (ITS) sequence data [5], [6], [7], [8]. Often for species identification of fungi used include the ITS region of ribosomal DNA genes (ITS1 and ITS2), the small and large subunits of the nuclear ribosomal RNA genes (SSU and LSU), and also three protein coding genes, namely translation elongation factor-1 alpha (TEF1) and the largest and second largest subunits of the RNA polymerases II (RPB1, RPB2) [7], [9].

Genetic variation and population structure of *V. inaequalis* were studied more than population and genetic diversity of *V. pyrina*. Different molecular tools are used to characterize genetic diversity of populations of *V. inaequalis* in various apple producing countries. Molecular markers such as random amplified polymorphic DNA (RAPDs) [10], restriction fragment length polymorphisms

(RFLPs), amplified fragment length polymorphisms (AFLPs) [11], and simple sequence repeat markers (SSRs) have been used to determine genetic diversity of *V. inaequalis* isolates from different regions of the world [2], [12], [13], [14].

Also, assessment of the level of scab intra-population variability was carried out on the basis of studying the variability of signs of its monosporous isolate colour and texture of the main air mycelium and the central tubercle. On the morphological and cultural characteristics were identified 34 morphotypes of *V. inaequalis* isolates [15], [16].

Rapid evolution of pathogens and emergence of new races of fungi that overcome the resistance genes in the host and also fungicides that leads to problems in the control of the disease. During the course of coevolution, apple has evolved mechanisms to prevent the severity of scab. The isolates of *V. inaequalis* evoke variable symptoms on different apple cultivars [17], [18] which depend on resistance (R) genes. Currently only one major resistance gene Rvp1 of European pear resistance to scab is identified [19], 15 apple resistance genes are known [20].

Several studies have been conducted on the biology and diversity of *V. inaequalis*, the causative agent of the apple scab on the world, but there are relatively few studies on the racial composition and genetic diversity of the pear scab, *V. pyrina*. Systematic research on the racial composition and population diversity of *V. inaequalis* and *V. pyrina* in Latvia was launched in 2010 and a lot data has been collected by now to help characterize the diversity of pathogen populations and to find out the race composition, as this would allow predicting the aggressiveness of pathogens and the formation of new races. Due to the large amount and variety of data semantic analysis can be applied to organize, trace patterns and to find relationships between data. The product of analysis is ontology. An ontology defines a common vocabulary for sharing the information in a specific domain. It contains definitions of basic concepts in the domain and relations among them. Such an ontology for apple and pear scab is presented in this paper. This is the first time an ontology is used for characteristics of diversity on *V. inaequalis* and *V. pyrina* populations in Latvia. Data used for development of ontology is based on processed data from the Institute of Horticulture. The aim of the constructed ontology is to be applied to develop guidelines or digital expert systems.

II. Materials and Methods

A. Related Work

There are plant disease ontologies which provide classification of diseases and describe their reasons. Following best practices principles existing ontologies were analysed to identify whether they can be reused when building the apple and pear scab ontology.

Plant-Pathogen Interactions Ontology (PPIO) [21] is an ontology that describes plant-pathogen interactions and offers a scaffold into which important domain data can be embedded in a precise and computationally-transparent manner. PPIO is being developed from a plant-pathogen interaction point of view, and intends to describe all biological features related to this process. In [22] authors design a system and an ontology for identifying rice diseases from a human observation. The resulting ontology represents abnormalities of rice diseases in terms of symptoms, colours, shapes, and infected plant parts. The Crop Ontology (CO) [23] current objective is to compile validated concepts along with their inter-relationships on anatomy, structure and phenotype of Crops, on trait measurement and methods as well as on Germplasm with the multi-crop passport terms. Plant Stress Ontology [24] describes biotic and abiotic stresses that a plant may encounter. The abiotic stress class has two subclasses: plant stress caused by an excess or deficiency of some element. The biotic stress class has two child terms, herbivory stress and plant disease.

B. Development Overview

The analysis of the existing ontologies was followed by the development of the apple and pear scab ontology. Ontology development process differs with each ontology. To ensure quality and reliability of the developed ontology a development methodology should be followed. Agile Methodology for Ontology Development (AMOD) [25] was selected for the purposes of this research. AMOD aims to bridge the gap between ontology engineering and software engineering by adopting the agile principles and practices in ontology development. AMOD classifies the ontology development into three phases: pre-game, development and post-game. The pre-game phase includes the identification of the ontology goal and scope, tools and techniques, competency questions and available information sources. Outcomes of the pre-game phase for Apple and Pear Scab ontology are summarized in Table 1.

TABLE I.   Outcomes of the Pre-Game Phase

Item	Outcome
Domain	Apple and pear scab
Goal	Finding relationship among data from research projects that have produced data covering various aspects of plant-pathogen interactions.
Scope	Domain knowledge for processing research data of Institute of Horticulture.
Tools and techniques	WebProtégé, Protégé, OWL 2 language
Knowledge sources	Interviews with domain experts, research data

Development phase consisted of two 4-week sprints: two iterations of development. Sprint planning sessions resulted in a set of tasks the development team decided to complete in the sprint. During the knowledge acquisition activities domain experts were interviewed in order to capture all the relevant terms related to the field of interest (concepts, properties, relations, etc.). Institute of Horticulture research data was analysed informally to extract relevant information. The research data consisted of

different apple and pear cultivars, their resistance genes such as Vf gene, Vm gene, cultivar location in the research field and location in Latvia, weather data, and pathogen morphological traits, pathogen genetic markers, isolate identification data, and field data from cultivar and pathogen interaction from different years.

Ontology was built on existing data from the Institute of Horticulture. The rose family (Rosaceae) served as a basis, where two genera (apples and pears) were selected from this family. The Ontology was constructed in such a way that it could be supplemented with other genera of the rose family, whose research is being carried out at the Institute of Horticulture. This division was based on the principles of the taxonomy of species. The next class was the breakdown of the cultivars of each species, with the cultivars at the Institute of Horticulture, and cultivars from around Latvia were used. The "Research subject" and "Research object" classes were divided into subclasses according to the research directions used in the institute,

such as: plants, bacteria, and fungi. Since one cultivar will have several trees in the research field, then the Institute of Horticulture field tree-finding system, based on blocks, rows, and the position of trees in a row, was introduced. Information on the pathogen was described from existing studies on morphological parameters [15], [16] as well as genetic parameters. For research on genetics of plants and pathogen parameters, databases known in the industry, such as GeneBank, CBS Fungal Biodiversity Centre were used. Information on the isolates was developed on a data recording system used by the Institute of Horticulture, which shows the origin of the isolate, what type of field type it was, and what genetic markers have been identified, such as ITS [26], [27], TEF [7], [9], and TUB genes [27], [28]. Both Latvian and English terms are industry specific.

Conceptualization activities resulted in a conceptual model of the ontology represented in the form of relationship diagrams (see Fig.1.)
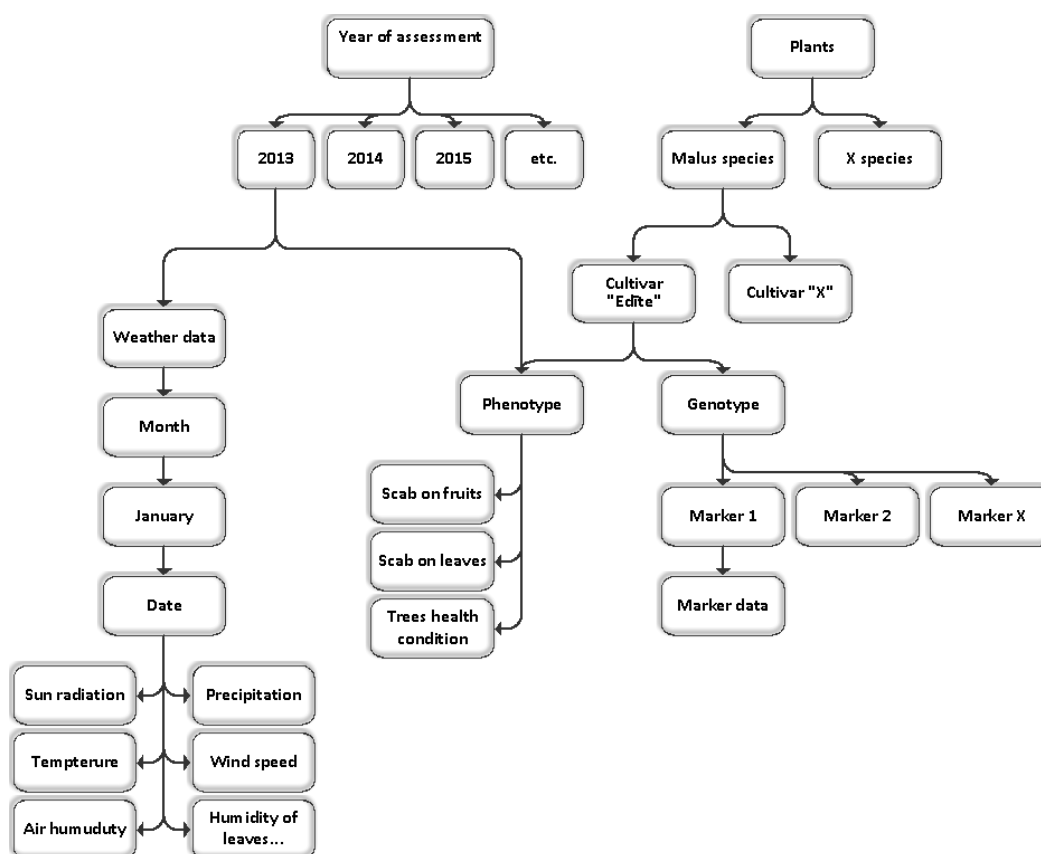
Fig. 1. Ontology conceptual model diagram example.

Formalization activities consisted of building a formal ontology based on conceptual model diagrams using WebProtégé ontology editor. WebProtégé was a tool of choice when building the ontology because WebProtégé is a free, open-source collaborative ontology development environment for the Web. This tool allowed domain experts and ontology engineers to work hand in hand, building the

ontology collaboratively. The ontology was developed using OWL 2 Web Ontology Language. OWL 2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents. The ontology was developed to support two languages: Latvian and English. At the end of each sprint the development team presented

the results to the project team and compared them to the plan set up in sprint planning.

HermiT reasoner supported by Protégé was used post-game to infer new information from the ontology and to ensure consistency. Reasoner revealed two types of new knowledge: 1. new and previously undefined relations between concepts; 2. new and incorrect relations which highlighted underlying errors in ontology structure and which were later corrected.

III. RESULTS AND DISCUSSION

The team of ontology engineers and domain experts have developed Apple and Pear Scab Ontology which will be applied in the development of digital apple and pear scab disease expert system and will serve as a basis for apple and pear scab prevention guidelines. Fig. 3. shows collapsed ontology class hierarchy as seen in WebProtégé.
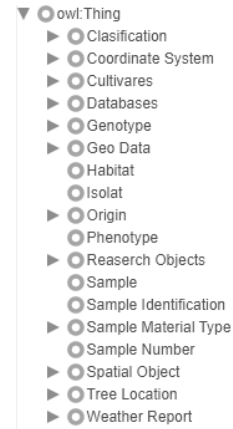
Fig. 3. Ontology class hierarchy.

The developed ontology consists of 70 classes, 49 object properties, 59 data properties and 611 individuals. Ontology entities are annotated using *rdfs:comment* annotation properties to provide context. The list of individuals contains individuals of apple and pear cultivars occurring in research data, and their isolates. An example of isolate individual entity graph is shown in Fig. 2.
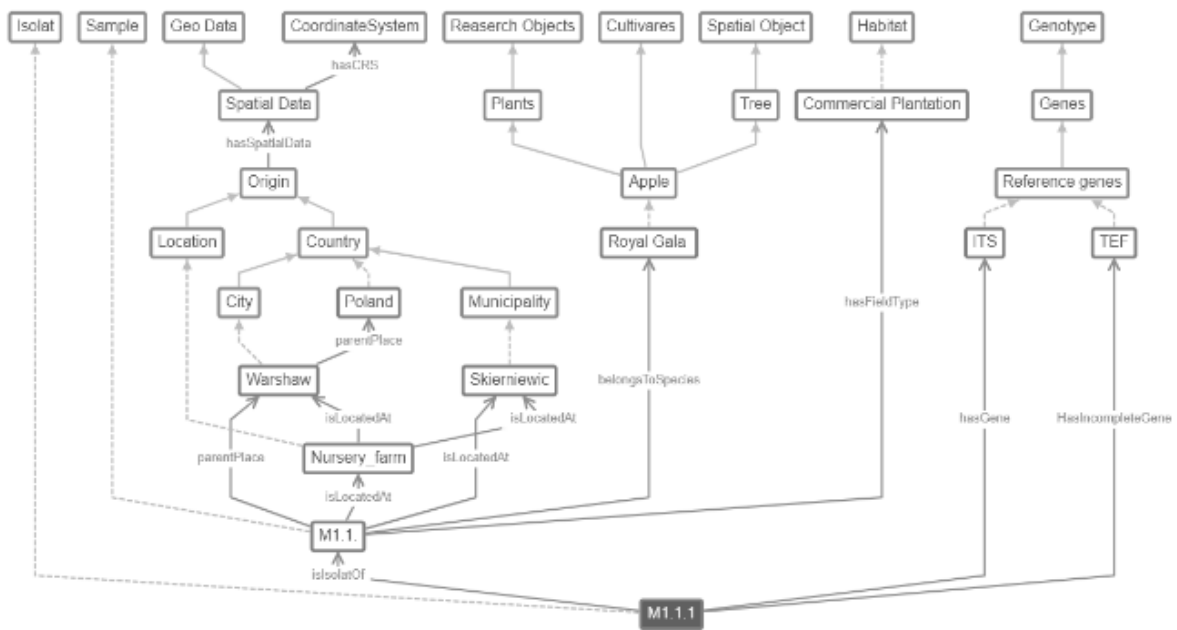
Fig. 2. An example of ontology individual entity graph.

The Sample data were collected from Institute of Horticulture data and added to the new ontology. For instance, in the ontology class "Family" were added the Rosaceae for pears and apples, and for the pathogens *Venturiaceae* for *Venturia inaequalis* and *V.pyrina*. The ontology class "Genus" consisted of several *Malus sp.* used in research at Institute of Horticulture. Likewise, several *Malus* pathogens were added to this class. Furthermore, 32 apple cultivars and 2 pear cultivars were added in the ontology. Additionally, five commonly used databases for pathogen identification and gene identification were added in the class "Databases". Four most used gene regions were added. In addition, several habitat types were added in the class "Habitat". For example, home gardens, commercial plantations, and collection gardens. Data from isolate samples were stored in the class "Isolate" therefore, more than 400 isolates were added. In addition, several locations

for the used samples were added. As a result, the ontology was populated with 611 individual data points.

IV. CONCLUSIONS

The ontology provides a significant first step towards collecting all data from different research directions such as cultivar breeding evaluation, meteorological data, genetic research, and pathogen research and combining in a single data system. Furthermore, adding the existing data set from earlier studies will extend the existing ontology. This ontology can be helpful in finding new links, the interaction between apple scab caused by *Venturia inaequalis* and *Malus sp.* cultivars, the resistance mechanics in cultivars, and the effect of weather on scab population changes. These results emphasize the importance of combining field and laboratory research data with ontologies to find properties and the relations between them. The method for building an ontology used here can be applied to different plant species, genera, and families with different pathogens. This is a fundamental area to be explored further.

The developed Apple and Pear Ontology will be updated with new individuals based on the latest research data of the Institute of Horticulture as it becomes available. In the future authors plan to publish the ontology in open access.

V. ACKNOWLEDGMENTS

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The Alzheimer's Disease Impact on Artificial Neural Networks

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Abstract - **The Alzheimer's Disease main impact on the brain is the memory loss effect. Therefore, in the "neuron world" this makes a disorder of signal impulses and disconnects neurons that causes the neuron death and memory loss. The research main aim is to determine the average loss of signal and develop memory loss prediction models for artificial neuron network. The Izhikevich neural networking model is often used for constructing neuron neural electrical signal modeling. The neuron model signal rhythm and spikes are used as model neuron characteristics for understanding if the system is stable at certain moment and in time. In addition, the electrical signal parameters are used in similar way as they are used in a biological brain. During the research the neural network initial conditions are assumed to be randomly selected in specified the working neuron average sigma I parameters range.**

Keywords - Neuron network, Alzheimer's Disease, Neuron synchronization.

I. Introduction

There are 10^{11} neurons in the human brain. Neurons are unique in the sense that only they can transmit electrical signals over long distances.

From the neuronal level we can go down to cell biophysics and to the molecular biology of gene regulation. In addition, from the neuronal level we can go up to neuronal circuits, to cortical structures, to the entire brain, and finally to the behavior of the organism.

A typical neuron receives inputs from more than 10,000 other neurons through the contacts on its dendritic tree called synapses. The inputs produce electrical transmembrane [1] currents that change the membrane potential of the neuron. Synaptic currents produce changes, called postsynaptic potentials (PSPs).

Small currents produce small PSPs; larger currents produce significant PSPs that can be amplified by the voltage-sensitive channels embedded in the neuronal membrane and lead to the generation of an action potential or spike, an abrupt and transient change of membrane voltage that propagates to other neurons via a long protrusion called an axon.

There are two main different neuron models are being implemented: chemical and electrical models.

The main difference between them besides the main equations of the signal transmission, is the signal reverse direction distribution. The chemical model do not assume it, but electrical does.

The chemical model structure is usually represented by such figures:
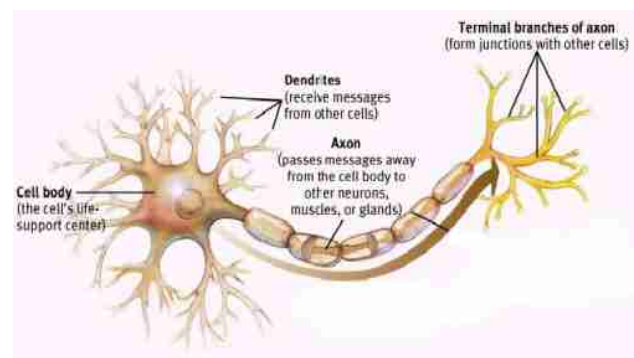
Fig. 1. Neuron chemical model structure.

The electrical model structure is usually represented by such figures:
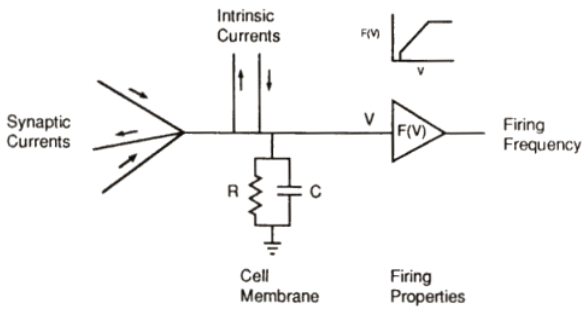
Fig. 2. Neuron electrical model structure.

II. NETWORK MODEL

The chemical neuron model is used within this paper.

The transition between resting and spiking modes could be triggered by intrinsic slow conductance, resulting in the bursting behavior. There could be millions of different electrophysiological mechanisms of excitability and spiking [2]. Fig. 3. demonstrates the general spike plot of the neuron.
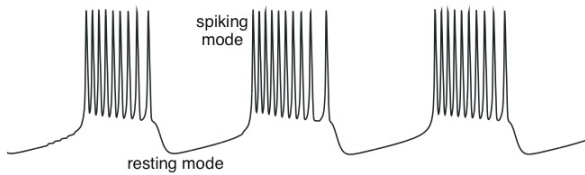
Fig. 3. General neuron spike plot.

III. WAYS TO SIMULATE THE NEURON WORK

There are a lot of ways to simulate the neuron work developed to make adaptive and adaptive response systems.

- Hodgkin-Huxley Model was produced by Hodgkin and Huxley in 1952. The model explains the ionic mechanisms underlying the initiation and propagation of action potentials in the squid giant axon.
- Izhikevich Model is transformed continuous-time Euler's Discretization.
- 3 Rulkov Models can be used in different chaos prediction.
- Courbage–Nekorkin–Vdovin (CNV) Model is quite similar to chaotic Rulkov Model.
- etc.

The Izhikevich Model was chosen to be used for numerical experiments.

A. Alzheimer's Disease Modeling

The Alzheimer's disease problem for the brain is a fast and tending neuron isolation from the brain neural network. It means that during the Alzheimer's disease the brain "loose" cells of memory and analytical skills developed in whole live time. Eventually, some part of neural network can loose connections to whole neuron clusters even if they produce signals between themselves:
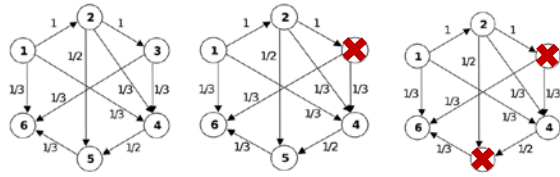
Fig. 4. General exclusion of the neuron from the neuron network.

B. The Izhikevich Model

The Izhikevich Model is originally continuous-time, but Euler discretization with a time step of 1 ms transforms it into the map.

There are several parameters needed for making Izhikevich neural map-based neural model calculations for calculating the membrane voltage difference between inside and outside) sides and additional variable described as follows:
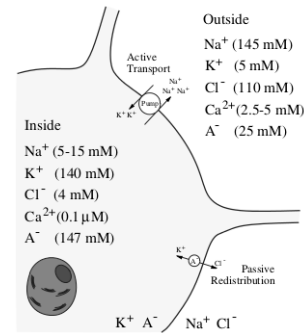
Fig. 5. Structure of the nuron that is assumed as general for the experiments.

The main equation of the Izhikevich model combines values of the neuron collectable voltage in time and neuron output membrane threshold that works similar to electrical conductor and can be describes as follows:

$$v(t + 1) = F[v(t), I - u(t)],$$
$$u(t + 1) = \begin{cases} u(t) + a \cdot [bv(t) - u(t)], & \text{if } v(t) < 30, \\ u(t) + d, & \text{if } v(t) \geq 30, \end{cases}$$

$$F(v, I) = \begin{cases} \min(0.04v^2 + 6v + 140 + I, 30), & \text{if } v < 30, \\ c, & \text{if } v \geq 30. \end{cases} \quad (1)$$

, where v [mV] is membrane voltage (potential), u [mV] represents a membrane recovery variable, which accounts for the activation of K+ ionic currents and inactivation of Na+ ionic currents is additional variable depends on membrane voltage, I (synaptic currents or injected dc-currents) is electricity source connected from outside, a, b, c and d are just neuron parameters.

The parameter a - describes the time scale of the recovery variable u. Smaller values result in slower recovery. A typical value is a=0,02.

The parameter b - describes the sensitivity of the recovery variable u to the subthreshold fluctuations of the membrane potential v. Greater values couple v and u more strongly resulting in possible subthreshold oscillations and low-threshold spiking dynamics. A typical value is b=0,2.

The parameter c - describes the after-spike reset value of the membrane potential v caused by the fast high-threshold K+ conductances. A typical value is c=-65mV.

The parameter d - describes after-spike reset of the recovery variable u caused by slow high-threshold Na+ and K+ conductances. A typical value is d=2.

There are another equations that represents same ones:

$$\begin{cases} C_m \dfrac{dV_m}{dt} = k(V_m - V_r)(V_m - V_t) - U_m + I_b + I_{syn} \\ \dfrac{dU_m}{dt} = a(b(V_m - V_r) - U_m) \end{cases}$$

if $V_m \geq V_{peak}$, then

$$\begin{cases} V_m = c \\ U_m = U_m + d \end{cases} \tag{2}$$

For one of variations of the neuron parameters values the v and u plot would be Fig. 6 for predefined parameter values (a = 0.02, b = 0.25, c = −55, d = 0. I = 0.8):
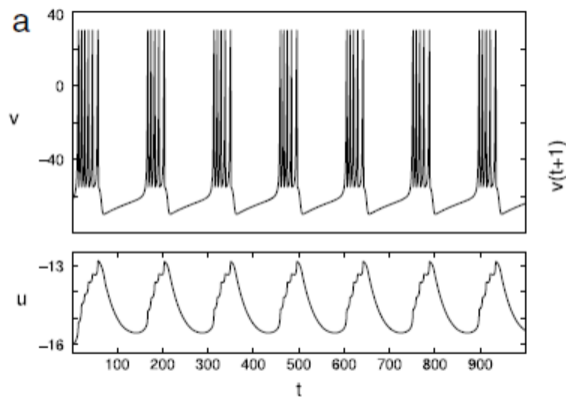
Fig. 6. Neuron v and u values.

IV. NUMERICAL EXPERIMENTS

For numerical experiments the 6 neuron model was used implementing the connectivity matrix that describes the was how each neuron is connected to other neurons in the neuron network model:

$$C = \begin{pmatrix} 0 & 1 & 0 & 1/3 & 0 & 1/3 \\ 0 & -1 & 1 & 1/3 & 1/2 & 0 \\ 0 & 0 & -1 & 1/3 & 0 & 1/3 \\ 0 & 0 & 0 & -1 & 1/2 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1/3 \\ 0 & 0 & 0 & 0 & 0 & -1 \end{pmatrix}.$$

Fig. 7. Neuron network connectivity matrix.

The neural network for the corresponding connectivity matrix is following:
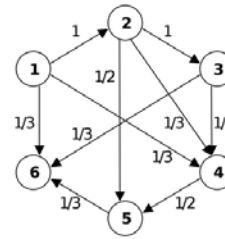
Fig. 8. Neuron netowrk structural model.

The numerical experiments assume neural network analyse that involves Fast Fourier Transformation, Synchronization degree, network coherence, and phase synchronization degree.

The Synchronization degree is described as follows:

$$\sigma = \sqrt{\frac{1}{T} \int_{t=t_0}^{T} \sigma(t)\, dt} \tag{3}$$

$$\sigma(t) = \frac{1}{N} \sum_{n=1}^{N} [x_n(t)]^2 - \left[\frac{1}{N} \sum_{n=1}^{N} x_n(t)\right]^2 \tag{4}$$

, where T is the duration of the time series, t_0 is the duration of transients, N is the number of nodes (n=1,2,…,N).

The network coherence is described as following equations:

$$H = \frac{1}{N} \sum_{n=1}^{N} h_n{}^2 - \left(\frac{1}{N} \sum_{n=1}^{N} h_n\right)^2 \tag{5}$$

$$h_n = \sqrt{\frac{1}{M-m0+1} \sum_{m=m0}^{M} R_m(n)} \tag{6}$$

, where R_m is inter-spike interval (ISI) between m-th and (m+1)-th spike, M is the number of spikes (m=1,2…,M), m0 is the number of transient spikes.

The Phase synchronization degree is described as following equations:

$$\Phi = \sqrt{\frac{1}{M} \sum_{m=1}^{M} \psi_m} \tag{7}$$

$$\psi_m = \frac{1}{N} \sum_{n=1}^{N} \varphi_n{}^2 - \left(\frac{1}{N} \sum_{n=1}^{N} \varphi_n\right)^2 \tag{8}$$

$$\varphi_n = \tan^{-1}\left(\frac{dy_n}{dt} / \frac{dx_n}{dt}\right) - \tan^{-1}\left(\frac{dy_1}{dt} / \frac{dx_1}{dt}\right) \tag{9}$$

, where φ is the phase difference.

When a neuron is isolated it still works, but without any connections to other neurons. It means that it is possible to

create full neuron set rhythm plot to find out periodic value behavior.

The simplest way to analyze a neuron network is to calculate neuron synchronization plot line. Generally, as more time the neuron network working process is simulated as more synchronized neurons become. Literary, it means as more straight the synchronization plot line and more synchronized the neuron network is [3].

For example, the Fig. 8. neuron network without neuron isolations synchronization plot looks as follows (N – simulation time step):
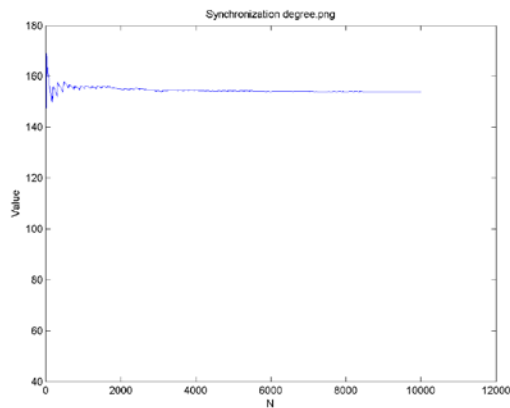
Fig. 9.   Example network synchronization plot.

The same network U values plot is following:
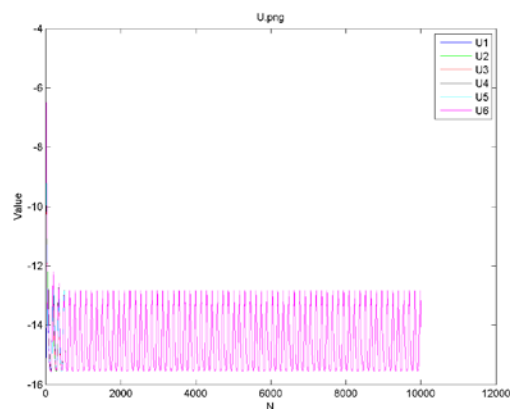
Fig. 10. Example network U values.

In case of Fig. 4. case with isolated neurons the synchronization plot line and U values plot line look as follows:
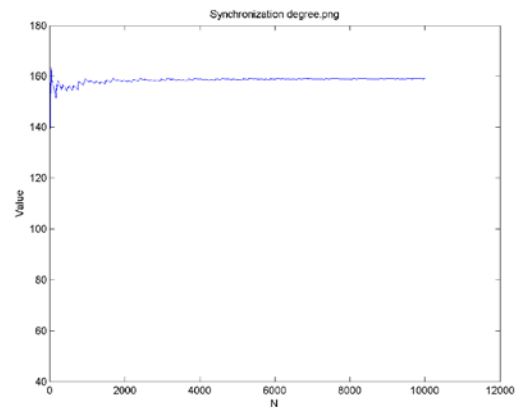
Fig. 11. Example network synchronization plot.

The same network U values plot is following:
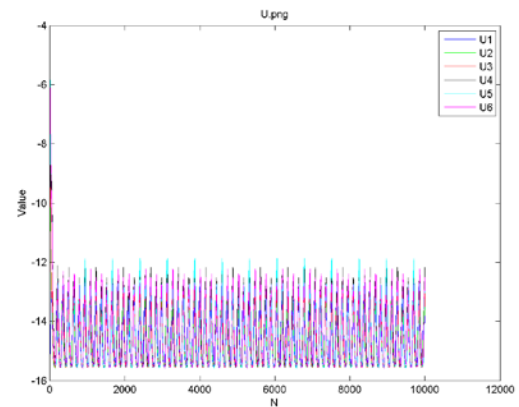
Fig. 12. Example network U values.

As it is seen from graphical results the second network case is less synchronized in comparison to the first one as well as U values are quite periodic, but values are significantly changes in time, that makes it clear that value changes (because of a lot of factors) can provide changeable states of the neuron network.

V.   CONCLUSIONS

1. There are several useful neuron work simulation models.
2. Several factors such as neuron signal delay and neuron isolation have to present in Alzheimer's Disease problem analyze solutions.
3. The Izhikevich Model gives stable results during calculations.
4. The neuron signal receiving delay make big impact the overall neuron network system behavior.
5. Neuron synchronization level impacts only the neural network stabilized state process time.
6. The research made it clear there is a lot of next steps to be done to analyze an effect on the neuron network overall level/percentage (if applicable) of memorized information.

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Implementation of the Difference Scheme for Absorption Equation Type Problems Applying Parallel Computing Technologies

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Abstract - **This paper describes a way of parallel algorithm technology usage for analyzing physical processes parabolic differential problems on the surface. This analysis determine the temperature distribution on the surface. Such analysis can fit calculation of Maxwell and Maxwell-Stokes equations and can be focused on mathematical models that can be reduced to the absorption or diffusion-convection-reaction equations with the initial and boundary conditions of different order (1st, 2nd, 3rd order of boundary conditions). Parallel computing technologies usage provides an acceleration possibilities of mentioned calculations in different way and effect depending of parallel technology type and method combinations used during the calculations.**

Keywords - Parabolic equation, difference scheme, boundary conditions, parallel calculation.

I. Introduction

In the modern technology the large computing power is available.

The current CPU (central processor unit) processor frequency reaches up to 4 GHz. GPU (graphical processor unit) and graphics processor cards have reached up to 1,000 units in a single map, and each processor frequency reaches up to 1GHz.

This means that it is possible to create a computer system that could be designed for solving non-stationary physical phenomena modelling problem of the three-dimensional space.

II. Parallel Computing Technologies

The essence of parallel computing is to split the calculation procedure into several calculation nodes. Based on which technology will be used, a computer program

must be created that will use the most optimal aspects of its technology to realize the best possible after use time and resources. There is the fact that parallelization of calculations takes place within a single processor (multi-core processor), then it must be ensured that each core OS-based process will use the same RAM memory area to read matrix elements.

A. Shared Memory

Shared Memory [3] is a memory that shared between processor core processes as a "shared access memory," which includes both hard disk space (non-removable) and RAM memory. A block diagram of this kind of memory type can be represented as follows (Fig. 1.):
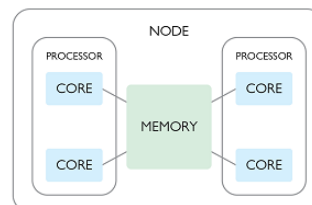
Fig. 1.   Shared Memory Systems.

Since processor / processor kernels of one or more processor / processor cores typically use equivalent processors / processor cores, it may be considered that in the algorithm's parallelization process it would be appropriate for each processor / processor core to execute approximately the same number of operations by executing identical code snippets. Based on modern CPU architecture (fast execution and time delays for switching between processes), it is objectively necessary to split the parallel-generated code into large parallel code fragments to reduce

inefficient CPU usage for processor / processor kernel switching between OS processes.

B. *Distributed Memory*

The Distributed Memory [3] means that the "relative total" memory, which is distributed over computers on the network and is connected to one indivisible computing system. This system can represent computers-curators and computer-based data processing computers. Such computers can be both stationary and portable, both virtual and processor tiles. An intermediate communication tool is text messaging. Each computer has its own processor, RAM memory and hard disk (not always). Each computer receives signals from the host computer. These signals are code fragments of the computer program or their execution parameters. Moreover, it is possible to set up a dataset for sending and receiving data between computers. The logical structure of this kind of memory allocation technology can be represented as follows (Fig. 2.):
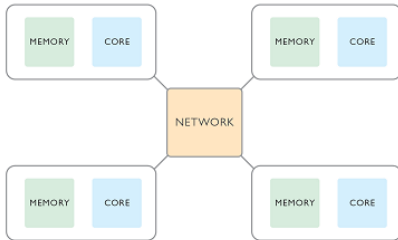
Fig. 2. Distributed Memory.

The method of parallelization of this algorithm would be useful only for the parallelism of the significant fragments of non-interlinked code. Otherwise, sending / receiving data between nodes can undermine the utility of the technology. Therefore, it is advisable to include in the calculation process the computers that are connected with the Internet connection within one router in order to take computer data interchange in relatively short time.

C. *Shared Memory and Distributed Memory symbiosis*

This type of memory combines the two-way division of executable instructions. In practice, here is a combination of two pre-reviewed technologies [3]. The logical structure of such memory allocation as follows (Fig. 3.):
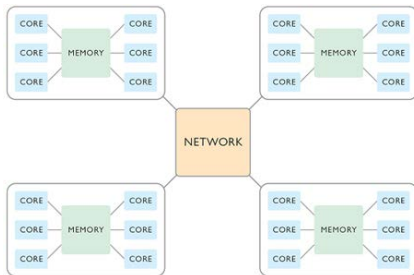
Fig. 3. Shared Memory and Distributed Memory symbiosis.

In using this method, the recommendations of the previous sections should be taken into account when performing the parallelization of the algorithm.

III. PARALLEL CALCULATIONS

Mathematical modeling is based on the application of numerical methods. The paper was written by overlooking the finite difference method. The essence of this method is the unbroken division of a space into a number of nodal points, where the central point of each node is the node average value representation. As more points in the node network, as the node is less sized, so the depth of the calculation or efficiency is increased. The final difference method means that before the calculation process is started, at least the first approximation values must be known in the entire discrete area as consideration (boundary conditions must be known as well). One of the most popular point stencils is the 5-point stencil that combines calculable nodes as follows (Fig. 4):
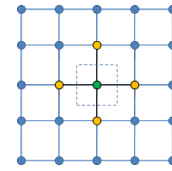
Fig. 4. 5 point stencil.

which means that the value of each point is equivalent to the sum of the values of 4 surrounding points (up, bottom, right and left)

An example is the absorption or Helmholtz 2D equations (Eq. 1):

$$G_x D_x \frac{\partial^2}{\partial x^2} \varphi(x, y) + G_y D_y \frac{\partial^2}{\partial y^2} \varphi(x, y)$$

$$\pm \sigma \varphi(x, y) = 0 \qquad (1)$$

The difference equation matrix method allows to build a solving equation for each unknown point of the grid. These equations contain the current for the certain equation surrounding point coefficients in a way shown in Eq 2:

$$k_{ij-1} u_{ij-1} + k_{i-1j} u_{i-1j} + k_{ij} u_{ij} + k_{ij+1} u_{ij+1} + k_{i+1j} u_{i+1j} = 0 \qquad (2)$$

It is possible to find out that for each point of the node, using the i and j indexes, there exist the coefficients of the existing point and four surrounding each P_{ij} points (multipliers) (Eq 3):

$$k_{ij-1} = \frac{G_y D_y}{h_y{}^2}; k_{i-1j} = \frac{G_x D_x}{h_x{}^2};$$

$$k_{ij1} = -\left(2\frac{G_x D_x}{h_x{}^2} + \frac{G_y D_y}{h_y{}^2} \mp \sigma\right); \qquad (3)$$

$$k_{ij+1} = \frac{G_y D_y}{h_y^2}; k_{i+1j} = \frac{G_x D_x}{h_x^2};$$

Using the above, it is possible to draw up a matrix equation (a system of absolute sets of i and j index equations for each node) that looks as follows (Fig. 5.):

$$
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & . & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & . & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & . & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & . & 0 \\
k1\,x1 & 0 & 0 & k4\,x4 & k5\,x5 & k6\,x6 & 0 & 0 & 0 & k10\,x10 & . & 0 \\
0 & k2\,x2 & 0 & 0 & k5\,x5 & k6\,x6 & k7\,x7 & 0 & 0 & 0 & . & 0 \\
0 & 0 & k3\,x3 & 0 & 0 & k6\,x6 & k7\,x7 & k8\,x8 & 0 & 0 & . & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & . & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & . & 0 \\
. & 0 & 0 & 0 & k5\,x5 & 0 & 0 & 0 & k9\,x9 & k10\,x10 & . & 0 \\
. & . & . & . & . & . & . & . & . & . & . & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & . & 0
\end{bmatrix}
=
\begin{matrix}
u_1 \\ u_2 \\ u_3 \\ u_4 \\ 0 \\ 0 \\ 0 \\ u_8 \\ u_9 \\ 0 \\ \\ u_m
\end{matrix}
$$

Fig. 5. Linear equation system for difference equation solving process using matrix method.

In order to make calculation time enhancement the modified time step was created by using absolute and relative errors of calculated temperature for l+1 time moment in order to speed up calculations by managing simulation time step based on absolute and relative errors of the calculations.

For the "x" unknown set classical calculation method the Ax=B matrix equation has be to used and then "A⁻¹Ax=A⁻¹B => x=A⁻¹B". Matrix inversion calculation process is very "expensive" in terms of necessary HPC cluster needs in order to significantly reduce the time spent on parallel computing. If the matrix has Dim points in one direction so Dim^4 operations should be performed to find out the matrix inversion.

The disadvantages of this method are mainly related to computerized rounding and long calculation time and required computer resources. Special "expensive" by the necessary computing time and computer resources, it is a matrix inversion operation (A^{-1}) (matrix inversion method). An example is a 2D matrix, which has 10000 elements in the each direction. This means that this matrix has 10^8 elements. Each element has a data type. If each element occupies 8 bytes, then the matrix takes a minimum computer memory 8x10⁸B = 8x105KB = 8x102MB = 800MB, which is required to store the matrix. "Good" matrix inversion algorithm requires the number of operations, which is equal to the number of matrix elements squared. In 10000x10000 matrix case, it would be 10^{16}, or 10^{10} million operations. Considering that today's non-threading CPU can calculate 10^9 operations per second, the total calculation time is 10^7 seconds = 2778 hours = 115 days. Parabolic differential equation problems need at least 10000 time step calculation. This means that the total time consumed one problem needs 115x10000 days equal to 3151 years.

Looking at the [2] reference, the solution uses a locked-circuit calculation based on the ADI method. It means that the time step is divided into 2 stages, in which the calculations take one of the directions as an open scheme and 2 directions as an enclosed scheme, where at the top

the index "l" means the time slice index (Fig. 6.). In order to elaborate the parallel calculation method, the difference scheme was decomposed by space and time by applying ADI [1] method assumes calculation half steps using two calculation directions with initial and border conditions:

Fig. 6. ADI calculation split in directions.

$$
u_{i,j}^{l+\frac{1}{2}} - u_{i,j}^{l} = \frac{1}{2}\tau\alpha\left(\frac{u_{i-1,j}^{l+\frac{1}{2}} - 2u_{i,j}^{l+\frac{1}{2}} + u_{i+1,j}^{l+\frac{1}{2}}}{(\Delta x)^2} + \frac{u_{i,j-1}^{l} - 2u_{i,j}^{l} + u_{i,j+1}^{l}}{(\Delta y)^2}\right) \quad (4)
$$

$$
u_{i,j}^{l+1} - u_{i,j}^{l+\frac{1}{2}} = \frac{1}{2}\tau\alpha\left(\frac{u_{i-1,j}^{l+\frac{1}{2}} - 2u_{i,j}^{l+\frac{1}{2}} + u_{i+1,j}^{l+\frac{1}{2}}}{(\Delta x)^2} + \frac{u_{i,j-1}^{l+1} - 2u_{i,j}^{l+1} + u_{i,j+1}^{l+1}}{(\Delta y)^2}\right) \quad (5)
$$

Each partstep equation contains 3 unknowns in only one direction for a 5 point stencil (examples: 5 point stencil for 2D space and 7 point stencil for 3D space) and all other direction unknowns' values are taken from the previous partstep. Since there are only 3 unknowns and they are located in one direction it is possible to construct a 3 diagonal matrix. It means that there are totally separated 3 diagonal matrix calculations for each directions' index values that do not have unknowns series within current partstep. For example, if direction X is the direction for current partstep, that means that it is possible to solve a 3 diagonal matrix with unknowns in direction X for each Y index separately.

The calculations of the ADI method include non-interconnected calculations, which can be separated between several unit nodes. This means that ADI calculations make it possible to use a modern processor with 100% power per computer, using a common memory area. This can significantly reduce the time of one-step calculations. For ADI method implementation in 3D space, there have to be 3 equations instead of just 2.

IV. ENHANCEMENTS

In order to make calculation time enhancement the modified time step was created by using absolute and relative errors of calculated temperature for l+1 time moment in order to speed up calculations by managing simulation time step based on absolute and relative errors of the calculations.

Absolute and relative error calculations for X direction (same for Y and Z) as follows in the beginning of each next iteration starting from second one in order to:

```
For[x=1,x<=DimX,x++,
ErrorAbsoluteX[[x]]=0.00;
ErrorRelativeX[[x]]=0.00;
For[y=1,y<=DimY,y++,
For[z=1,z<=DimZ,z++,
ErrorAbsoluteX[[x]]=ErrorAbsoluteX[[x]]+(Prognos
eX[[x]][[y]][[z]]-
CurrentStepResult[[x]][[y]][[z]])^2;
ErrorRelativeX[[x]]=ErrorRelativeX[[x]]+CurrentS
tepResult[[x]][[y]][[z]]^2;
];
];
ErrorRelativeX[[x]]=ErrorAbsoluteX[[x]]/ErrorRel
ativeX[[x]];
ErrorX[[x]]=ErrorRelativeX[[x]];
];
```

Finding the maximal error for X direction (same for Y and Z) is implemented as follows:

```
ErrorAbsoluteXYZ=0;
ErrorRelativeXYZ=0;
ErrorXYZ=0;
For[x=1,x<=DimX,x++,
If[
ErrorAbsoluteXYZ<MatricaErrorAbsoluteX[[x]],
ErrorAbsoluteXYZ=MatricaErrorAbsoluteX[[x]];
];
If[
ErrorRelativeXYZ<MatricaErrorRelativeX[[x]],
ErrorRelativeXYZ=MatricaErrorRelativeX[[x]];
];
If[
ErrorXYZ<MatricaErrorX[[x]],
ErrorXYZ=MatricaErrorX[[x]];
];
];
```

It is possible to calculate next iteration time step length based on previously found out ErrorXYZ value. As follows:

```
If[
(ErrorXYZ³toltol/2),t1=t;t=t/tkoef;If[t<tmin,t=t
min];];
If[
(ErrorXYZ£toltol/2)ß(ErrorXYZ³toltol/5),t1=t;t=t
];
If[
(ErrorXYZ£toltol/5),t1=t;t=t*tkoef;If[t>tmax,t=t
max];];
```

, where ErrorXYZ = maximal error between predicted and calculated results, toltol = error threshold, tau1 = temporary variable, tau = time step, taukoef = coefficient of time step changing, taumin = minimal time step, taumax = maximal time step.

When the next iteration time step is found out it is possible to calculate prediction for the next iteration calculation results as follows:

```
For[x=1,x<=DimX,x++,
For[y=1,y<=DimY,y++,
For[z=1,z<=DimZ,z++,
PrognoseY[[x]][[y]][[z]]=CurrentStepResult[[x]][
[y]][[z]]+t/t1*(CurrentStepResult[[x]][[y]][[z]]
-PrevY[[x]][[y]][[z]]);
PrognoseX[[x]][[y]][[z]]=CurrentStepResult[[x]][
[y]][[z]]+t/t1*(CurrentStepResult[[x]][[y]][[z]]
-PrevX[[x]][[y]][[z]]);
PrognoseZ[[x]][[y]][[z]]=CurrentStepResult[[x]][
[y]][[z]]+t/t1*(CurrentStepResult[[x]][[y]][[z]]
-PrevZ[[x]][[y]][[z]]);
PrevY[[x]][[y]][[z]]=CurrentStepResult[[x]][[y]]
[[z]];
PrevX[[x]][[y]][[z]]=CurrentStepResult[[x]][[y]]
[[z]];
PrevZ[[x]][[y]][[z]]=CurrentStepResult[[x]][[y]]
[[z]];
];
];
];
```

V. APROBATION

The author aprobated the described approach and received same results applying different methods of calculations for 3rd order boundary conditions shows in figure 7:
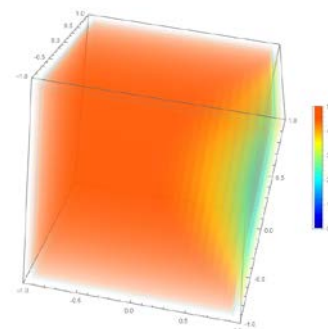
Fig. 7. 3D calculated temperature disctibution using 3rd order boundary conditions.

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Ethical Development and Implementation of Artificial Intelligence

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Abstract - **The paper discovers an essence and importance of introduction of ethical dimension in all phases of artificial intelligence (AI): development of concept and source code, implementation in real-life applications and support and improvement of existing solutions. Modern society largely depends on cybertechnologies most of which are using elements of AI and ethical aspects of it is of paramount importance.**

Keywords - Ethical Artificial Intelligence, Artificial Intelligence, Ethics, Cyber Security, Safety of Artificial Intelligence.

I. Introduction

The paper gives some insights into importance of ethical development and implementation of artificial technology as a part of modern digital world. Several researchers stated that in the recent years (from near 20 till 100) a machine capable to perform on at least human level on all tasks will be developed [3, 4, 11, 14, 22]. Our society on practically all aspects are already depending on digital technologies and AI itself. Despite different predictions whether strong or clever AI will be developed, many researchers agree that this problem is very important and urgently needs serious attention from scientific and technological society [1,2,7,12,26]. Ethical side of the problem is being often forgotten or put to least important category.

This issue is becoming more and more important due to rapid development of AI both on software and hardware levels, wide implementation of AI in business, governmental structures, military, medicine, finance, and personal life. The research in this field is in a very beginning and at the same time is crucial to our development and safety. Ethical side of AI and digital technologies are crucially important due to several reasons, firstly, ethical principals are vital for normal life of whole humanity and for each its person, secondly, ethical problem in digital technologies has its own features.

Ethical principles are based on core values, are of a universal nature. For example, cross-cultural studies have shown the universality of values such as assistance to relatives, support of their group, mutually beneficial sharing costs and benefits, respect for elders, respect for private property [6]. However, core values get different readings depending on the context and refraction into specific ethical requirements. In this case context is the structure of everyday life, including technology, who shape it.

Knowledge of the ethical dilemmas of digitalization and AI, about the emerging rules of ethics of digital technologies, especially important for government, and those who provide their professional training and professional development. To receive positive effect decision-makers should be aware of technological development, understand what economic and social the consequences will be caused by their application. Public administration and interaction with citizens are also digitalized. The effectiveness of such interaction is not in the last place depends on whether the ethical risks.

The issue of ethical AI development and implementation can also be useful to those who are responsible for the development digital services, products, and systems (including in the public sector), targeting citizens as recipients of services and consumers or as workers. Potential conflicts and risks associated with ethical side of the use of technology, can be prevented, if you pay attention to this when designing a service or product.

II.   DEFINITION OF ETHICS AND ITS CONTEXT IN ARTIFICIAL INTELLIGENCE

According to Merriam-Webster's dictionary ethics is "the discipline dealing with what is good and bad and with moral duty and obligation" [19].

Ethics shows what the consequences can be if a specific idea will be perceived by an individual or society, what kind of preconditions and prospects. Thus, ethics can be defined as a reflection of morality. From other means of social regulation - rights, traditions, customs - moral norms differ in that they involve freedom of choice and are regulated primarily by such feelings as shame, duty, remorse [28].

The main system of ethical principles is humanism. Precisely by the principles of humanism mankind is guided in formulating the most important international instruments such as the Universal Declaration of Human Rights [25]. Humanism involves caring for a specific person, striving society to create conditions for the satisfaction of individual needs and personal fulfillment. The main principles of humanism include:

- ✓ guarantees of fundamental human rights as a general condition for genuine private existence;

- ✓ support for the weak, going beyond conventional wisdom a given society about justice;

- ✓ formation of social and moral qualities that allow personality to self-actualize using social values [28].

Going back to IT side let us consider McCumber Information Security Model (widely known as Cybersecurity Cube), which gives us all aspects of information security (Fig. 1).

McCumber INFOSEC Model
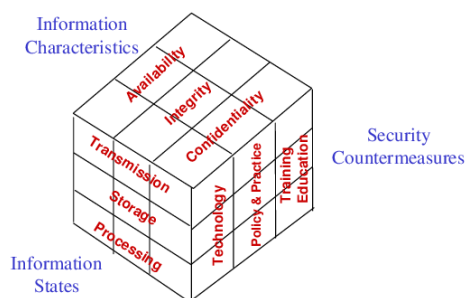
Fig. 1. Cybersecurity cube or McCumber INFOSEC model [17].

Looking from an ethical perspective we should treat all sides and aspects of this cube from an ethical dimension, taking into account ethical considerations developing each side of artificial intelligence system and implementing its security firstly from ethical side, starting from education of developers and ending with ethical support of such systems.

III.   RESPONSIBILITY OF AI

The problem of responsibility for the actions of AI systems is the most important and most discussed among application of AI. Problem responsibility appears in areas of trust where a person has to rely on the actions of the AI system, especially in such areas like medicine, finance, politics, education, law enforcement etc.

Discussions suggest different approaches to the principles establishing responsibility for the actions of AI, including [27]:

- ✓ full exemption of anyone from responsibility for actions AI (by analogy with force majeure circumstances);

- ✓ partial exemption from liability (exemption specific person from any responsibility and the simultaneous payment of compensation to victims from various sources);

- ✓ responsibility through fault, arising only depending on fault a specific entity, for example a manufacturer, developer, person, responsible for training AI, owner, user, etc .;

- ✓ innocent responsibility (a certain person (most likely, manufacturer), as a general rule, is considered to be responsible for AI system actions);

- ✓ personal responsibility of robots subject to the endowment of robots legal personality (rights and obligations, status electronic personality).

There is still no consensus in AI responsibility problem, therefore it is valuable to give several interesting opinions on this topic, published in [25]:

Razin A.V., Doctor of Philosophy sciences, professor, head. department ethics of philosophical Faculty of Moscow State University M. V. Lomonosov: "There is a concept of shared responsibility in ethics: in one way or another degree responsibility is borne by all participants - and the developer of the system artificial intelligence, and its owner, and the user (if he has the ability to customize it), and the system itself. "

Karpov V.E., Cand. tech. Sci., Vice President of the Russian Association of Artificial Intelligence, head of laboratory of robotics NRC "Kurchatov Institute": "Most often, this responsibility is assigned to the "programmer", but he is only an operator who lays down the rules of behavior, determined by an expert, a specialist in some subject area. In the case of ethics, by some moral philosopher, for example. It is the expert who is the moral philosopher and is responsible for the essence of the system's behavior and what the logic should be based on decision making. What "moral code" will be provided; this will be implemented by a "programmer". "

Dushkin R.V., Director for Science and Technology of the Agency of artificial intelligence: "There are several options for who is responsible: the developer, the owner,

users and the artificial intelligence itself. The fourth option is radical, and that is what I preach. In most countries, the legislation is arranged in such a way that if something happened, the person who is to blame, compensates for the damage in money or falls to jail. Accordingly, an intelligent system can also be responsible for your mistakes with money. Let us take an autonomous drone or a car, it has certain needs: fuel, electricity, maintenance, parts and need in money for it all. He earns them with his functionality, continuous movement around the city, transporting passengers from point A to point B, for which passengers pay him, as they pay now Yandex or Uber. The machine spends less than it earns and saves money with which she will answer if something happens, and from her compensation for damage will be recovered. "

Milke V.E., PhD in Computer Science and Machine Learning, England Ruskin University (Cambridge, Great Britain): "Ethics in artificial intelligence is largely dependent on manufacturers of these solutions and very few from consumers or service companies - legal owners of systems artificial intelligence. We concentrate a lot on the question "Who is to blame if ...?". In fact, when the discussion begins on ethics of artificial intelligence, the broader question: how to develop artificial intelligence to avoid all kinds of risks. No need to invent something new, when there are ten commandments: do not steal, do not kill, honor your father and mother, etc. Many well-known ethical principles, for example from the Asilomar conference, written in modern technical language, but they say the same thing: do not steal data, do not harm your developments, system crashes in artificial intelligence must be discovered and explored, the superintelligence must be designed solely for the benefit of humanity, and self-learning systems should be under control of humanity, etc."

Neznamov A.V., Executive Director of Sberbank, founder of the Robopravo project, lead. researcher in Institute of State and Law of the Russian Academy of Sciences: "The term "artificial intelligence" has no single definition; therefore, it is rather difficult to talk about uniform rules of application of AI in all areas. Accordingly, the question responsibility also cannot be resolved unequivocally. Today only one rule could be called universal: the person is responsible. To a greater or lesser extent, but the responsibility for the actions of AI is a sole responsibility of a specific person. It seems necessary avoiding the two extremes: when there is no responsibility at all and when the responsibility is borne by the system of artificial intelligence. Both options seem completely irrelevant in the existing conditions".

IV. EXPLAINABILITY OF ARTIFICIAL INTELLIGENCE

In explainable or transparent AI a user should clearly and fully understand the output of an AI system and make corrections if necessary.

The concept of explainable AI (XAI) is shown in Fig. 2, which clearly shows that today the user usually does not know the answers to the following questions:

- ✓ why computer do it;

- ✓ why not something else;

- ✓ when it succeeded;

- ✓ when to trust a computer and how to correct errors.
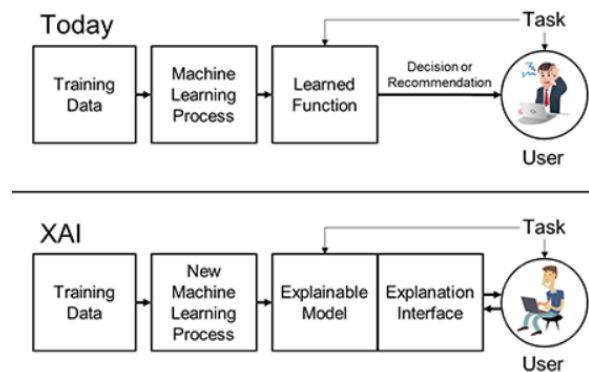
Fig. 2. Explainable AI [9].

In the case of XAI the user will have answers to all these questions.

Andres Holzinger presents an approach of a complete machine learning pipeline beyond algorithm development [13].

Wojciech Samek provides several reasons why explainability is so important for AI research and its safety aspects [23]. There reasons are: verification of the system; improvement of the system; learning from the system and compliance to legislation.

The sensitivity analysis (SA), Layer-Wise relevance propagation (LRP) and other methods make AI more transparent and explainable.

Unique algorithms created by developers are intellectual property and should not be fully disclosed (except for open source or individual cases stipulated by the contract for development). Accordingly, the explanatory component should work in such a way as to explain the results of a system, without revealing the entire process of its functioning. The presence of an explanatory component is an obligatory property of artificial system, otherwise trust in it and therefore its value is being questioned.

V. BIAS IN ARTIFICIAL INTELLIGENCE

The problem of bias in AI systems is one of the most important in the application of AI. Biases and assumptions that are subtle at first glance can be hidden in data, and systems that are built on their basis can inherit both, which affects the objectivity of the system and makes its decisions unethical and biased. As a result, AI can make recommendations or take actions, which only reinforce and reproduce these biases. The fairness of algorithms is one of the most important areas in creating ethical AI.

However, there are also good examples of AI systems helping to tackle that bias, for example reducing racial inequality in the criminal justice system [15] or automated

financial underrating systems can be helpful for applicants with an undervalued credit history [8].

On the other hand, a violation of ethical standards in data collection, insufficient anonymization or insufficient validation of input data used to train AI systems may lead to discrimination of persons involved in that process.

For instance, trained on partially fictional case histories, IBM Watson sometimes makes deadly cancer treatment recommendations [21]. In the United States, the PredPol crime prediction program trained on an ethnically distorted sample, more often sends the police to the addresses where the representatives of ethnic minorities live [16]. Examining credit history when making hiring decisions can hurt disadvantaged citizens, although there is no proven link between quality of credit history and behavior at work [24].

Amazon discontinues its picking system staff after bias-related bias was found in the algorithm. The algorithm recognized patterns of words in the resume, not the corresponding skillsets. The input data for training the system turned out to be mostly white men's resumes. The algorithm excluded resumes that contained words more commonly used by women. As a result, bias towards women in hiring was manifested [10].

Understanding these facts and a danger of AI biases several approaches have been proposed to reduce the risk of errors and mistakes of artificial systems.

The specialists of the London-based company DeepMind suggested as a defense against the influence of human prejudice use the hypothetical fairness method (counterfactual fairness). To formulate a fair and unbiased judgment about a citizen, AI forms a hypothetical situation in which a given citizen has the opposite characteristics: a woman turns into a man, a poor person turns into a rich person, an African American turns into a white one, etc. Thus, the real status does not affect the assessment of the citizen's actions. A judgment is formed in a hypothetical situation. Such a judgment is considered free from prejudice, and therefore fair [5].

The second approach is to improve the AI systems themselves, from the way data is used to design, implementation, and application processes, to prevent individual and societal biases from perpetuating or creating bias and related problems. Interdisciplinary collaboration aims to ensure the further development and implementation of technical improvements, working methods and ethical standards [25].

An important part of the fairness of AI systems is mandatory inclusion of direct human participation. While fairness statistics are certainly useful, they cannot consider the nuances of the social context in which the AI system is deployed and the potential problems associated with, for example, data collection [20].

VI. RESULTS AND DISCUSSION

The paper shows that the research made in the direction ethical AI needs serious attention and there are several issues to be solved. All the proposed approaches for solving above mentioned problems are limited and do not assure the complete confidence of AI user that this technology will have only positive effects.

The research directions should answer the following questions:

- ✓ Where exactly and in what form is human judgment needed in the ethical development and operation of AI?

- ✓ Who decides when an AI system has already minimized bias and is safe to use?

- ✓ In what situations and contexts automated decision making is allowed and ethical?

No computer algorithm can answer these questions on its own, and they cannot be entrusted to any machine. They require human judgment and reflection from a variety of disciplines, including computer science, sociology, economics, psychology, law, and ethics. For this purpose, in each area and every location the trustworthy group of experts motivated to behave honestly and ethically should act to help a mankind ensure safe and ethical use of AI and digital technologies. This is an ultimate goal and success factor of our future.

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ENGINEERING EDUCATION

Transversal Competencies for Digital Readiness and Development of Human Capital in Engineering Education

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Abstract - **The research is carried out within the framework of Rezekne Academy of Technology, Latvia in cooperation with West Ukrainian National University, Ukraine LV – UA project "Gender aspects of digital readiness and development of human capital in regions" Nr.LV-UA/ 2018/3.**
Nowadays, educational institutions have to adapt to the new situation, make changes that would promote the transformation of the study process, promote the development of digital readiness and human capital.
The aim of the research is to study the need for transversal competencies, innovation, entrepreneurship and development of digital readiness and human capital in engineering studies. The monographic and descriptive method has been applied for studying scientific literature and modeling method for a professional development plan.

Keywords - digital readiness, engineering education, human capital, transversal competencies.

I. INTRODUCTION

The coronavirus (COVID-19) pandemic in all over the world places people in a new situation and it demands the need for competencies for all employees and all professions to work in specific and health-hazardous conditions. Covid-19 has changed the global economy, accelerating the transformation of higher education and improving the digital skills of staff and students.

The research is carried out within the framework of Rezekne Academy of Technologies, Latvia in cooperation with West Ukrainian National University (previously Ternopil National Economic University), Ukraine LV – UA project "Gender aspects of digital readiness and development of human capital in regions" Nr.LV-UA / 2018/3.

The study is based on research about digital readiness and gender inequality in cultural and regional terms by the project "Gender aspects of digital readiness and development of human capital in regions".

Engineering sciences are a widely represented field. In the Law on Scientific activity of Latvia is marked the field of Engineering and Technology, which includes civil and transport engineering, electrical engineering, electronics, information and communication technologies, mechanical engineering and mechanics, chemical engineering, materials engineering, medical engineering, environmental biotechnology, industrial biotechnology, nanotechnology and other engineering sciences and technologies, including food and beverage technologies [1].

Rezekne Academy of Technologies implements engineering study programmes, preparing professionals for the labor market, such as Mechatronics, Civil engineering, Engineer of programming, Environmental engineer, Laser Technologies, etc. In these programmes the main emphasis is placed on the professional study courses. However, nowadays educational institutions have to adapt to the new situation, make changes that would promote the transformation of the study process, promote the development of digital readiness and human capital. It is now obvious that the education system must not only provide theoretical and practical knowledge in a profession specific field, but also develop the social skills useful to live and work in today's changing society [2], [3].

The aim of the research is to study the need for transversal competencies, innovation, entrepreneurship and the development of digital readiness and human capital in engineering studies.

The monographic and descriptive method has been applied for studying scientific literature and modeling method for a professional development plan.

II. TRANSVERSAL COMPETENCIES FOR THE DEVELOPMENT OF DIGITAL READINESS AND HUMAN CAPITAL IN ENGINEERING

The industrial revolution has been the most important in the history of human development, it has increased industrial productivity, changed economic development and created the structure of education. The paradigm shift in engineering education is closely linked to the industrial revolution (table 1).

During the first industrial revolution, workers had enough with basic knowledge to work with equipment. Workers did not need or have access to education, only the richest people could afford to study [4].

The second industrial revolution introduced conveyor lines, products were produced in bulk, the worker needed basic reading, writing and specific work skills on his work equipment [5].

During the third industrial revolution, digitalization took place, automated control of equipment was introduced, introduction of digital control (CNC) machine tools, development of microprocessors. During this period, the worker must be educated to be able to operate and program various equipment [6].

The fourth industrial revolution, 'Industry 4.0', brings together everything that has been known so far, creating interdisciplinary, replacing all works with digital and remote access, as well as artificial intelligence. During this time, the employee is expected to have extensive knowledge in several areas. It is no longer enough to have one narrow specialty, it is necessary to solve tasks related not only to the field itself, but also to digitization, autonomy. At this stage, unequal digital readiness and development of human capital in the regional aspects appears and it is emerging. 'Industry 4.0' is influencing production processes that are becoming increasingly complex and industry is being digitized. Smart systems need trained staff to deal with a variety of unexpected situations, changing working conditions [7], [8].

Analyzing the materials of Latvian periodicals available on the portal *Periodika.lv*, it can be concluded that engineering education has been relevant in the past as well. In 1935, Professor A. Tramdahs explained the responsibilities of an engineer's work, in general it is called a creative process in solving certain problems, a high-quality engineer must apply several important skills "The work of an engineer begins with the understanding the problem and the solution of the resulting tasks on the basis of science, with scientific methods" [9].

In the 1982 newspaper *Plēsums*, assistant G. Zaķis mentioned his thoughts about what an engineering specialist should be like, for example, basic knowledge in the specialty, sociability, efficiency, logical thinking, research skills and humanity [10].

TABLE 1 INDUSTRIAL REVOLUTION

Title	Period	Description	Keyword
The 1st Industrial revolution	Middle of the 18th century – middle of the 19th century (1760 - 1840)	Transition from manufacturing to industrial production. Production mechanization.	Mechanical
The 2nd Industrial revolution	End of the 19th century – beginning of the 20th century (1870 - 1914)	Introduction of conveyors. Mass production.	Electrical
The 3rd Industrial revolution	1970 – 2010	Manual devices have been replaced by CNC machines. Automated production.	Digital
The 4th Industrial revolution	2010 – present	Complete computerization, interconnection of mechanisms, interdisciplinary, artificial intelligence.	Internet of Things

III. PROFESSIONAL DEVELOPMENT PLAN FOR ENGINEERING STUDENTS FOR THE DEVELOPMENT OF DIGITAL READINESS AND HUMAN CAPITAL

Boston Consulting Group (BGC) has identified nine technology trends as key elements of Industry 4.0 (Figure 1). Equal quality, digital readiness and gender equality must be ensured in the education process in all regions.

It is important to connect the education system to industrial changes, to adapt to the latest trends. Engineers also need training in the latest technologies related to the field of information technology – Internet of Things, cybersecurity, cloud services, virtual reality, big data and analytics, autonomous robots, simulations.

In education, it is important to think interdisciplinary, to use different methods to achieve the goal. Research indicates that engineering education must be flexible, constantly updating and adapting to the latest technologies [11].
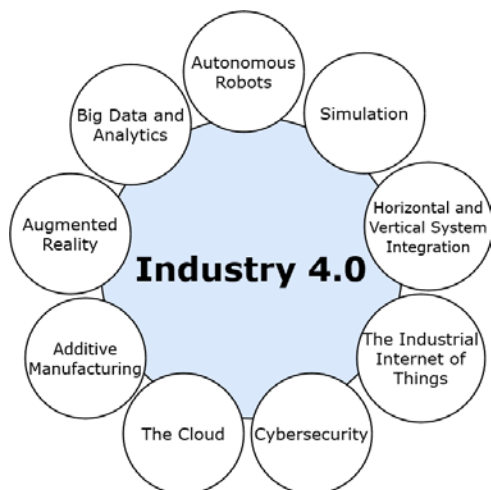
Fig. 1. **Industry 4.0 key technologies** [12]

Leandro Cruz & Saunders-Smith (2019) conducted a research to determine the level of competencies of bachelor's and master's degree graduates based on the industry's understanding of competencies. This research highlighted entrepreneurship, innovation, communication, teamwork and lifelong learning competencies [13], [14].

The project of University of Latvia "Assessment of the Students' Competences in Higher Education and their Development Dynamics during Study Period" ESF 8.3.6.2. "Development of Education Quality Monitoring System" 8.3.6.2/17/I/001 (23-12.3e/19/103) has created an entrepreneurship, innovation and digital competence structure (Figure 2).
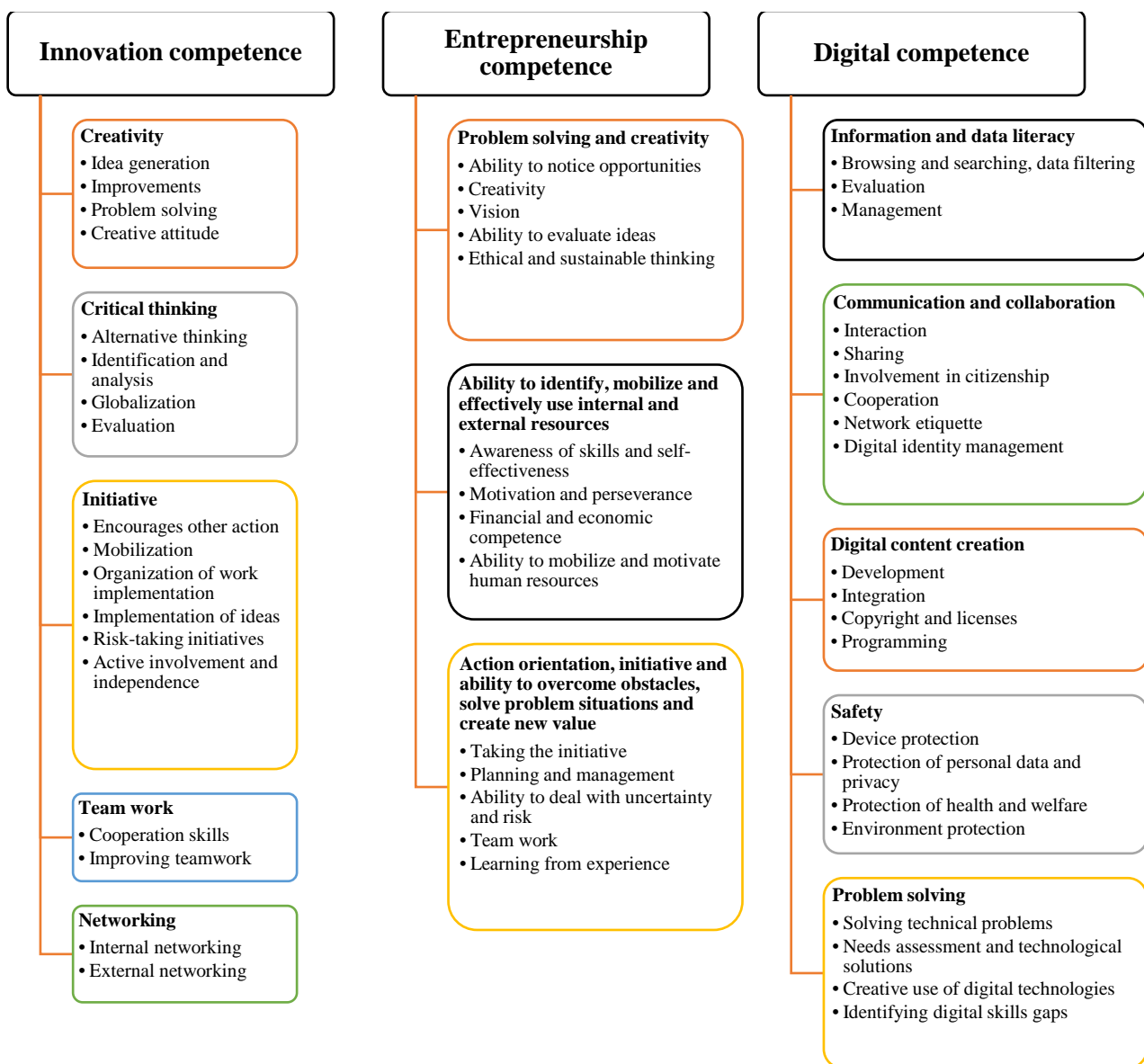
Fig. 2. **Structure of transversal competencies** [15]

Analyzing the scientific literature, different ways of learning transversal competencies are described, for example, problem-based learning, project-based learning, games, simulations, discussions [16], [17], [18], [2].

Following the theoretical module of O. Mikhailenko, T. Blayone, I. Žogla, V. Lubkina has been developed a professional development plan, which improves digital, entrepreneurship and innovation skills of Mechatronics students in the study course "Sensor data processing" (Figure 3) [19].

In the successful interaction of all components, students' skills are improved in several areas, as well as digital readiness is developed. Transversal competencies are increasingly being recognized by engineers because work becomes increasingly interdisciplinary. According to the research by S. Coşkun, Y. Kayıkcı, E. Gençay, the integration of 'Industry 4.0' in engineering education requires 3 basic stages - a curriculum, laboratories and a student club, where students have the opportunity to design, present and further develop their projects [20].

In order to fully master the course, theoretical lectures are required, where the basics of the topics corresponding to the course, guest lectures by industry experts or, for example, video tours in companies are provided. In the study process must be provided skills for the development of innovative, entrepreneurship and digital competence. This process also requires practical classes, such as laboratory work, where theoretical knowledge and digital and innovative competence must be applied. Individual work will be presented using entrepreneurship competence.
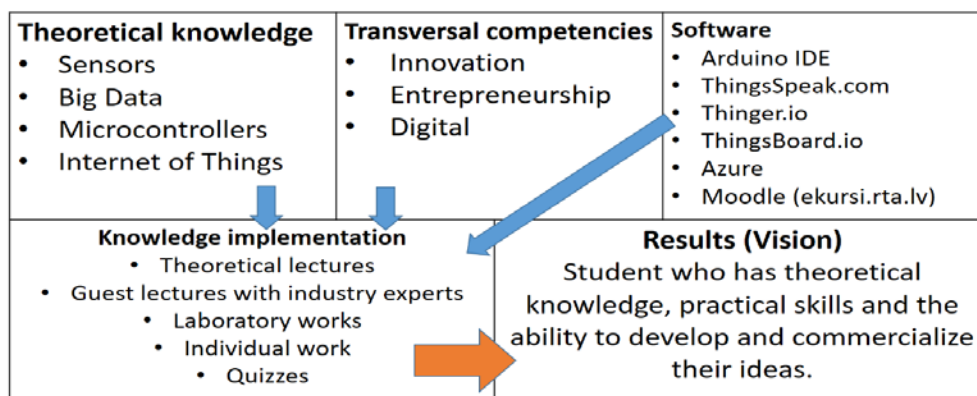
Fig. 3. **Professional development plan**

IV. CONCLUSION

The education system is not suitable for nowadays life. The education system must not only provide theoretical and practical knowledge in a profession specific field, but also prepare students for the digital environment, gender equality and the social skills needed to live and work in today's changing society.

Getting acquainted with historical sources in Latvia, it can be concluded that engineering education has been important in the past, as well as it has been significantly influenced by the Industrial Revolutions. We are currently in the Industry 4.0 processes, which affects the production process, it is becoming increasingly complex and the work is interdisciplinary. Technological changes are especially important for future engineers, who will have to work in this period of change.

Within the framework of the research, the professional development plan has been developed, which will be used as a basis for the improvement of the course "Sensor data processing". It provides an example of how to acquire the study course by combining it with transversal competencies using digital tools and various teaching methods. This will improve students' digital, entrepreneurship and innovation competences.

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Engineering Master Students' Views on Digital Entrepreneurship in a Host European Country

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Abstract - **The importance of engineering education in promoting engineering students' entrepreneurial attitudes and behaviours now is widely recognised. The aim of the research is to explore international engineering Master students' views on digital entrepreneurship in a host European country underpinning the elaboration of implications for engineering education in a host country. The research methods imply the use of both - theoretical and empirical - methods. Theoretical methods included analysis of scientific literature, theoretical modelling, systematisation, synthesis, comparison, generalisation. The empirical study was carried out in Germany in February 2021. 32 engineering Master students took part in the online survey. The online survey was based on the online questionnaire. The obtained data were described with the use of percentage, standard deviation and weighted average. The data description was followed by data interpretation and summarization. The use of the theoretical methods allows identifying that digital entrepreneurship is a supplement to traditional settings entrepreneurship proceeds in. The theoretical research resulted in the conceptual framework built of engineering student's intention to become a digital entrepreneur, the use of the host country language, the use of engineering knowledge in digital entrepreneurship. The results of the empirical study allow finding out that the engineering Master students' view digital entrepreneurship in a positive way. The survey results show that the engineering students focus their digital entrepreneurship on their professional field, namely engineering. The survey also outlined two major factors, namely host country language and host country rules, that limit the opportunities of becoming a digital entrepreneur in a host country. The implications for engineering education, that international engineering Master students receive in a host country, imply the integration of entrepreneurial culture, namely host country language and host country rules, into engineering education in a host country. The emphasis of the host country language and host country rules should be placed on their use for entrepreneurial purposes. By the entrepreneurial purposes, specific activities that are tied to entrepreneurship are meant. Training of host country language and host country rules within engineering education should be centred on their use for entrepreneurship.**

Keywords - Digital entrepreneurship, engineering students, host country, master studies.

I. Introduction

Engineering education has always been in the locus of the research community due to its significant role in promoting the engineers' and prospective engineers' skills necessary for finding innovative solutions in respond to pressing environmental, social and other challenges. Therefore, engineering education conventionally focuses on innovation creation and management. It should be noted that "innovation is the specific instrument of entrepreneurship, the act that endows resources with a new capacity to create wealth" [1]. It should be also stressed that entrepreneurship is a fundamental economic resource or factor of production [2]. Entrepreneurship being an

economic resource influences the development of regional economics. Entrepreneurship in regional economics is often revealed by teaching international Master students at local universities [3].

Innovation in the absence of entrepreneurship generally yields nominal restricted economic impact [4]. It is the entrepreneurial spirit that paves the way to continued economic growth by using the multi-dimensional aspects of innovation [4]. Figure 1 illustrates the relationships between the development of regional economy, engineering education and innovation. It should be highlighted that entrepreneurship may be restricted to a place while innovation is dynamic and portable [4]. The development of digital technologies motivates new innovations through technology transfer [5].
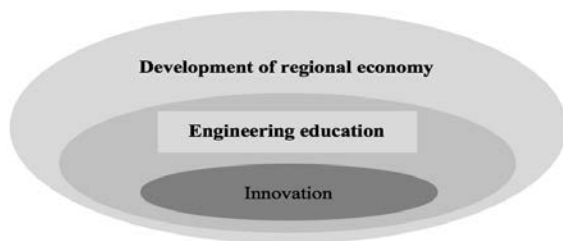
Fig. 1. The relationships between the development of regional economy, engineering education and innovation.

This relationship between innovation and entrepreneurship as shown in Figure 2 leads to the incorporation of entrepreneurship education into engineering studies [6], [7].
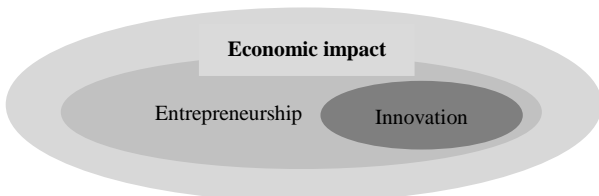
Fig. 2. The relationships between the economic impact, entrepreneruship and innovation.

A positive effect of entrepreneurship education on engineering students' entrepreneurial intentions [8], [7] as well as knowledge, skills and attitude to run their own business and/or enterprise [6] has been revealed.

Along with the development of digital technologies, digital entrepreneurship has attracted more attention from researchers and educators worldwide. Engineering students were introduced to Enterprise 2.0 and 3.0 [9] as well as e-Business applications [10]. It should be pointed that the COVID-19 pandemic significantly influenced the fast growth of digital entrepreneurship in the world. Extreme events such as the COVID-19 pandemic change the framework conditions and thus create new entrepreneurial opportunities and change risk perception because the risk of alternative activities changes [11]. Against this background, immigrants, including

engineering students with migrant background, who are engaging in digital entrepreneurship have been neglected in current related literature [12].

Analysis of scientific literature allows finding out that immigrant entrepreneurship has played a critical role in the socio-economic development of most advanced countries from the 1970s [13]. Regional economic benefit from the entrepreneurs with migrant background, in terms of improvement of opportunities in the economic, social and civic life of their new country [14]. The previous research discovered that employment of immigrants, who communicate in a language of the country local companies do business with is proposed to be beneficial for all the stakeholders, namely host country' companies, partners of host country' companies, and the employed immigrants [15]. The impact of immigrants' home-country entrepreneurial ecosystem (EE) factors on transnational immigrant entrepreneurs (TIEs) has been investigated [16], too.

As the importance of engineering education in promoting engineering students' entrepreneurial attitudes and behaviours now is widely recognised, the enabling research question is: What are engineering Master students' views on digital entrepreneurship in a host European country?

The aim of the research is to explore international engineering Master students' views on digital entrepreneurship in a host European country underpinning the elaboration of implications for engineering education in a host country.

II. Conceptual Framework

The conceptual framework of the present work is shaped by the implementation of theoretical methods such as

- Analysis of scientific literature,
- Theoretical modelling,
- Systematisation,
- Synthesis,
- Comparison,
- Generalisation.

Digital entrepreneurship embraces all new ventures and the transformation of existing businesses that drive economic and/or social value by creating and using novel digital technologies [17]. The authors support the view that digital entrepreneurship is a supplement or complement to traditional settings [18] as depicted in Figure 3.
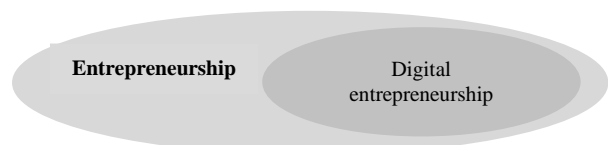
Fig. 3. The relationships between entrepreneurship and digital entrepreneruship.

In turn, the theoretical framework of immigrants and asylum seekers' digital entrepreneurship competence created for training purposes includes [18]

1. The opportunity competencies that are related to identifying, assessing and seeking market opportunities: identification and definition of a viable market niche; development of products/services appropriate to chosen market niche/innovation; idea generation; environmental scanning; recognising and envisioning taking advantage of opportunities; formulating strategies for taking advantage of opportunities.

2. The organizing competencies that are related to managerial functions such as planning, organizing, leading and controlling: development of the management system necessary for long-term functioning of the organisation; acquisition and development of resources required; business operational skills; involvement with start-ups; financial and budgeting skills; management style; marketing skills; industry skills; the ability to implement strategy (develop programmes, budgets, procedures, evaluate performance); market analysis skills; business plan preparation skills; goal setting skills.

3. The relationship competencies that embrace the ability to build, keep and use networks with stakeholders: development of organisational culture management system; delegation skills; collaboration skills; the ability to motivate others (individuals and groups); personnel management skills; human relation skills; leadership skills.

4. The conceptual competencies that refer to creative thinking, innovative behaviour, assessment of risk, etc.: creative thinking; innovativeness; organisational skills; interpersonal skills; emotional intelligence; the ability to manage customers; coordination skills; written communication skills; oral communication skills; decision making skills; analytical skills; logical thinking; critical thinking; deal-making skills.

5. The strategic competencies that deal with setting, evaluating, and implementing strategies of a venture: strategic management skills; vision and goals setting skills; research and analysis skills; data management; decision making skills; developing of the monitoring systems; quality assessment skills.

6. The commitment competencies that are the abilities that drive the entrepreneur to work hard and face the difficulties involved in sustaining the business: sustainable leadership skills; team building; coaching and mentoring; personal development; commitment to excellence; persuasive techniques; trustworthiness; change management.

7. The digital-based entrepreneurship competencies: using the potential of network‐based business; care about technological developments and market dynamics; maximum use of information technologies and supply

management improvement; innovation management and implementation.

Digital entrepreneurship as well as students' digital entrepreneurship are formed in a socio-cultural environment [19] as shown in Figure 4.
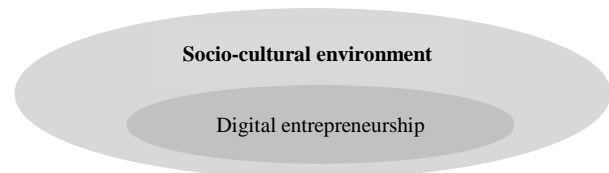
Fig. 4.   The relationship between socio-cultural environment and digital entrepreneurship.

Socio-cultural environment is life, our real, subjective, everyday life [20]. Socio-cultural environment is mediated through culture and language.

Training of migrants who expressed their intention to become an entrepreneur often faces the issues of [15], [21] - [22]

- Use of the host country language as the language of instruction,
- Migrants' busy lifestyle in the host country,
- A different level of entrepreneurial skills,
- Required resources.

Hence, before the training, training participants' views have to be analysed. View is identified as individual's opinion based on his/her knowledge, skills and attitudes to a phenomenon [23].

It should be emphasized that university teachers are also training participants. Their view on training of engineering Master students was presented in the theoretical framework on master programme for international students [24]. One of the key concepts in the framework was students' language proficiency and problems. The authors propose that students' language proficiency and problems should be considered from the perspective of the unity of all the student's language, namely mother tongue, second language, foreign language, host country language, etc [25] within International Master studies. Often master programmes for international students are delivered in English. The reason for European higher education programmes in English are to remove language obstacles for the enrolment of foreign students [26].

Based on the conceptual framework of the present research, engineering students' view on digital entrepreneurship is built on considering such aspects [7], [15] as

- Engineering student's intention to become a digital entrepreneur,
- Use of the host country language,

- Use of engineering knowledge in digital entrepreneurship.

III. METHODOLOGY OF THE EMPIRICAL STUDY

The present empirical study was enabled by the research question: What are engineering Master students' views on digital entrepreneurship in a host European country?

The purpose of the empirical study was to analyse the views of engineering Master students on digital entrepreneurship.

The empirical study was carried out in February 2021. The sample was composed of 32 engineering students who were enrolled in the International Master programme "Information and Electrical Engineering" at Hochschule Wismar, Germany. It should be noted that the International Master programme "Information and Electrical Engineering" is taught in English. The host country language, namely German, is provided to the international engineering Master students only during the 2nd semester of the Master studies. As the period of the implementation of the empirical study coincided with the lockdown due to the COVID-19 pandemic, the host country language, namely German, was given to the 2nd semester students online. The content of the German course was not specified.

The engineering Master students were chosen for their participation in the empirical study as master studies are innovation oriented in wide terms. The group of 32 students was heterogenous (the field of study and work, languages, etc):

- 25 students were male, and seven students were female.
- The students were between 20 and 29 years old.
- 31 engineering Master students were originally from India, and one - from Pakistan.
- 21 students indicated a beginner level of German language knowledge.
- The engineering Master students from India were from different regions of India, thereby obtaining different cultural and educational background.
- The students received Bachelor degrees in different fields of engineering: mechanical, electrical, computer, etc.

Hence, Germany was the host country for these international engineering Master students who participated in the online survey.

Furthermore, engineering is the professional field for the international engineering Master students who took part in the survey.

The sample was also multilingual, thereby multicultural:

- Two students spoke two languages,
- 11 students were able to communicate in 3 languages,

- 13 students were able to perform in four languages,
- Three students obtained the knowledge of five languages.

Only three students indicated that they spoke one language, namely English.

The differences in students' cultural and educational experience highlighted the significance of each student's contribution to the study.

The empirical study was of the exploratory nature. The exploratory study was chosen due to the uncertainty in the research field [27]. An exploratory study is characterised by a high degree of flexibility and lack of formal structure [27]. An exploratory study aims to identify the boundaries of the social environment in which the problems, opportunities or situations of interest are likely to reside [27]. The methodology of the exploratory study proceeded [28]

- From Exploration in Phase 1
- Through Analysis in Phase 2
- To Research Question in Phase 3.

The data were collected via an online survey. The online survey was based on the online questionnaire. As the authors support the view that digital entrepreneurship is a supplement or complement to traditional settings [18], the term "entrepreneur", referred to both – entrepreneur and digital entrepreneur, is used in the survey. The online questionnaire was built of such questions:

1. How long have you been staying in the host country?
2. Do you intend to become an entrepreneur?
3. What are your advantages to become an entrepreneur in a host country?
4. What are limitations of becoming an entrepreneur in a host country?
5. Do you intend to become an entrepreneur in your professional field?

The obtained data were visualised. Descriptive statistics were used to feature the sample. Percentage, standard deviation and weighted average were presented to characterize the sample. Afterwards, the data were interpreted and summarised.

IV. RESULTS AND FINDINGS OF THE EMPIRICAL STUDY

The present part of the paper reveals the results of the online survey and findings of the study.

In regard to Question 1 about the period of students' staying in the host country, the majority of the respondents or 31 students answered that they had been staying in the host country, namely Germany, between 1-3 years. Only one respondent had been staying in the country longer than 3 years. Figure 5 illustrates the percentage and standard deviation of the students' responses.

How long have you been staying in the host country?

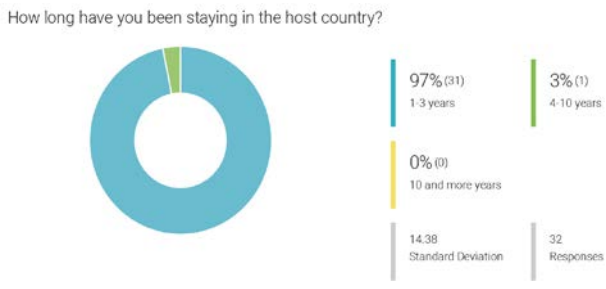|	
97% (31) 1-3 years	3% (1) 4-10 years
0% (0) 10 and more years	
14.38 Standard Deviation	32 Responses

Fig. 5. The respondents' answers to Question 1 of the survey.

The majority of the engineering Master students expressed their intention to become an entrepreneur as shown in Figure 6. Figure 6 also presents the measurement scale of 10 levels. The 10 levels are ranged between 1 "Extremely poor" and 10 "Extremely good".

22 Do you intent to become an entrepreneur?

I*	0	1	2	3	4	5	6	7	8	9	10	Standard Deviation	Responses	Weighted Average
Extremely Poor - Extremely Good	0 (0%)	0 (0%)	0 (0%)	1 (3%)	0 (0%)	0 (0%)	1 (3%)	6 (20%)	4 (13%)	6 (20%)	12 (40%)	3.72	30	8.57 / 10
														8.57 / 10
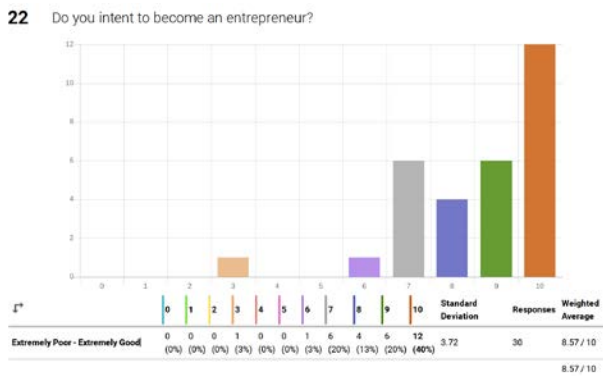
Fig. 6. The respondents' answers to Question 2 of the survey.

The majority of the international engineering Master students determined their advantages to become an entrepreneur in a host country as speaking a couple of languages as presented in Figure 7.

43% or nearly the half of the respondents indicated contacts in their origin country as an advantage for entrepreneurship in a host country as depicted in Figure 7.

Two students indicated other advantages they can use for entrepreneurship in a host country as revealed in Figure 7:

- One student considered great opportunities the host country provided to the entrepreneur.
- Another student emphasized continuous trying to improve the host country's language each day.

23 What are your advantages to become an entrepreneur in a host country?

50% (15) Speaking a couple of languages	43% (13) Contacts in your origin country
7% (2) Other (Please Specify)	
5.72 Standard Deviation	30 Responses
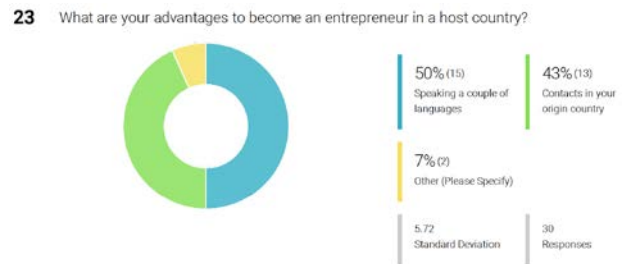
Great opportunities are provided.

I am currently fluent in 3 languages: Bengali , Hindi and English. And I also speak a little German which I am continuously trying to improve each day.

Fig. 7. The respondents' answers to Question 3 of the survey.

On the other hand, the majority of the respondents opined that the host country language is a limitation for becoming an entrepreneur as disclosed in Figure 8. About one third of the respondents pointed that host country rules limit the entrepreneurial intentions of the respondents.

24 What are limitations of becoming an entrepreneur in a host country?

57% (17) Host country language	37% (11) Host country rules
7% (2) Other (Please Specify)	
6.16 Standard Deviation	30 Responses
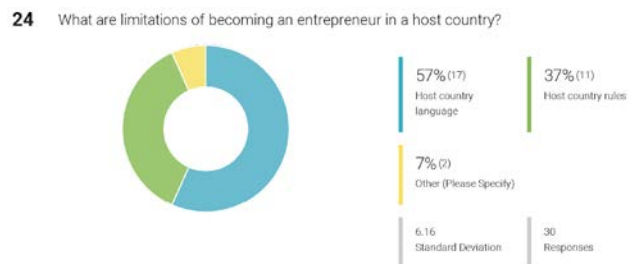
No limitations specific to host country.

Language is a limitation at the moment but I'll be able to overcome it soon.

Fig. 8. The respondents' answers to Question 4 of the survey.

The majority of the respondents expressed their intention to become an entrepreneur in their professional field, namely engineering. Figure 9 shows that 24 students or 80% among the survey respondents answered positively to the question.

Do you intend to become an entrepreneur in your professional field?

80% (24) Yes	20% (6) Not
0% (0) Other (Please Specify)	
10.2 Standard Deviation	30 Responses
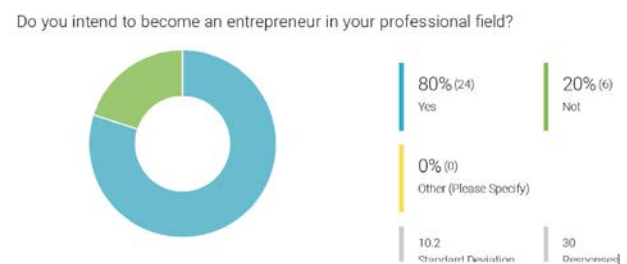
Fig. 9. The respondents' answers to Question 5 of the survey.

The results of the empirical study allow finding out that the majority of the engineering Master students are willing to become entrepreneurs. Another finding is that the majority of the engineering Master students wish to develop their entrepreneurship in their professional field, namely engineering. The survey results show that the respondents were multi-lingual. However, the host country

language required more efforts from the students with the migrant background to become the students' advantage in entrepreneurship.

Overall, the engineering Master students' view on digital entrepreneurship is positive.

CONCLUSIONS

The theoretical research results in the conceptual framework for the analysis of engineering students' view on digital entrepreneurship. The conceptual framework is built of such aspects as engineering student's intention to become a digital entrepreneur, use of the host country language, use of engineering knowledge in digital entrepreneurship. The conceptual framework acknowledges that the unity of all the student's language, namely mother tongue, second language, foreign language, host country language, etc [25] is the key concept and issue in an International Master programme.

The empirical study allows drawing the conclusion that international engineering Master students view digital entrepreneurship in a positive way. The survey results show that engineering students' digital entrepreneurship should be centred on their professional field, namely engineering. The online survey also outlined two major factors, namely host country language and host country rules, that limit the opportunities of becoming a digital entrepreneur in a host country.

The implications for engineering education in a host country imply the integration of entrepreneurial culture, namely host country language and host country rules, into engineering education. The focus of the host country language and host country rules should be placed on their use for entrepreneurial purposes. By the entrepreneurial purposes, specific activities that are tied to entrepreneurship are meant. Hence, host country language and host country rules trained within engineering education should be focused on their use for entrepreneurship. Some examples include

- Preparation of a business plan in a host country language,
- Legal regulations for opening the company in a host country,
- Culture of project management in a host country, etc.

It should be noted some cultural differences between international engineering students with the Indian cultural background and their educators with the German cultural background applicable to entrepreneurship have been pointed [29]. The identified differences included [29]

- Use of people names,
- Addressing people,
- Understanding of time management,
- Expression of politeness.

The research has some limitations. A limitation is the link between international engineering student's intention to become a digital entrepreneur, use of the host country language, use of engineering knowledge in digital entrepreneurship. Another limitation is the empirical study

conducted by involving only the students of one higher education institution in one country. A limiting parameter also is the participation of only international engineering students in the online survey. Only the respondents at master level of engineering studies took part in the survey that also limits the results of empirical study.

Further theoretical research intends to re-consider the conceptual framework to be applied to the analysis of engineering students' views on digital entrepreneurship. Two major factors, namely host country language and host country rules, that limit the opportunities of becoming a digital entrepreneur in a host country, will be further structured and described as language and culture are the basis of entrepreneurial activities. Training for engineering students' digital entrepreneurship will be further specified. In future, the proposed research will tend to implement empirical studies in other respondents' groups, other institutions and other host countries. The research will broaden the dataset with newly collected qualitative and quantitative data. Implementation of empirical studies will be based on the search for relevant and appropriate methods to analyse engineering students' view on digital entrepreneurship. A comparative research and studies of other countries could be carried out, too.

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Concrete, Reinforced By Carbon Fibre Composite Structure, Load Bearing Capacity During Cracking

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Abstract - **Different authors conducted studies on fiber reinforced concretes (FRC) with carbon fibres of different lengths and some results showed that concrete mix with homogeneously distributed short fibres in their volume have good strength and ultra-strain compared to normal plain concrete mix. However, this study is focused more on 3-dimensional (3D) carbon fibre reinforced plastic (epoxy) CFRP composite thin rods frame used as a reinforcement in concrete which shows good increase in loadbearing and ductility. Were investigated concrete mixes with superplasticizer, nano-silica, quartz sand, fine natural sand and gravels. Diagonal cross bracing carbon fibre epoxy frames were used as a reinforcement giving better ductility results. Proposed study approach is to show that the reinforced concrete with provided materials have an increased performance in terms of ductility, sustainability, and load bearing in cracked statement. Total, four groups of concrete and each group with three beams were casted and tested in this experiment, three groups with three different shapes of carbon frames and three beams without frames to compare the mechanical properties after 28 days. Failure mechanisms in any particular case were analysed.**

Keywords - carbon fiber, composite rods frame, concrete, bending, deflection, ductility.

I. INTRODUCTION

The most used material in the construction sector is concrete. Despite the centuries-old experience of using concrete, its composition is constantly being improved and optimized depending on the purpose and tasks [1]. Back in the days of the Roman Empire, concrete made a real revolution in construction [2], [3]. Since then, concrete has been reinforced in various ways and materials, for example: bars made of different materials [4]–[7], different short fibres [8]–[10], and using different technologies [11]–[14]. The addition of discrete fibers to the concrete mixture to enhance its toughness and tensile strength is well acknowledged. Studies have also shown that fiber-reinforced concrete (FRC) [15] can be favorable for its enhanced behavior in tension and compression [16]. This behavior, which is attributed to the confinement action of the fibers, is, in general, superior in terms of strength and ductility, compared to plain concrete [17]. Fibers act as the reinforcement and bridge the gaps and micro - cracks within concrete, resulting in the high strength and energy absorption capacity of fiber - reinforced concrete [18], [19].

Short fibres in the specimens are randomly distributed across the volume. Short fibre-reinforced concrete is a homogeneous material. But saying "homogeneous" it doesn't means homogeneous in reality, because during filling the construction formwork and mix flowing process, fibres added to the concrete mix blend are obtaining non-homogeneous distribution and orientations in the fresh mix concrete volume which inevitably affects the mechanical properties of FRC [20]–[24]. In the same time, the reinforcement with rods provides for their guaranteed, local 2D or 3D arrangement. Here we want to accent thin rods instead thick rebars. Modern fibers (Carbon, Boron, etc.) can have high elastic modulus (few times higher

comparing with steel) and high strength. Preparing thin rods 3D frames will allow to create densely reinforced

Carbon fiber reinforced polymers (CFRP) are innovative composite materials that have been applied for repairing and retrofitting civil engineering structures. CFRP can not only be used as a strengthening material for the reinforced concrete (RC), but also can play a protective coating layer role [25]. Carbon fiber reinforced concrete (CFRC) have more advantages regarding the properties compared to the concrete without any fibers in it [26]. Coming to the 3D fiber polymer matrix reinforcing frame in the concrete, there are many advantages of this combination, the frame placement and orientation in the concrete remarkably affects its load carrying, strength, cracking and energy absorption performance. It was identified that the concrete reinforced by multi axis 3D composite fiber structure has strain hardening behavior. The strain hardening increased the energy absorbing capacity of the reinforced concrete [27]. Fibers yarns impregnated by epoxy resin are forming composite rods in 3D frames providing stiffness and strength [28].

Present research assumes the use of custom-made carbon fiber rods frames in concrete with their 3D orientation.

II. MATERILAS AND METHODS

2.1 Concrete mix materials

In the current research the following components were used for FRC mix materials:

1.   Cement– CEM I 52.5 N, Ordinary Portland Cement (OPC);

2.   Fine Sand, Quartz sand - 0-1 mm and Quartz powder 0-120 mk were used for the concrete mix;

3.   Sikament® 56 - superplasticizer was used to provide mix flow ability and good dispersion of micro-particles. Basic properties: light yellow and easy flowable liquid, density 1.08 ± 0.02 kg/dm^3, pH 4.5 ± 1, solid content 37 ± 1 %. (Recommended dosage: in the range 0.1-2.0 % by weight of cement).

2.2 Fibres

Carbon fibers were used in this research (Table 1). In the plywood plate were screwed in few screws. Around these screws were stretched carbon fiber string, forming different structures (see Fig. 1a-c). Stretched string between fixed screws was impregnated by epoxy resin. After epoxy matrix solidification carbon fiber composite frame is becoming stiff. Frames were taken away and were used as reinforcement in the concrete prisms. Three frames (groups) with different geometry were fabricated, box (rectangle shape) frame was named as the group 1, V shape bracing was named as the group 2 and the cross bracing was named as the group 3. No reinforcement/frame was named as the group 4 (Fig. 1a-1c & Table 2).

TABLE 1 PROPERTIES OF CARBON FIBER

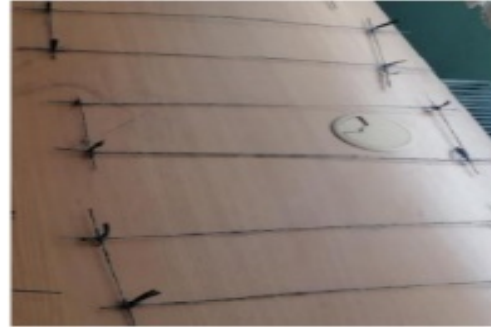|	
Diameter, mm	2
Density, kg/m^3	1820
Tensile strength, GPa	7.06
Modulus of elasticity, GPa	441

Fig.1a Box frame

Fig.1b V frame

Fig.1c Cross frame

TABLE 2 REINFORCEMENT SHAPE AND GROUPING

Group No.	Reinforcement type/Shape of frame
Group 1	Box frame
Group 2	V shaped frame
Group 3	Cross frame
Group 4	No reinforcement

2.3 Concrete mix design: The water to cement ratio was W/C= 0.75 in each group and the amounts of

ingredients are tabulated for 1m³ of volume of concrete as per the table 3.

TABLE 3 MIX PROPORTION

Vol of Concrete	1 m³
Cement Content (kg)	400
Water Content (kg)	300
Fine Sand (kg)	1400
Superplastcizer (kg)	3
Quartz Powder (kg)	250

2.3 Samples preparation:

2.3.1 Concrete mixing:

The concrete mix was prepared according to the design to maintain the workability [29] of concrete. Fibre frames were placed at the centre of the mould by filling the bottom part first with the concrete layer 2cm thick, placing the frame carefully and filling the remaining part till the concrete layer thickness rich 8cm. Then the second frame was placed and after that concrete was filled till the top of the mould providing the required strength to the specimen (see Figure 2). By this two fiber frame, the risk of fibers orientation and stress concentration [30] at one place in the sample can be avoided and the stress will be equally distributed. We have a total of four groups of FRC with three fabricated beams per each group, making it twelve beams in total.

Three groups with the carbon fibre frames and the fourth group without any fiber frame in it.

2.3.2 Sample sizes

The FRC was placed into the prism's moulds of size 100×100×400 mm. All groups were casted as per the code provisions, placed for the curing [31] in water and tests were done for 28 days.

III. EXPERIMENTAL TESTS AND RESULTS

3.1 Tests for Structural properties

3.1.1 Compressive strength testing procedure of concrete cubes

In concrete design and quality control, compressive strength is the property generally specified and by which concrete is classified. Compressive Testing Procedure and strength of concrete cube the defining strength properties of these materials, be detected both by non-destructive methods [32]–[34] and by the classical destructive method in accordance with EN 12390-3. Standard compressive cube tests using 100×100×100 mm specimens were conducted to determine of the concrete compression strength without any fibers in the concrete including three specimen's data after 28 days. The compressive strength for the concrete is 24.91 N/mm². According to the EN 206 is corresponds to the concrete strength class C16/20.

3.1.2 Four Point Bending Test (4PBT)

The 4PBT is traditionally used to find out the flexural strength of the concrete specimen. In the used test for FRC mechanical and fracture properties determination test is carrying in a mode of crack propagation during bending. We used 4PBT as a test with constant bending moment in a sample, placed between the two upper supports as shown in fig. 2. We have several standards, such as *EN 14651, ASTM C1018-97, ASTM C 1399, ASTM C 1609, DAfStb-Richtlinie: Stahlfaserbeton, DVB Merkblatt Stahlfaserbeton,* and *RILEM TC 162-TDF* for this test to obtain the results as per the standards. Testing is carried as per those standards and results were noted.
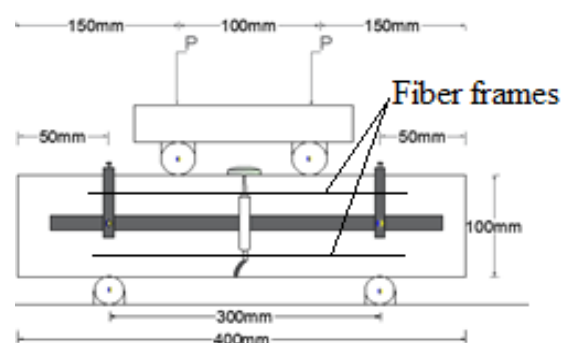
Fig. 2 Four Point Bending Test scheme
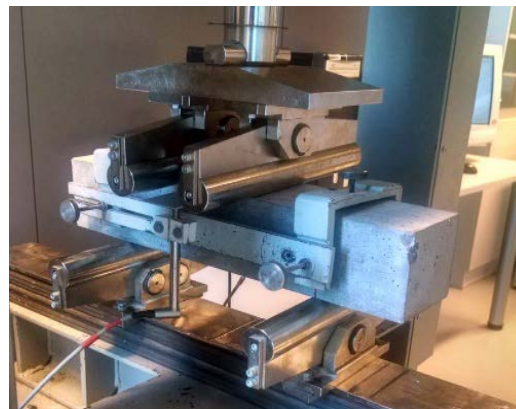
Fig. 3 Testing of FRC beams

3.1.2 4PBT Testing Procedure:

The four groups of FRC, were experimentally tested by placing them as shown in the scheme (fig. 2) according to the markings made on them as per the load points. Later, the frame with two HBM WA20 LVDTs sensors on its sides used for recording deflection of the beam during the test were placed on the same marks. Mechanical properties verification was carried out by 4PBT method using Controls Automax 5 loading machine. Load was applied in 0.25 kN steps for the span of 60 seconds.

The loading was applied monotonically in small increments, while the load and deflection were

recorded at each increment. The midspan vertical deflection was measured with LVDT. The load versus vertical deflection (of the middle of a span) curve was obtained in every loading. The measurement data from the strength measurements by using HBM Spider-8 data acquisition system was processed, synchronised, and saved in MS Excel files which later were used to form the required graphs. Deflection of the beam was obtained by considering and summing the values from both sides sensors and the average value was calculated for every loading step in every experiment. The graphs showing the processes in FRC, were created from these files with MS Excel.

The test procedure was carried out for all the four groups in the same manner as shown in the fig. 3 and the graphs were plotted. Loads were applied until the every beam fails and breaks completely.

3.2 Four Point Bending Tests graphs
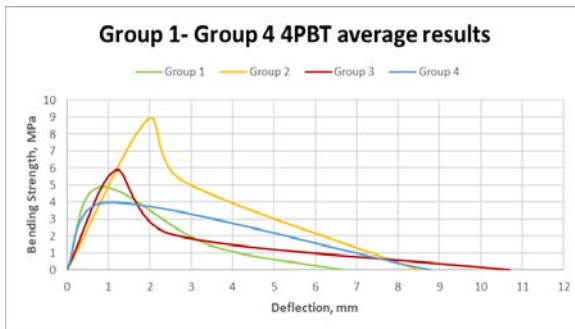
Fig. 4 Average graphs: Stress-middle of a span Deflection, for all groups

All values were taken for four groups, strength-deflection average values were plotted using the *MATLAB* software for the 4PBT test and based on them, the average graphs were drawn for all the groups. In majority of the performed tests, one single crack was formed on the bottom part of the beam during its bending until rupture. Performed by different authors geometrical evaluations shown that in this case middle point vertical deflection is equal to crack mouth opening displacement (CMOD).

Discussing obtained data is possible to note:
Group 1:
1. This frame is very easy to make but these samples show lowest maximal bending strength. This group has the maximal bending strength of 4.90 MPa with maximal midpoint deflection (CMOD) of 6.70 mm (fig. 4). Then beam failed. Only two composite sticks reinforced bottom part of the beam. Reinforcement raptured by carbon fibers failure and pulling out of the fibers tails from the polymer matrix.

Group 2:
1. The group has the highest bending strength of 8.89 MPa, which is almost double the strength of the group 1 with the maximal deflection (CMOD) of 8.49 mm.
2. This frame is not as easy to make as the group 1. Due to the joints on one of its sides, this group looks different.

Group 3:
1. The group with the good performance in terms of deflection, which is 10.70 mm, better than all the groups. We can suppose that in this case single fiber failure inside the sticks happened at bigger length (pulled out tails were longer). Nevertheless, it needs additional experimental investigation.
2. Bending strength of this group is 5.90 MPa, which is less than the group 2 but higher than in the group 1 and 4.

Group 4:
1. This group have the bending strength of 5.53 MPa, greater than group 1 and near to group 3. Deflection of this group is 8.79 mm.

Along with these, some more observations can also be made,

a. Concrete beams with these kinds of reinforcements (framed) will have the fibers positioned well compared to beams with short fibers thrown into the concrete mix.

b. Results scatter is smaller.

c. There will be no wastage like breaking/damaging of fibers while mixing the concrete.

d. Fiber frames can be placed exactly in the necessary location inside the beams what is not possible to make with the short fibers.

e. Since the reinforcement is a single member, the elongation of the fibers will be more compared to the each individual fiber.

IV. CONCLUSIONS

The following conclusions can be made from the above results:
1. The group 2 is the strongest of all with the highest bending strength. This helps the structures to bear the loads acting on it and provides the strength required but the deflection is not as expected.
2. The frame made in the group 1 can be labelled as the weakest group among the first three groups as the Bending strength is less compared to all the other groups. It can also be said that it is still better than the group without any kind of fiber frames in it.

3. For the group 3, the connections between its corners made it to perform well regarding the deflection. The centre of frame made it so as the diagonals meet each other at the centre and thereby increasing its elongation strength.

4. The group 4, with no kind of fiber frame in it have the better deflection than the group 1 and almost similar to group 2.

5. Geometry of the concrete mix member must be taken care while adding the frame type reinforcement.

6. It was obtained that the compressive strength of concrete cubes with fibers is more than the cubes without fibers.

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Pedagogical Conditions for the Formation of Graphic Culture of School Students in the Process of Using Computer Technologies

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Abstract - **The aim of the study is the scientific and experimental identification of a complex of effective pedagogical conditions for the formation of the graphic culture of school students in the process of using computer technologies. In the article, based on the analysis of the structure of graphic culture in the system of the general culture of the personality of a student of the XXI century, as well as identifying the features of the use of computer technologies in modern school education, the effectiveness of creating pedagogical conditions for the formation of the graphic culture of school students is theoretically and experimentally substantiated: the use of a complex of program-methodological and pedagogical teaching aids using computer technology, the implementation of an active learning model in the organization of educational activities and the interaction of the teacher and students in the classroom. The article describes an empirical study of the conditions for the formation of the graphic culture of school students in sketching lessons: the diagnosed parameters are determined, a comprehensive test of the level of graphic culture in secondary school students is carried out, an assessment of the effectiveness of the influence of a complex of pedagogical learning conditions on the formation of the graphic culture of students is given. The experiment revealed the need to create special pedagogical conditions that form the basis for the development and implementation of the elective course program "Technical Sketching Using CAD".**

Keywords - computer technology, graphic culture, pedagogical condition, school education.

I. INTRODUCTION

Informatization of all spheres of human life, on the one hand, simplified the solution of the problems of collecting, processing, interpreting and transmitting information, visualizing images in relation to various fields of science and technology; on the other hand, it showed the importance and meta-subjectness (interdisciplinarity) of information culture, which was initially interpreted in the context of the optimal organization of human intellectual activity.

Information culture acts as a phenomenon that reflects a special, virtual culture, which includes many spaces [1] - from communication to network, - which affect the culture of a person's personality, in general, and modify it, taking into account the requirements of optimal orientation in the information picture of the world, adaptation in the information society.

I. V. Chugunova [2] in the structure of the general culture of the student's personality, in addition to moral, environmental, informational and other types of culture, distinguishes graphic culture as the highest degree of skill in transforming graphic objects and mastering the graphic language. At the same time, a truly "personal component" is emphasized - the ability to self-expression - which fills the concept of "graphic culture" with axiological meaning.

Following I. V. Chugunova [2], the authors of the graphic culture of school students will be interpreted as a set of educational and personal achievements in the field of mastering and using graphic methods of transforming information. The author's contribution to the definition of the concept of "graphic culture of a schoolchild" consists in concretizing its structural components and their functions, as well as in clarifying the content and

experimentally checking the level of actualization of each component under the influence of specially created conditions.

As the educational practice and research of A. A. Temerbekova and G. V. Bajkunakova [3] show, the level of graphic knowledge of students is quite low, which is explained by the lack of relevant content in the curriculum, as well as the uncertainty of the conditions for broadcasting content aimed at the formation of a graphic culture (M. V. Nepobednyj, A. P. Sysoev, and E. A. Mramornova [4]).

Thus, the aim of the study is the scientific and experimental identification of a complex of effective pedagogical conditions for the formation of the graphic culture of school students in the process of using computer technologies.

II. MATERIALS AND METHODS

In the course of the research, a set of methods was used: analysis and generalization of scientific views on the problem of finding relevant conditions for the formation of the graphic culture of school students in the process of using computer technologies, a pedagogical experiment, testing of students, and generalization of work results.

Graphic culture in research is considered as:

- a set of achievements of society in the field of creating and mastering graphic methods of displaying, storing, transmitting geometric, technical and other information about the objective world (I. V. Chugunova [2]);

- component of information culture (A. A. Temerbekova and G. V. Bajkunakova [3], M. V. Nepobednyj, A. P. Sysoev, and E. A. Mramornova [4], A. Z. Takov [5]);

- the process of mastering the graphic language, the skills of operating with graphic information and the ability to use it in various areas of educational activity (A. Temerbekova and G. V. Bajkunakova [3, p. 189]);

- a certain level of mastering graphic methods and methods of transferring information, assessed by the quality of execution and reading of drawings I. V. Chugunova [2];

- algorithmic process of forming graphic skills and abilities (M. Frostig [6], I. V. Chugunova [7]);

- the ability to design and model the studied processes and phenomena using modern computer technologies (R. Yu. Ovchinnikova [8];

- a set of methods for transmitting information in a graphic way, as well as the willingness to creatively transfer the system of skills for processing visual information into various spheres of social life - graphic education (N. V. Mishina [9]).

Various ways of forming the graphic culture of school students are considered - from art technologies (A. Temerbekova and G. V. Bajkunakova [3]) to solving graphic problems and computer calculations (S. M. Ganeev [10], A. V. Kostrjukov, S. I. Pavlov, and Ju. V. Semagina [11], I. S. Jakimanskaja [12]).

The analysis of scientific sources in the process of identifying the structural components of the graphic culture of high school students by means of computer technologies showed in various author's concepts of the interpretation of the concept of "graphic culture" the reflection of the ideas of systemic, integrative, activity and personality-oriented approaches (E. I. Purgina [13], I. V. Chugunova [14]).

Since graphic culture is a component of the general culture of a person's personality and is filled with a value sense, this phenomenon can be considered in the context of a humanitarian culture, represented by cognitive, axiological and activity-practical components, based on the triad: "cognition" (graphic knowledge), "values" (self-actualization in the process of creating a graphic (creative) product, pre-professional orientation), "experience" (graphic skills and abilities, activities), in accordance with the norm-regulating, culture-creating and socializing functions [15].

The above ideas are illustrated in "Fig. 1" (Authors).
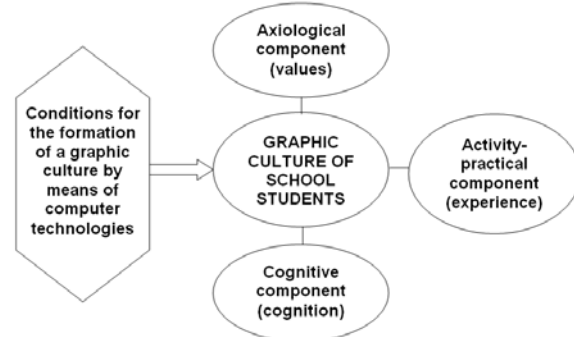
Fig. 1. Structural model of the graphic culture of the student.

Since in the research it is computer technologies that act as a means of forming a graphic culture, it is necessary to note some advantages and barriers of their application in teaching [16] - [17]:

1) barriers are associated both with restrictions due to the requirements for working on a personal computer and with a shortage of software; in some cases, they point to the problems of material and technical equipment of the educational process;

2) speaking about the advantages, they emphasize the "convertibility" of such education (the competitiveness of a specialist who owns information technologies, the availability of information retrieval systems, the possibility of modeling cognizable objects).

Since, in the opinion of the pedagogical community, among school subjects, it is in drawing lessons that the tasks of forming a graphic culture are priority solved, and drawing is one of the few academic disciplines that optimally correlate with computer learning technologies, a restriction was introduced into the study: the stated hypothetical conditions were implemented in drawing lessons.

Table 1 presents the content (Authors and L. V. Brykova [18]) of each component of the graphic culture formed within the framework of drawing lessons in grades 10-11.

TABLE I THE CONTENT OF THE STRUCTURAL COMPONENTS OF THE STUDENT'S GRAPHIC CULTURE

The structural component of the student's graphic culture	Component content
Cognitive component	Graphic thesaurus; knowledge of the general rules for drawing up a drawing and types of drawings; knowledge of the types of computer graphics, understanding of the designs of technical devices.
Axiological component	Graphic aesthetics; activity in solving graphic problems; the ability to apply graphic knowledge in new situations when solving problems with creative content.
Activity-practical	Ability to reproduce images of technical objects in a drawing, skill in graphic constructions, proficiency in applied graphic programs.

The first condition is the use of a complex of software, methodological and pedagogical teaching aids using computer technologies. The clarification of the program content was associated with the possibilities of using CAD - computer-aided design systems: AutoCAD and KOMPAS 3D programs. These programs provide an opportunity to implement integrative ties in a new way in teaching subjects such as drawing, mathematics, computer science.

It is important to note the need to use both traditional (textbooks, test materials, visual aids) and modern computer tools, because, according to O. V. Shtejmark [19], using only computer tools does not fully solve informative, communicative and educational tasks. Electronic testing programs such as "AISST", "Airen", "Test Constructor", "EasyQuizzy" and others can be used to control the knowledge of students.

The second condition is the implementation of an active learning model in the organization of educational activities and interaction between the teacher and students in the classroom. The scientific and pedagogical community [4] believes that the explanatory-reproductive method of teaching still dominates in schools, which does not contribute to maintaining interest in cognition, since

there is no problem in it, the opportunity for the student to experience an intellectual sense of delight from the independent solution of graphic problems. The formation of the graphic culture of school students, according to scientists (I. V. Chugunova [2], [7], A. Z. Takov [5], B. F. Lomov [20]), will not be effective without the problematic nature and personification of the teaching content.

The organization of the process in this direction involves the active use of technologies such as project activities, design analysis, portfolio, and technologies for the development of critical thinking, which are largely aimed at interaction, self-control and self-presentation of students.

III.   RESULTS AND DISCUSSION

These conditions were created in the course of the implementation of the elective course "Technical drawing using CAD" for grades 10-11 (the course was compiled in accordance with the program content of the textbooks V. V. Stepakova, L. V. Kurcaeva, M. A. Ajgunjan and others [21] and the program V. V. Stepakova, A. P. Boguslavskij [22].

The course, in addition to organizing an effective process of forming a graphic culture, is aimed at deepening and expanding the content of the basic drawing program of the basic school and is designed for 130 hours, 65 hours per academic year, 2 hours a week.

The course consists of an introduction and three sections:

- maintenance: the concept of the Unified System for Design Documentation, the drawing of a part as the basis of graphic documentation (1 hour);

- Section 1: the concept of a part and an assembly unit (5 hours);

- Section 2: detachable and one-piece connections of parts in the drawings (26 hours);

- Section 3: reading drawings, development of design documentation in AutoCAD and KOMPAS 3D (96 hours).

Under the conditions of the experiment, conditions were created to increase the level of the graphic culture of students: a program for the formation of a graphic culture was developed and implemented, including a description of the system of activities and interaction between the teacher and students in the lesson, a system for monitoring and assessing the level of formation of the graphic culture of students; the didactic capabilities of computer technologies, contributing to the formation of graphic culture, are determined. Thus, a system of methodological support for the development of the graphic culture of students was developed and implemented.

The formation of the levels of graphic culture, as multicomponent formations, occurs in the course of the

interaction of individual parameters. The following parameters are highlighted:

- reproductive level - knowledge of the general rules for drawing up a drawing and types of drawings, skills in graphic constructions;

- productive level - knowledge of the general rules for drawing up a drawing and types of drawings, skills of graphic constructions, the ability to reproduce images of technical objects in a drawing, a graphic thesaurus, knowledge of types of computer graphics, graphic aesthetics;

- creative level - knowledge of the general rules for drawing up a drawing and types of drawings, skills in graphic constructions, the ability to reproduce images of technical objects in a drawing, a graphic thesaurus, knowledge of types of computer graphics, understanding of designs of technical devices, graphic aesthetics, knowledge of applied graphic programs.

All parameters of the levels of graphic culture are taken equal, therefore the level of graphic culture is determined by formula 1, created by the authors:

$$II = \frac{1}{8}(P1 + P2 + \cdots + P8) \qquad (1),$$

where P1 - knowledge of the general rules for drawing up a drawing and types of drawings, P2 - graphic construction skills, P3 - the ability to reproduce images of technical objects in the drawing, P4 - graphic thesaurus, P5 - knowledge of types of computer graphics, P6 - understanding the structures of technical devices, P7 - graphic aesthetics, P8 - possession of applied graphics programs, II - integral indicator.

The Pi parameters were determined as the ratio of the number of correct test answers to the total number of questions.

The study was conducted on the basis of the Municipal Budgetary Educational Institution "Secondary School No. 24 named after L.I. Malyakov", Pskov in the control (28 subjects) and experimental (28 subjects) samples. 10 lessons were held according to the thematic plan of the course "Technical drawing using CAD".

Determination of the level of graphic culture formation in the control and experimental groups of school students by eight differentiated parameters at the beginning and at the end of the experiment included eight tests, consisting of a total of 69 questions and tasks. Data analysis confirms the effectiveness of the proposed conditions for the formation of a graphic culture, implemented within the framework of a special elective course. Positive dynamics is visible in all parameters ("Fig. 2" (Authors)).
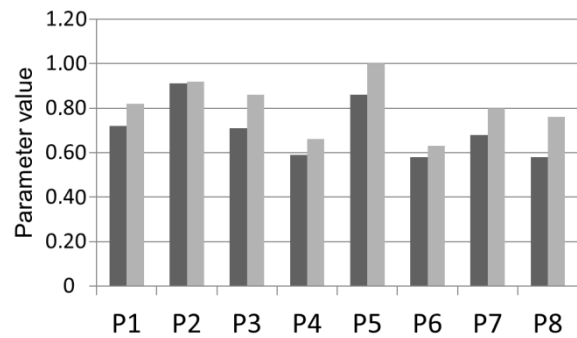
Fig. 2. Results of determining the parameters of graphic culture.

Fig. 3 (Authors) illustrates an increase in the level of graphic culture of the experimental sample, compared with the control, within the productive level. At the same time, the levels were initially measured as equal.
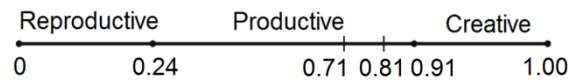
Fig. 3. The level of graphic culture of the experimental (0,807) and control (0,705) sample.

Thus, the complex of software, methodological and pedagogical teaching aids using computer technologies, developed taking into account the requirements for creating special pedagogical conditions, contributes to the formation and development of graphic culture in drawing lessons among school students of the experimental sample.

IV. CONCLUSIONS

Graphic culture is a multifaceted sociocultural phenomenon. The formation of the graphic culture of students is the process of developing the experience of transforming graphic objects and mastering the graphic language, which is used in technology, science, production, design, and other areas of activity, which is currently not effective enough. The main reason for this situation is that not all computer technologies at school have found their proper application, and the existing methodology and organization of teaching at school do not fully contribute to ensuring the interest and motivation of students in obtaining a high level of knowledge in drawing.

With regard to school teaching, the level of formation of graphic culture is assessed through the ability to consciously apply graphic knowledge, skills and abilities, as well as the ability to navigate in the environment of graphic information technologies. In the study, the graphic culture of school students is understood as a set of educational and personal achievements of students in the field of mastering and using graphic methods of transforming information.

The analysis of educational and methodological works and scientific works in the field of personification of school students' education shows that the process of forming the graphic culture of school students can be successful only if a certain complex of pedagogical conditions is created, aimed at solving the problems of the content and organization of training, taking into account the structure of graphic culture, represented by cognitive, axiological and activity-practical components.

Experimental work on the implementation in practice of the course on the formation of graphic culture using computer tools demonstrates the effectiveness of the proposed pedagogical conditions.

V. ACKNOWLEDGMENTS

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Web-Technologies and Multimedia Systems in the Training of Professionals in the Education System

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Abstract - **Contemporary technologies of training specialists in different professions envisage mastering the skills of a 'quality user' of computer technologies. At the same time, the issues of training primary school teachers, specialists in inclusive and remedial education to use more complex multimedia systems with the need to understand programming processes have often been excluded from basic courses as an 'unnecessary' component.**

But considering the current trends towards distance education, the "rejuvenation" of 'advanced users' and the need to maintain a educator's reputation, the trend towards introducing such systemic courses in the training process for specialists in primary, inclusive and correctional education has become a kind of concept for professional competence. It was based on the needs of today's teachers to transfer knowledge through multimedia systems (creating interactive databases, web pages, blogs or websites, preparing and conducting WebQuests, using computer games from producers or their own development through the platforms Wordwall, Etreniki, Flippity and Scratch programmes, etc.) that became the deciding factor for introducing specific topics on their use into training courses and expanding basic programmes of computer competency. Also, the training process began to include interaction with the training audience through social media. This multi-component work to develop a «modern/advanced» teacher provides the basis not only for improving the quality of the educational process, but also for its individualization according to the needs of each participant and his/her special educational needs, allowing to change the complexity of tasks, the saturation of tasks with audiovisual information.

Keywords - high school, informatization, social networks, web-technologies, multimedia systems, teacher training, special educational needs.

I. Introduction

It is impossible to imagine the modern world and society without technology. They meet us at every stage of our lives, in professional activities. And in connection with the events of 2019 - technology «got» in the structure of the educational process.

After all, education itself in the classroom-lesson system has existed for over 240 years. And it has been particularly difficult to change these processes in the training of specialists in the humanities - elementary school teachers, remedial teachers, and other professions related to the education of the younger generation.

It is also worth noting that within the framework of the New Ukrainian School (NUSH) reform we need to focus

on the formation of children's and teachers' information and digital competence as one of the priorities within the ten core competencies spelled out in the basic documents of NUSH.

Thus, according to the terminology, the concept of information and digital competence consists of confident and at the same time critical use of information and communication technologies to create the search, processing, exchange of information at work, in the public sector and in personal communication. In addition, the ethical issues of working with information (copyright, intellectual property, etc.) and basic skills (information and media literacy, basic programming, algorithmic thinking, robotics with databases, Internet security skills, cybersecurity) are separately prescribed, which will fully allow the individual to be «in flow» with the modern trends of society and all areas of human activity [1].

In this important role played by the human ability to form connections necessary to achieve online transmission of multimedia information, as well as to share resources, forming an ideal multimedia network environment and because multimedia is a combination of text, graphics, animation, video, sound, special effects, etc.; contains infinite space imagination, we not only change the learning and understanding of the issue, but also change the way information is distributed [2]. Which is very important to ensure effective Among the features of new multimedia are: Integration; Nonlinear characteristics of Non - linear; Nonlinear characteristics of Non - linear; Real-time; Edit ability; Ease of the use of information [2]. In addition, all this we need to consider when developing and preparing materials for teaching disciplines for future teachers.

In addition, our study was based on certain aspects proposed by the global scientific community as practices to change and improve the quality of the presentation of lecture and practical material in the educational process. For example, we took advantage of theoretical developments in terms of using films to teach inclusive education technologies through ease of perception and the corresponding perception of usefulness, as well as the adoption of the main messages of the proposed discipline [3].

In addition, the selection and refinement of the presentation of certain topics, especially those related to speech therapy issues, was influenced by research based on differences in learning processes and outcomes of using multimedia systems with / without the addition of audio; the impact of such materials in teaching children with speech development problems and for their typically developing peers [4].

A separate part of our work was to use the study's work with manipulations and effects:

- from studying and testing with text and images;
- learning with text and images, but testing with text only;
- text-only learning and text-and-image testing;
- text-only learning and text-testing [5].

It was important to use the developments of the project, which considered the development of computer technology for two diametrically opposed groups of children (children with autism and children with Down syndrome). As well as the results obtained by the researchers on the inexpediency of using the same multimedia learning system due to the differences in perception and processing of information by these categories of children [6].

In addition, we were also able to note some of the benefits of multimedia applications for teaching and learning described in research projects. Such as the ability to transform abstract concepts into concrete content; the ability to present large amounts of information in a limited amount of time with less effort; the ability to stimulate students' interest in learning and giving the teacher the opportunity to know the students' position in learning [7]. All these components quite strongly influence the construction of the learning process, the selection of the proposed material and, very importantly, the ability to follow the individual characteristics of each participant in the learning process and taking into account the dynamics of the group.

It was these changes that allowed us to take more seriously the training of future professionals to use web technologies and multimedia systems in practice.

Thus, to understand the current situation, we identified as the main goal of the proposed report - the rationale for the use and practical training of non-technical professionals to use web technologies and multimedia systems in professional activities. In this regard, we identified the following tasks for this report:

1. Analyze work programs of ICT teaching for non-technical specialties (elementary school teacher, pre-school teacher, inclusive class teacher, remedial educator, etc.).

2. To analyze practicing teachers' and students' awareness of the possibilities and practices of using web technologies and multimedia systems in the educational process.

3. To outline the main problems of the introduction and use of such technologies in the daily practice of teachers.

II. Materials and methods

In our study, which originally focused on «Features of the use of ICT in Speech Therapy Practice of Preschool Institutions» and was conducted in 2017-2018, we investigated the awareness of practicing speech therapists (20 focus group participants) in organizing consultations and presentation of work experience using web technologies [8]. The results of the professional development can be found in the previous article.

Further, the study was expanded and revised in the context of the organization of the educational process 2019-2020. It consisted of the work within the study of disciplines of inclusive education with the use of multimedia systems and web technologies in the process of presenting information. Also from the organization of independent work of students (64 participants of the focus

group). The results of the research will be presented soon in a separate publication on «Inclusive Practices in Distance Education: Challenges and Necessity».

To date, we continue to conduct an in-depth study for the 2020-2021 academic year. This is the third phase to examine the impact of distance learning on the outcomes of the educational process within the disciplines of the inclusive cycle and the subsequent professional engagement of graduates. As part of this phase, we engaged 60 participants. Part of the respondents - 19 students are elementary school teachers and teaching assistants, who receive additional education in the specialty «Inclusive Education» and 41 respondents - inpatient students, who receive the first specialty bachelor's degree.

As the experiment is ongoing, in this report we present the results of the ascertaining experiment, which consisted of surveys, questionnaires, and interviews of engaged respondents.

III. RESULTS AND DISCUSSION

Thus, at the first stage of our research in the format of this report, we started from the issues of training non-technical specialties, such as teachers of elementary school, educators of pre-school institutions, remedial teachers, specialists of inclusive education, which are in the public domain. We took as a basis the existing training programs: «Information and communication technologies in elementary school» (Lutsk, 2015) [9], «Information technologies in special education» (Kiev, 2019) [10], «Information technologies in inclusive education of children with developmental and socialization complications» (Ivano-Frankivsk, 2019)» [11], «Information and communication technologies in scientific research» (Vinnitsa, 2019) [12]. It is important to note that only one of them is a compulsory discipline [12], and the others are elective. What all of these programs have in common:

- a theoretical part on the development of ICT;
- theoretical part on basic terminology and positive and negative aspects of ICT usage in educational practice;
- elements of computer literacy and familiarity with software;
- introduction to different services (Microsoft Office Word, Excel, Access, PowerPoint; Google Cloud Services).

But what is important is that, in fact, most students already use these products every day. Of course, they may not know the «official» name of this or that product, but everyone can understand and be a confident user today.

It is worth noting that in the training of specialists of a wide range of specialties quite a big emphasis is placed on:

- The study of theoretical material;
- Familiarity with various projects operating in Ukraine (mainly for high school - graduating classes, as well as students);
- Methods of preparing and conducting web classes;

- Technology WikiWiki;
- Issues of using electronic educational and methodological complexes of disciplines.

The distinctive features of the other programs is a narrow focus and the selection of each of the areas of training necessary to implement in professional activities the most appropriate models of use of multimedia systems and web-based technologies.

So, for elementary school teachers and educators use the familiarity and hands-on development of assignments using KSU Feedback, Windows Movie Maker [9].

For special educators (remedial educators, rehabilitation teachers, teachers, defectologists, speech therapists) demonstrate the possibilities of working with the application InShot, Padlet virtual interactive whiteboard, Web-services to create intelligent maps, charts, infographics, online video editors, images, animation, Canva, Crello, UGC-hosting, online community «Parents SOS», etc [10]. Special technical devices and programs for working with children with different nosologies also deserve special attention in this course. But the questions of studying and actually using them are often hindered by problems of financing. That is why the study is done in words and on the basis of the description of the products offered, such as «handheld computer» (ChatPC), «Talking mittens», special bracelets, programs of the hearing and speech complex «Communication», communicators, multifunctional device «Tango», speech training simulator «Delfa-142. 1», training and software complex «Adaptation-Logo», computer program «zaikanie.net», hearing and speech complex «Live sound», simulator «World of Sounds», program «Games for Tigra», etc. In rare cases of high-quality cooperation with specialized centers, medical institutions, public or private organizations, students can get acquainted with them in reality.

In the issues of training specialists in inclusive education and developing their information and digital competence, one can see a targeted focus on studying the characteristics of children and a lack of clear recommendations for the study of ICT proper, which can, should and must be used in the work with children with special educational needs.

At the same time, it is worth noting that the quarantined limitations of offline learning have led to improvements in the educational process. The use of multimedia systems and web technologies. This was also reflected in changes in the program of elective disciplines. Thus, in Vinnitsa State Pedagogical University named after Mykhailo Kotsyubinsky today for the specialties Elementary School, Pre-school Education, Inclusive education offers one compulsory educational discipline of professional training cycle («Information and communication technologies in the organization of the educational process in institutions of pre-school education and elementary school») and five elective subjects («LMS Methods of development and use of electronic resources», «Digital innovation technology»,

«WEB-programming», «Fundamentals of WEB-design» and «Management of distance learning product»). Although some programs are in closed access, we can note improvements in the training of non-technical specialists, which allows the teacher to be «on equal footing» with confident users - which are modern children.

Continuing to consider the results of our study, we concluded that, due to several factors, distance learning allowed teachers to «recognize» the need to improve the quality of work and the use of web technologies and multimedia systems in the educational process.

So, before the beginning of our experiment, we conducted a questionnaire followed by an interview with 60 participants in the experiment. Among the questions that we asked the participants we can note the most important for us in blocks:

- General information;
- Basic level information on mastery and understanding of web technologies and multimedia systems;
- Information on the use of educational programs and applications with programming elements for educational purposes;
- Information on the use, as well as the desire to learn to use more complex designs in the form of web quests and programs with game development based on basic programming elements.

On the basis of the questionnaire, as well as to develop and refine the next stages of our work, we identified four levels of information and digital competence:

- high – possession of basic skills of using and creating online presentations, videos, knowledge and understanding of web quest technologies, practical use of various platforms to create educational games Wordwall, Etreniki, Flippity and more serious programming elements - Scratch;
- intermediate – almost identical to high, but without the ability to create sites and use software with programming elements
- sufficient – the student has the skills to create online presentations, uses web technologies and multimedia systems, but is not familiar with the process of their creation;
- low – the level of technology does not allow the student to use «blanks» to create an interactive, connect to the questionnaire without outside help, and create presentations and videos.

The result of the survey was that some respondents showed a high level of proficiency in the proposed set of technologies - they already had skills in creating web quests, materials on the Scratch platform. There were 20% of such students (12 people). However, during the interview it was determined that 8 people chose these items because they had heard that other professionals use something similar, looked at the Internet during the questionnaire, or took the name as work with scratch cards, scratch map of the world, where it is necessary to erase the top layer hiding the image or information. Thus, the

percentage of students with the necessary for our study high level of information and digital competence was - 7% of the total number of participants.

Further, according to the results of the questionnaire, we identified a group of students who know the proposed technologies at an above-average level. Thus, these students know and are able to create websites, pages, maintain blogs and use a number of platforms with elements of programming certain game material - about 72% of respondents (43 people). Nevertheless, the clarifying and leading questions during the interview showed that some respondents «did not quite understand the question»; «decided that the use of websites in the Internet»; «subscribe to a channel», proposed in the list of platforms etc. Is also a process of creation - the number of people with an average level of information and digital competence was not more than 47% of the whole group of respondents (15 people dropped out).

We also noted that 12% of the respondents could not pass the questionnaire and confirmed a low level of proficiency in this competence. Later on, we included five more respondents to this group, who were excluded from the group with an average level after the interview. This group in the subsequent work also required more attention to the details of the proposed work, the inclusion of additional time to demonstrate the principles of work and the algorithm of action.

Based on the analysis of the questionnaire and the results of the interview, the sufficient level of information and digital competence was 27% (16 people).

Our further work consisted in taking participants through a web quest based on the basic theory of the disciplines of the inclusive cycle. The important thing for us in using this type of work was that we were not limited in educational resources; there was a connection of educational material with real life. The greatest emphasis, as in other studies of the scientific community, was on the active involvement of students in research activities, and the role of the teacher was advisory in nature [13].

After the respondents passed the web quest, a two-part questionnaire on the results awaited them. The first component allowed us to consider the emotional state, and the second component allowed us to consider the students' readiness to try their hand at creating a web quest and shaping their programming skills.

It is important to note that students under the age of 25 had no problems with connecting, setting up and going through the web materials offered. Whereas the students of the older group - working professionals, who receive additional specialty quite often, had difficulties from connecting to the interactive whiteboards to sending Google Forms during the web quiz (15% of participants). This aspect not only influenced the changes in the educational process in the direction of increasing the time to explain the technical features of the work, but also made it clear that the status of one or another respondent in the eyes of the modern student is quite low. In addition, this

«status» will be impossible to «roll back» when we return to the usual standards of offline education.

Thus, based on our findings, we conclude that the most significant and requiring attention to the problems of implementation and use of such technologies in the daily practice of non-technical professionals - teachers are:

- Insufficient training of already working professionals to take advantage of web technologies and multimedia systems;
- «Lack of interest» in the development in the direction of interactive work online without specially created conditions;
- Rather «superficial» basic educational programs in the training of non-technical specialists in the formation of information and digital competence;
- Lack of incentives to «spend time» on additional courses or methodological developments to improve qualifications, even after training at the university or in non-medical areas of MES
- Low level of material and technical support, especially with regard to the use of special technologies to support the educational process for children with developmental disabilities.

IV. CONCLUSIONS

Of course, this is only part of the modern challenges for specialists in pedagogy, special and remedial, primary and preschool education, but at the same time - it is an opportunity to review existing practices, adapt materials for online work and improve the quality of education as professionals themselves, and their wards. Since the experiment is ongoing, we cannot reveal in more detail all the aspects of our data, to present partially worked out by the students themselves interactive games and other types of interaction developed in the process of classroom and independent work. But, at the same time it is worth noting that some of the students already use the created developments in their daily or educational practice, which has a rather strong impact on the «authority» of the teacher in the eyes of children.

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Formation of Top Job Skills of Tomorrow Among Computer Engineering and Information Technologies Undergraduate Students in the Process of Learning English

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Abstract - **The main aim of the study was to investigate Computer Engineering and Information Technologies undergraduate students' attitude towards the most important job skills of tomorrow and to provide methodology for their enhancing in the process of learning English. To collect data essential for developing methodology aimed at enhancing top job skills of tomorrow in the process of learning English, 295 Computer Engineering and Information Technologies undergraduate students aged from 17 and 21 were selected to take part in the web-based survey. In total, research sample was presented by 64 female students and 231 male students. The team of researchers developed the educational content of the English elective course targeted at developing top job skills of tomorrow among undergraduate students. Taking into account the fact that English holds great didactic potential for developing knowledge, skills and aptitudes among students of different specialties at higher education institutions necessary for reaching success in the future, the educational content of the English elective course is oriented towards increasing motivation to master English among undergraduate students of the mentioned specialties, on the one hand, and to boost the identified job skills of tomorrow, on the other hand. The realization of the proposed educational content is based on the integration of the fundamental principles of action-oriented, competence-based, mastery-based and project-based approaches. Considering English as an efficient medium of instruction we can suggest the following idea: upgrading the educational content can provide endless opportunities for professional development of undergraduate students. To be exact, on their way of gaining professionally valuable knowledge and skills generally subdivided into two groups (soft skills and hard skills) they are involved in the activities that could guarantee the development of abovementioned skills. Thus, the created English elective course could serve as an example to follow.**

Keywords - Computer Engineering and Information Technologies undergraduate students, English elective course, English as a medium of instruction, top job skills of tomorrow.

I. INTRODUCTION

A review of scientific literature indicates that the majority of contemporary scholars and practitioners begin to embrace the concept that to take a rightful place in the ever-changing society young people have to acquire a wide range of lifelong learning skills while studying and academic institutions of different levels must play an important role in this endeavour [1; 2; 3]. In the light of various momentous events that have already disturbed the human conscience it is obvious that knowledge on universal values and their influence on the process of forming lifelong learning skills and competences, a set of soft skills and job skills of tomorrow among current and future generations of professionals may become a strong basis for building a cohesive world community. In that context, university education has an invaluable role to play. To live in peace and harmony for years to come people around the world should acquire knowledge and skills that will enable them to respond rapidly to changes that are constantly happening in the world. This will be possible only if the content of university programs takes into account trends in various spheres of the world economy and is aimed at equipping students with job skills of tomorrow anticipating their importance. To withstand global upheavals brought about by natural and man-made disasters people all over the world should act collectively regardless of professional, ethnic or religious affiliation. This is most evident now when all the nations of the world have expressed their willingness to help each other in combating the Covid-19 pandemic placing the highest value on the person. In this regard universities and nearest future university education can play a crucial role not only in training highly competent specialists but in creating global citizens sharing common universal values.

Considering the ideas declared the value of learning and mastering English strengthens greatly and the proper knowledge of English becomes an effective way and means for communicating and exchanging innovative ideas concerning the problems of the globalised world. That can also be regarded as one of the important objectives of the professional development of Computer Engineering and Information Technologies undergraduate students. The problem of upgrading the learning content of English as an obligatory (or an elective) course converts into being mainstream. And the perspective to guarantee an effective solution to the problem discussed the team of researchers sees in combining the objectives of learning and mastering English and in providing the actual and up-to-date professionally-valuable content for learning and mastering English as an essential means for enhancing top job skills of tomorrow among undergraduate students. In most universities all over the world in the countries where English is not the first or the second official language, the English course as an academic discipline is included into university training programs. And that is one more powerful reason for concentrating our attention on forming top job skills of tomorrow among undergraduate students of mentioned specialties in the process of learning English. So, taking into account the fact that English holds great didactic potential for developing knowledge, skills and aptitudes among students of different specialties at higher education institutions necessary for reaching success in the future, the educational content of English as an elective (or obligatory) course could be oriented towards increasing students' motivation to master English, on the one hand, and to boost the development of the identified job skills of tomorrow, on the other hand.

To fulfil themselves as highly qualified professionals along with profound theoretical knowledge future entrants into the world and national labour markets need to acquire various skills while studying at universities [4; 5]. According to World Economic Forum 2020 [6], the important job skills of tomorrow that will enable young people not only to survive in our rapidly changing world but to succeed are presented in four categories, each of which contains different skills: problem-solving, working with people, self-management, technology use and development. Thus, analytical thinking and innovation; complex problem-solving; critical thinking and analysis; creativity, originality and initiative and reasoning, problem-solving and ideation belong to the Problem-solving category. The Self-management category encompasses such skills as active learning and learning strategies and resilience, stress tolerance and flexibility. Leadership and social influence skills are linked to the Working with people category. Technology use, monitoring and control skills and technology design and programming skills are associated with the Technology use and development category. It should be noted that our research which drew from the abovementioned classification was aimed to investigate Computer Engineering and Information Technologies undergraduate students' attitude towards the most important job skills of tomorrow and on the basis of the obtained results to provide methodology for enhancing the identified skills in the process of learning English.

II. MATERIALS AND METHODS

The team of researchers carried out the exploratory study targeted at investigating Computer Engineering and Information Technologies undergraduate students' attitude towards the most important job skills of tomorrow and providing methodology for their enhancing in the process of learning English. The data the researchers were interested in were collected between October and December 2020 via online Google Form. The choice of an online survey through the distribution of the developed Google Form is explained by the need to comply with the coronavirus control measures taken and

to follow stay-at-home orders to slow the spread of Covid-19.

The sample of the study included 295 Computer Engineering and Information Technologies undergraduate students aged from 17 and 21: 64 female (21.70%) and 231 male (78.30%) participants. The sample was selected by applying a convenience sampling method and the link to the developed Google Form was sent to undergraduate students of the mentioned specialties who studied at Kyiv National University of Technologies and Design (Kyiv, Ukraine) and Interregional Academy of Personnel Management (Kyiv, Ukraine). The respondents' participation in the online survey was voluntary. All the respondents were informed that the data were collected only for one reason to find out their attitude towards the most important job skills of tomorrow and on the basis of the data received to provide methodology for enhancing the identified skills in the process of learning English.

The team of researchers developed a web-based questionnaire using the Google Forms web app. All the participants who agreed to take part in the online survey completed the proposed questions including socio-demographic information and questions aimed at finding out their attitude towards the most important job skills of tomorrow. The participants were also asked to rate the importance of top job skills of tomorrow on a 5-point Likert-type scale (5 – extremely important; 4 – very important; 3 – moderately important; 2 – slightly important; 1 – not important). The list of proposed job skills included analytical thinking and innovation; active learning and learning strategies; complex problem-solving; critical thinking and analysis; creativity, originality and initiative; leadership and social influence; technology use, monitoring and control; technology design and programming; resilience, stress tolerance and flexibility; reasoning, problem-solving and ideation. The respondents were also asked whether the mentioned job skills of tomorrow were being developed at university and to explain what way the identified skills would help them reach their full potential.

254 respondents (86.10%) provided answers to the open-ended questions which enabled the researchers to summarize statements frequently occurring in their comments.

The obtained results were analysed qualitatively and quantitatively in order to provide methodology for enhancing job skills of tomorrow in the process of learning English.

III. RESULTS AND DISCUSSION

Table 1 demonstrates the research results obtained among Computer Engineering and Information Technologies undergraduate students.

TABLE 1 RESPONDENTS' OPINION ON THE IMPORTANCE OF JOB SKILLS OF TOMMOROW FOR PURSUING THEIR CAREERS

Ten Job Skills of Tomorrows	Not important (%)	Slightly important (%)	Moderately important (%)	Very important (%)	Extremely important (%)
Analytical thinking and innovation	0.00	0.00	25.00	25.00	50.00
Active learning and learning strategies	0.00	0.00	20.00	35.00	45.00
Complex problem-solving	0.00	0.00	15.00	25.00	60.00
Critical thinking and analysis	0.00	0.00	5.00	20.00	75.00
Creativity, originality and initiative	0.00	0.00	20.00	25.00	55.00
Leadership and social influence	0.00	0.00	10.00	25.00	65.00
Technology use, monitoring and control	0.00	0.00	0.00	40.00	60.00
Technology design and programming	0.00	0.00	5.00	30.00	65.00
Resilience, stress tolerance and flexibility	0.00	0.00	5.00	45.00	50.00
Reasoning, problem-solving and ideation	0.00	0.00	0.00	40.00	60.00

Source: own study (N=295)

The results obtained and presented in Table 1 enabled us to make a conclusion that the majority of respondents considered the identified job skills of tomorrow as essential for pursuing their career. And this is obvious considering the statements declared in the materials of the World Economic Forum 2020 [7]. Thus, the main idea expressed is that by 2025 more than half of the labour force of the world will need re-skilling. The second idea is that in the next five years the significance of such skills as critical thinking and problem-solving will be increased greatly. To be able to respond quickly to the present-day challenges employees will need to be resilient, stress tolerant and flexible. They will have to become active learners and display a wide range of lifelong learning skills. What is more, it can take up to six months to re-skill around 40% of labour force all over the world [8].

Thinking about lifelong learning and lifelong learning skills, Peat, Taylor and Franklin come to the conclusion that the paramount task of any present-day university is to equip its graduates with knowledge and skills that will enable them to respond promptly and effectively to all the changes in the labour market because students' "ability to learn tomorrow is as important as the ability to learn today" [9, p. 135].

The similar idea is expressed by Laal and Salamati who are convinced that a person who is equipped with

lifelong learning competences and skills "will keep up with society by staying current and aware of changes in such areas as technology, news and political trends or finance and money issues" [10, p. 403].

Peat, Taylor and Franklin propose their own classification of lifelong learning skills that includes eight categories: communication, interpersonal, information management, research, perspectives, business and personal [11, p. 146]. What is more, scholars suggest innovative teaching practices aimed at developing generic lifelong learning skills successfully implemented into biology courses at the University of Sydney. Among the innovative teaching practices special importance is given to the virtual learning environment, the online tutorial and assessment modules, and online discussions with large groups of students. The scholars are convinced that since the virtual learning environment enables to take into consideration students' learning styles it is very effective in developing their lifelong learning skills. The online tutorial and assessment modules are focused on the improvement of students' independent learning skills, and online discussions are useful in practicing students' thinking and communication skills.

We cannot fail to agree with the idea contained in the paper by Kommers and Fischer that for today "Lifelong learning is more than adult education and/or training — it is a mindset and a habit for people to acquire" [12, p. 3]. It means that university graduates equipped with lifelong learning skills will be better prepared to cope with changes in society. The scholars insist that to be successful in developing lifelong learning skills among university students, university lecturers should organise instruction within the context of authentic problems and learning-on-demand needs. Moreover, organizational and collaborative learning must be provided taking into account the fact human mind has some limitations.

Responding to the question concerning the development of the identified job skills of tomorrow at university the majority of Computer Engineering and Information Technologies undergraduate students replied (92.00%) that although these skills were being developed the process had to be intensified and university lecturers should use more interactive methods and techniques.

Explaining what way the identified job skills of tomorrow would help to reach their potential the majority of respondents (87.00%) reported that they would be able to prove themselves as highly qualified professionals and contribute greatly to the communities they were a part of.

Based on the obtained results we can state that when providing upgraded university training programmes as being adapted to meet the requirements of current conditions of global development (and, moreover, influenced by such unpredictable impacts as the Covid-19 pandemic) the scholars should take into consideration the following issues, to be exact: 1) orientation towards simultaneous development of students' hard and soft skills on their way of gaining professionally-valuable knowledge; 2) seeing the development of a set of lifelong learning skills and competences, a set of soft skills and top skills of tomorrow as one of the most important implicated objectives of future specialist' professional training; 3) organizing the training process within some certain academic disciplines (humanities are preferable) targeted at gaining knowledge on the content essence and the functionality of the mentioned skills and competences in pursuing their careers. Within the described range of investigation matters the team of researchers focused their research on providing methodology for enhancing job skills of tomorrow in the process of learning English.

Considering English as an efficient medium of instruction we can suggest the following idea: upgrading the educational content can provide endless opportunities for professional development of future specialists. To be exact, on their way of gaining professionally valuable knowledge and skills generally subdivided into two groups (soft skills and hard skills) students are to be involved in the activities that could guarantee the development of abovementioned skills. Thus, the created English elective course could serve as an example to follow. Such an English course can be organized as a 10-unit course (6 to 10 hours are offered to be spent on each unit). To obtain the desired results on the way of mastering job skills of tomorrow the learning content of each unit should reflect the content of the mentioned job skills of tomorrow. The original source for organizing English learning content within the course provided could be materials available on the sites of the World Economic Forum [13] and World Skills [14].

The obtained results showed that respondents highly appreciated upgrading English learning content in accordance with the problem closely connected with the formation of job skills of tomorrow by involving them actively into the activities targeted at developing the declared set of job skills of tomorrow, to be exact: analytical thinking and innovation; active learning and learning strategies; complex problem-solving; critical thinking and analysis; creativity, originality and initiative; leadership and social influence; technology use, monitoring and control; technology design and programming; resilience, stress tolerance and flexibility; reasoning, problem-solving and ideation.

The realization of the proposed educational content is to be based on the integration of the fundamental principles of action-oriented, competence-based, mastery-based and project-based approaches under current conditions of blended learning model of educational process organization. Having analysed the students' responses as for their attitude towards the problem of top job skills development while studying at university, the team of researchers made an attempt to create the learning content of the English course on the

basis of the following methodological algorithm. Within the worked out algorithm the developed taxonomy of innovative techniques are to be implemented when organizing and providing the English course: 1) To organize English teaching and learning on the grounds of the integration of the fundamental principles of action-oriented, competence-based, mastery-based and project-based approaches under conditions of blended learning model introduction. The transformed conditions of providing university education demand fundamental ideas of several approaches (the mentioned ones) as a united set that could be regarded as a new educational paradigm. And this paradigm is called to guarantee the enhancement of top job skills of tomorrow [15]. 2) To enrich English teaching and learning by means of integrating formal, non-formal and informal types of learning. We believe that such kind of integration can effectively influence the improvement of undergraduate students' top job skills of tomorrow. It will also help to share the experience gained in the process of learning English [16]. 3) To stimulate Computer Engineering and Information Technologies undergraduate students' participation in network professional communities [17; 18]. 4) To show the potential benefits of using open educational resources, on the one hand, and open professionally-oriented resources (sharing their information in English), on the other hand [19; 20]. 5) To involve Computer Engineering and Information Technologies undergraduate students in different types of activities aimed at developing top job skills of tomorrow considering their learning styles [21].

IV. CONCLUSIONS

Computer Engineering and Information Technologies undergraduate students' attitude towards the most important job skills of tomorrow has been investigated. Scientifically backgrounded methodology for enhancing their job skills of tomorrow in the process of learning English has been provided. Practically-oriented methodological mechanism presented as a taxonomy of innovative techniques to be implemented in the process of teaching and learning English is aimed at developing top job skills of tomorrow Computer Engineering and Information Technologies undergraduate students.

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Soft Skills Development Strategies for Computer Engineering and Information Technologies Undergraduate Students Devised in the Process of Learning English

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Abstract - **The aim of the study was to devise soft skills development strategies for Computer Engineering and Information Technologies undergraduate students in the process of learning English. The research consisted of total 347 Computer Engineering and Information Technologies undergraduate students including 45 female students (13.00%) and 302 male students (87.00%) aged from 17 to 21. The research which was non-experimental in nature was conducted at four higher education institutions in Ukraine between October 2020 and November 2020. To reach the main aim of the study the team of researchers developed a web-based questionnaire containing open-ended and closed-ended questions. The use of the web-based questionnaire seemed to be quite logical for collecting the data necessary for devising soft skills development strategies for Computer Engineering and Information Technologies undergraduate students in the process of learning English taking into account the situation connected with the Covid-19 pandemic. The respondents who volunteered to take part in the survey were sent a link to the web-based questionnaire and guaranteed the complete anonymity. The data analysis covered processing of information collected from the anonymous web-based survey, displaying the data obtained in the form of tables and figures, devising soft skills development strategies based on research results and drawing general conclusions. The findings obtained enabled the authors to present six development strategies aimed at enhancing soft skills among Computer Engineering and Information Technology undergraduate students that could be applied in the process of learning English: a) combination of competence-based, action-oriented and** **blended-learning approaches in the English for Specific. Purposes classroom, b) integration of formal, non-formal and informal learning, c) participation in specially focused network professional communities, d) use of open educational resources for learning English, e) use of open professionally-oriented educational resources, f) introduction of learning-style based activities in the English for Specific Purposes classroom for boosting students' soft skills.**

Keywords - Computer Engineering and Information Technologies undergraduate students, English for Specific Purposes, soft skills, soft skills development strategies.

I. INTRODUCTION

Most researchers and educators seem to concur that improvements in soft skills are important prerequisites for students' comprehensive development, their readiness to adapt and respond to the challenges of our time. What is more, soft skills enable students to fully and meaningfully take part in all the decisions that affect their personal lives and future professional achievements. But nevertheless, the review of the scientific literature suggests that there is no consensus on the number of soft skills future entrants into the labour market should be able to gain while studying at universities. Thus, for instance, Klaus, Rohman, and Hamaker [1] identifies the following list of soft skills, namely, being self-aware, trustworthiness, conscientiousness, adaptability, critical

thinking, attitude, initiative, empathy, confidence, integrity, self-control, organizational awareness, likability, influence, risk taking, problem solving, leadership, time management.

The range of soft skills suggested by Shakir includes communication skills, critical thinking, problem solving skills, team work, lifelong learning and information management skills, entrepreneurship skills, ethics, professional moral skills, leadership skills [2].

Even more detailed classification of soft skills is presented by Majid et al. [3], to be exact: communication skills, leadership skills, persuasion skills, negotiation skills, conflict management and time management skills, problem solving and creative problem solving skills, teamwork spirit, personal effectiveness, strategic thinking, positive work attitude, willingness to learn, passion towards work.

The classification of soft skills suggested by Robles [4] could be regarded as a bit more generalized when comparing with the previous ones. The researcher identifies the following soft skills, namely: integrity, communication, courtesy, responsibility, social skills, positive attitude, professionalism, flexibility, teamwork, and work ethic.

Even more generalized classification offered by Balachandar, Jayam, and Jawaharrani [5] comprises communication skills including English communication skills, interactive listening skills, enthusiasm and positive attitude, team building skills.

According to OECD [6], soft skills essential for young adults encompass critical thinking, creative thinking, learning-to-learn, self-regulation, empathy, self-efficacy, responsibility, collaboration, manual skills, life skills, abilities to mobilise one's capacities and abilities to use and manipulate materials, tools, equipment and artefacts.

In our research, "Council Recommendation of 22 May 2018 on key competences for lifelong learning (Text with EEA relevance) (2018/C 189/01)" [7] is the major background document for identifying a set of soft skills essential for personal fulfillment of future entrants to the labor market. Soft skills comprise problem solving skills, critical thinking, team work skills, creativity, computational thinking, self-regulation, analytical thinking, resilience, intercultural skills and communication skills including negotiation skills.

The main aim of the research was to devise soft skills development strategies for Computer Engineering and Information Technologies undergraduate students in the process of learning English for Specific Purposes (ESP) in line with the results collected by researchers through a web-based survey.

II. MATERIALS AND METHODS

Subjects of the study were 347 Computer Engineering and Information Technologies undergraduate students including 45 female students (13.00%) and 302 male students (87.00%) aged from 17 to 21. The research sample was selected with the use of convenience sampling technique. The research which was non-experimental in nature was conducted at Kyiv National University of Technologies and Design (Kyiv, Ukraine), Taras Shevchenko National University of Kyiv (Kyiv, Ukraine), Interregional Academy of Personnel Management (Kyiv, Ukraine), H. S. Skovoroda Kharkiv National Pedagogical University (Kharkiv, Ukraine) between October 2020 and November 2020.

To obtain information necessary for devising soft skills development strategies for Computer Engineering and Information Technologies undergraduate students in the process of learning English for Specific Purposes, the researchers developed a web-based questionnaire which included open-ended and closed questions. The designed open-ended and closed-ended questions were aimed at finding out what soft skills were considered to be the most important for Computer Engineering and Information Technologies undergraduate students, what activities used in the process of learning English seemed to be the most effective for their enhancement. Two closed-ended questions of the web-based questionnaire also concerned age and gender of respondents. The respondents were asked to rate the level of importance of identified soft skills according to a 5-point Likert-type scale (5 – extremely important; 4 – very important; 3 – moderately important; 2 – slightly important; 1 – not important). The open-ended questions were aimed at finding out the range of disciplines which could promote the enhancement of soft skills and what way these skills could be useful for their professional activity.

After receiving anonymous responses from the web-based survey, the researchers started processing information obtained from respondents. This enabled them to display all the data collected, to devise and substantiate soft skills development strategies for Computer Engineering and Information Technologies undergraduate students in the process of learning English and to draw general conclusions.

III. RESULTS AND DISCUSSION

The results of the research among Computer Engineering and Information Technologies undergraduate students are given in Table 1.

TABLE 1 RESPONDENTS' VIEWS ON THE IMPORTANCE OF SOFT SKILLS FOR THEIR PROFESSIONAL DEVELOPMENT

Soft skills	Not important (%)	Slightly important (%)	Moderately important (%)	Very important (%)	Extremely important (%)
Problem solving skills	0.00	0.00	10.00	10.00	80.00
Critical thinking	0.00	0.00	20.00	15.00	65.00
Team work skills	0.00	0.00	5.00	30.00	65.00
Creativity	0.00	0.00	10.00	25.00	65.00
Computational thinking	0.00	0.00	20.00	40.00	40.00
Self-regulation	0.00	0.00	5.00	15.00	80.00
Analytical thinking	0.00	0.00	10.00	45.00	45.00
Resilience	0.00	0.00	10.00	20.00	70.00
Intercultural skills	0.00	5.00	0.00	35.00	60.00
Communication skills including negotiation skills	0.00	0.00	0.00	25.00	75.00

Source: own study

N=347

Concerning the questions aimed at finding out the range of disciplines which could promote the enhancement of soft skills and what way these skills could be useful for their professional activity the following results were obtained. Among the disciplines that could be regarded as potentially useful for developing Computer Engineering and Information Technologies undergraduate students' soft skills the majority of respondents (more than 75.00%) listed the English for Specific Purposes and Psychology. The obtained results explain the desire of researchers to design an optional course aimed at combining both the improvement of Computer Engineering and Information Technologies undergraduate students' English language proficiency and the enhancement of their soft skills. The learning content was organized within the units titled in accordance with the identified soft skills, namely, problem solving skills, critical thinking, team work skills, creativity, computational thinking, self-regulation, analytical thinking, resilience, intercultural skills and communication skills including negotiation skills. And nearly all the respondents (more than 90%) confirmed the importance of the identified soft skills for their professional development and career growth.

The findings obtained enabled the authors to present six development strategies aimed at enhancing soft skills among Computer Engineering and Information Technology undergraduate students that could be applied in the process of learning English: a) combination of competence-based, action-oriented and blended-learning approaches in the ESP classroom, b) integration of formal, non-formal and informal learning, c) participation in specially focused network professional communities, d) use of open educational resources for learning English, e) use of open professionally-oriented educational resources, f) introduction of learning-style based activities in the ESP classroom for boosting students' soft skills.

Strategy 1 – Combination of competence-based, action-oriented and blended-learning approaches in the ESP classroom. The results of the literature review clearly indicates that despite the high number of methodological approaches developed and substantiated by scholars and practitioners, there is still no universal methodological approach whose usage in the educational process helps to improve students' hard and soft skills. It proves the fact that the main ideas of several methodological approaches should be applied for enhancing both hard and soft skills among students of different specialties. Each individual case of choosing methodological approaches or a combination of methodological approaches is determined by educational results to be achieved upon completion of training programmes. As far as Computer Engineering and Information Technologies undergraduate students are concerned, the consideration of the fundamental principles of the competence-based, action-oriented and blended-learning approaches enables university lecturers to find effective ways of improving the identified soft skills. Considering that "language learning should be directed towards enabling learners to act in real-life situations, expressing themselves and accomplishing tasks of different natures" [8, p. 29], the use of the action-oriented approach enables to develop students' soft skills by means of a variety of problem solving, team building, creative thinking and communicative activities. To reach success in today's globalized world higher education graduates should acquire a wide range of skills and competences. It is explained by the fact that skills and competences they acquire while studying at university "enable them to participate fully in society and manage successfully transitions in the labour market" [9, p. 7]. The publication of a book "The Action-oriented Approach: A Dynamic Vision of Language Education" by Enrica Piccardo and Brian North [10] provides new perspectives on language and education. Following the authors of the book the term "the action-oriented approach" refers to the choice made by CEFR itself to reach its mission, i.e. to contribute transparency and coherency to the vast and complex field of language use and language education; it does not intend to push a particular methodological agenda [11]. For today the foreign language proficiency is becoming increasingly critical to both personal and societal development. Taking into consideration the fact that the action-oriented approach turned to be the object of particular attention from the side of educators involved in foreign languages teaching and also from the creators of foreign languages training curricula, new methodological knowledge

appeared aimed at upgrading foreign languages content that can meet learners' requirements. The discussed methodological improvements in foreign language education are not resulted in terms of practices and policies of education but also in terms of societal importance. The issues mentioned became the starting points for making a suggestion that foreign language learning could be converted into some certain effective way of boosting educational mechanisms and techniques guaranteeing the development of students' soft skills. The process of teaching ESP at higher education institutions is aimed at providing students with the proper scope of foreign language knowledge and communicative skills and it proves the rightness of the combination of competence-based and action-oriented approaches. Current transformations taking place in the system of higher education in general and in the professional training of Computer Engineering and Information Technologies undergraduate students in particular tend to combine best practices of distance learning and in-person instruction (especially taking into account the situation connected with the Covid-19 pandemic). That is the reason why implementation of the main ideas of the competence-based and action-oriented approaches should be influenced by the major issues of blended learning as a featured methodological approach. Thus, we consider the combination of competence-based, action-oriented and blended-learning approaches in the ESP classroom as one of the most significant strategies to be realized in the process of learning English targeted at enhancing soft skills among Computer Engineering and Information Technologies undergraduate students. The strategy implies the fulfillment of the following assignments: 1) to carry out a theoretical review of scientific literature aimed at understanding how methodology is conceived in teaching and learning English for Specific Purposes; 2) to analyze the mentioned language teaching approaches, principles they are based on, learning outcomes they are aimed at, the advantages and disadvantages of their use in the foreign language instruction process focused on development of soft skills; 3) to understand what influences the choice of the mentioned combination of approaches for improving Computer Engineering and Information Technologies undergraduate students' languages competence and soft skills [12].

Strategy 2 – Integration of formal, non-formal and informal learning. The team of researchers conducted the study aimed investigating the influence of combining formal, non-formal and informal learning on improving Computer Engineering and Information Technologies undergraduate students' training through the increase in their general self-efficacy [13]. It became the basis for defining the second influential strategy targeted at enhancing soft skills among Computer Engineering and Information Technologies undergraduate students in the process of learning English as the integration of formal, non-formal and informal learning. The realization of this

strategy implies the fulfillment of the following tasks: 1) to investigate the influence of combining formal, non-formal and informal learning on improving Computer Engineering and Information Technologies undergraduate students' soft skills; 2) to share the experience gained in the process of learning English focused on enhancing Computer Engineering and Information Technologies undergraduate students' soft skills.

Strategy 3 – Participation in specially focused network professional communities. Considering that entering the labor market, many young specialists (and Computer Engineering and Information Technologies specialists are not an exception) are not often ready to realize their full potential [14]. As the practice shows the reason for this lies in the lack of special professionally-valuable experience, lack of special knowledge of how to share innovative ideas with other colleagues and even fear to ask for advice on issues of concern. The authors are convinced that "there is no easy way out of this situation, but due to the spread of the Internet, easy access to information resources, services and specially focused network communities specialists of different spheres can discuss acute problems, share personal experiences in coping with them, improve their self-efficacy and, as a result, achieve their creative potential and contribute greatly to the organization or company they work for" [15, p. 229]. So within the research presented we took a decision to determine the third strategy to be realized in the process of English learning focused on enhancing Computer Engineering and Information Technologies undergraduate students' soft skills as the participation in specially focused network professional communities. The additional reason for taking such a decision is the fact that the majority of network professional communities use the English language as a means for exchanging ideas and information. And participation in the mentioned network professional communities can provide a great deal of opportunities for improving Computer Engineering and Information Technologies undergraduate students' soft skills. To be exact, the students in the process of combining English learning and being active participants of the network professional communities can improve the skills identified by European Commission [16], namely: problem solving skills, critical thinking, team work skills, creativity, computational thinking, self-regulation, analytical thinking, resilience, intercultural skills and communication skills including negotiation skills etc. And the listed soft skills are regarded as being of great value for Computer Engineering and Information Technologies undergraduate students by the team of researchers. The implementation of the strategy implies the following tasks: 1) to define information regarding the rate of Computer Engineering and Information Technologies undergraduate students' participation activity in professional learning networks; 2) to assess the

influence of networked professional learning on developing Computer Engineering and Information Technologies undergraduate students' soft skills, on the one hand, and foreign language proficiency, on the other.

Strategy 4 – Use of open educational resources for learning English. Considering the results of the studies aimed at investigating open educational resources for learning English [17; 18], a decision was made to define the fourth strategy which is to use open educational resources for learning English to be implemented while developing Computer Engineering and Information Technologies undergraduate students' soft skills. The English language training practice demonstrates that the use of open educational resources significantly intensifies students' cognitive activity, the development of lifelong learning skills, on the one hand, and the scope of the soft skills declared in the research, on the other hand. The implementation of this strategy is targeted at accomplishing the sequence of the following objectives: 1) to analyze conceptual approaches for specifying the essence of the notion of "soft skills" and the variety of the content meanings of the identified soft skills, i.e. problem solving skills, critical thinking, team work skills, creativity, computational thinking, self-regulation, analytical thinking, resilience, intercultural skills and communication skills including negotiation skills; 2) to substantiate the choice of learning content (in the process of English learning focused on soft skills development) taught to Computer Engineering and Information Technologies undergraduate students. The various open educational resources can be used for developing students' soft skills, for instance, "Encyclopedia Britannica" [19], "Learn English Online" [20], "TED Talks" [21], "BBC Learning English" [22] etc.

Strategy 5 – Use of open professionally-oriented educational resources. Following the logic of identifying the fourth strategy we have come to the conclusion to define the fifth strategy as to use open professionally-oriented educational resources. But the choice of such open professionally-oriented educational resources should be imposed on Computer Engineering and Information Technologies undergraduate students. And this choice they make in accordance with their professional interests, the existing professional experience gained within the subject-matter disciplines. The strategy implementation implies the fulfillment of the following tasks: 1) to analyze conceptual approaches of the understanding of the peculiar features of the range of professions and the fields of Economy where Computer Engineering and Information Technologies students can work after graduating from higher education institutions; 2) to broaden professionally-valuable learning content by means of applying to open professionally-oriented educational resources (presented in the English language). The number of open professionally-oriented educational resources cannot be limited for use. It means that all resources found by Computer Engineering and Information Technologies undergraduate students can be used in the process of learning English aimed at the development of their soft skills.

Strategy 6 – Introduction of learning-style based activities in the ESP classroom for boosting students' soft skills. The sixth strategy that was determined by the team of researchers to be realized in the process of English learning focused on Computer Engineering and Information Technologies undergraduate students' soft skills development implied the introduction of learning-style based activities in the ESP classroom for boosting students' soft skills. The realization of this strategy was aimed at addressing the following challenges: 1) to determine the learning styles of Computer Engineering and Information Technologies undergraduate students by using the modality questionnaire by O'Brien [23; 24]; 2) to provide assistance in both acquiring the foreign language knowledge and developing soft skills by means of offering learning activities according to Computer Engineering and Information Technologies undergraduate students' learning styles.

IV. CONCLUSIONS

The research conducted enabled to devise and substantiate six development strategies aimed at enhancing soft skills among Computer Engineering and Information Technology undergraduate students that could be applied in the process of learning English: a) combination of competence-based, action-oriented and blended-learning approaches in the ESP classroom, b) integration of formal, non-formal and informal learning, c) participation in specially focused network professional communities, d) use of open educational resources for learning English, e) use of open professionally-oriented educational resources, f) introduction of learning-style based activities in the ESP classroom for boosting students' soft skills. The implementation of strategies devised by researchers in the process of learning English at higher education institutions significantly affects the development of soft skills among Computer Engineering and Information Technologies undergraduate students. The time spent on learning each individual unit can vary from 6 to 10 hours (as optimally recommended by the authors). The willingness of students to study the English language in such an upgraded way (in this very case as being combined with the process of soft skills enhancement) proves the fact that the learning content of the obligatory courses of English at universities is to meet the current requirements of the present-day globalized society. The development of such courses should be targeted at improving professional training of Computer Engineering and Information Technologies undergraduate students as future entrants to the labor market

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Proposal of Formal and Non-Formal Education for New Generation Digital Learning Demand in Engineering

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Abstract - **Millennial generation, starting from twelve-year-olds up to adolescents, is one of the most complicated generational cohorts; its ecosystem, beyond of formal and non-formal education boundaries, is more diverse than for any other previous generation.**
Digital learners prefer a digital learning environment, as the advantage of digital learning is the control over time, place, way and pace, enabling you to impersonate as an educational institution, applying smart personal network which consists of 3 domains: applied smart technologies; reflexive pedagogy for the digital century [1]; learning environment [2], thus without any confrontation of formal and non-formal education, but rather with consolidation of resources to promote engineering development of formal environment at school, higher educational establishments and informal activities – projects, scientists' night events, open days, interest-related education programmes, etc.

Goal of the research is to analyse the proposal of formal and non-formal education for the new generation digital learning demand and identify the examples of good practice in engineering, based on the identified digital leaning criteria obtained as a result of theoretical analysis.

In the design research of cross-sectional study 323 respondents took part: 226 representatives of formal education and 97 representatives of non-formal education.

In the research the quantitative and qualitative data collection (questionnaires, case analysis) and processing (nonparametric software in SPSS environment and content analysis) methods have been applied.

Results of Mann-Whitney U-test to two independent samples confirm statistically significant differences depending on the respondents' profile: representatives of non-formal education tend to value
Higher such digital learning criteria as situational

and authentic, whereas representatives of formal education value higher interactive digital learning on demand, which is related to application of different media platforms (p≤0.05).

The research analyses the examples of good practice in case studies in engineering.

Engineering can be geared towards fundamental research, but in the pupils' educational process the innovative solutions of technical sciences with a perspective of practical applicability arouse a greater interest. Learning efficiency and acquisition of new knowledge are successful if learning is linked to research work in higher educational establishments and transfer of findings in the education system in close collaboration with representatives of economic sectors and businesses.

Keywords - Millennial generation, formal, non-formal education, digital learning, engineering.

I. INTRODUCTION

The paradigm or conceptual framework shift, that has taken place in this new millennium, has brought changes in economics, culture, education and other sectors. Due to the social and economic conditions and shrinking of the labour market, the entering of the adult age has become more complex and requires a longer and more complicated "prologue of adult life". As the result it has created a new developmental stage (age of 17-18 years) called young or emerging adulthood, which is not universal, but a cultural construct characterized by changes of personality in cognitive, emotional, physical and social sphere [3].

Nowadays, the predicted forecasts that in the new era the marketplace will be replaced by the network, the property rights replaced by access, which will impact also the concept of personality as the idea of an autonomous personality existing in a particular space will be replaced with an idea of a changing personality, which is dependent on the others and exists is time [4] - have become a reality. Although the future is associated

with "an equation where all its variables are undefined" [5], digital learning is one of the answers to this challenge and the opportunity to overcome it [2] with the condition that in the learning process the focus is not on the use of technologies as an end in itself, but on the effective, efficient [6] and meaningful [7] use of technologies, providing educational sustainability, because "technology is only a tool" [8] and its meaningful use depends on the pedagogue.

In order to generate interest into engineering professions among the youth, a mobile Techno-buss financed by the Mechanical Engineering and Metalworking Association operates in Latvia, which is equipped with engineering devices for demonstration, where one can get acquainted with real examples of technology application, demonstrating a digitally programmable metalwork or making a part programmed with a 3D printer.

In order to prevent the overproduction of humanitarian and social workers and lack of specialists in the engineering field, broad reforms are being implemented in formal education in Latvia.

While reforming the educational content for the implementation of the competence-based approach in Latvia, in the basic education phase engineering has been included in the offer of the field of technology, where pupils will obtain some experience "to create useful engineering solutions for themselves and others - strengthen such engineering problem-solving skills as constructing and projecting, material strength and compatibility analysis, ability to make judgements on the need for a specific solution and its impact on the society and environment, observe work safety requirements and intensify the development of such general or transversal skills as problem-solving and creativity" [9]. In its turn, in the comprehensive secondary education succession is provided implementing educational programmes with a higher proportion of subjects in mathematics, natural sciences and technology.

During the last decade in order to raise capacity and consolidate resources for a qualitative teaching of the STEM (science, technology, engineering and mathematics) field subjects, providing the link with the content of the higher education study programme content and motivating pupils for a conscious career choice in the engineering/ technology area, a tendency can be noticed among higher educational institutions to establish secondary schools with a more profound acquisition of engineering (Riga Technical University) and technologies (Rezekne Academy of Technologies).

In the Education Law both formal education has be defined as the "system which comprises in itself levels of basic education, secondary education and higher education, whose acquisition is certified by a stated-recognized educational or professional qualification document" [10] and non-formal education as "educational activities organized outside formal education in compliance with one's interests and demand" [10], thus affirming the place and role of non-formal education in the interest and motivation creation about engineering and learning achievement improvement in hard sciences in general.

The objective of education is "to produce an unbridled hunger for "new" knowledge and "new" skills and competences. The place where all this can be found and all this can be learned is cyberspace. Present continuously here and everywhere, accessible to everyone" [5].

II. MATERIALS AND METHODS

In the teaching process, cooperating with learners, teachers have a challenge to build a trustful relationship with the millennial generation, which is characterized by scepticism and the slogan: "Do not Teach Me, Let Me Learn" [11].

Although it is not possible to draw direct conclusions about the impact of digital technologies on students' learning [12] - also the research studies reveal contradicting results: from one side they highlight the close relationship of millennials with information, their media literacy and the ability to use technologies for accessing the information [13], but they also claim that millennials "are not capable of dealing with modern technologies in a way, which is often ascribed to them (i.e., that they can navigate the world for effective and efficient learning and knowledge construction)" [6].

Millennial generation is characterized by:
- Independence, investing effort and succeeding;
- Diversity, characterized by openness to everyone and to everything;
- Engagement, supporting environmental and civil rights initiatives or activities;
- Knowledge management, quickly filtering the amount of information and selecting what is valuable;
- Pragmatism - when choosing career;
- Personal brands, presenting one's identity;
- Collaboration, practicing it in the physical and virtual environment [13].

Prefer a digital learning environment, millennial generation cope with the growing use of mobile devices and social media networks for academic purposes, but also their need for constant and instantaneous feedback on their learning process [14], [15]. Their need for success and immediate recognition is satisfied with such tools as gamification, a public leaderboard, social learning and quick feedback mechanisms [11].

The applied smart technologies (equipment, gadgets, necessary software, artificial intellectual technologies), digital pedagogy or *reflexive pedagogy* for the digital century [1] provide support for the smart technology application in the learning process; the learning environment "brings together the learner's academic portfolio and supporting learning network" [2], creates the smart personal net in digital learning environment for the millennial generation, obtaining control over time, space, manner and pace.

As a result of theoretical analysis, the digital learning criteria and indicators were identified:
- Interactive (attractive content and materials, which motivate the engagement and creative use of social media);
- Learner-centred (emphasis on educator's support during the learning, and student's responsibility for their own learning and modelling);
- Situational (use of technologies associated with genuine learning and internal motivation);
- Collaboration (learning as a social activity);
- On-demand (use of different media platforms to access the content);
- Authentic (active and meaningful activity, which is based on a real-life learning models) [13].

The research questions are:

- What is the relevance of the *digital learning* offer to Millennial generation demand in formal and non-formal education?
- Are there any differences in the assessment of *digital learning* criteria depending on the respondents' profile?
- Is there correlation between the *digital learning* criteria?

The research method: exploratory research applying a quantitative and qualitative research approach. An online survey was administered by applying a questionnaire containing a 5-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = somehow agree, 4 = agree and 5 = strongly agree).

In the design research of cross-sectional study 323 respondents took part: 226 representatives of formal education (111 pupils and 68 students, 30 teachers and and 17 academic staff) and 97 representatives of non-formal education (38 pupils and 26 students, 20 teachers and and 13 academic staff) from different education institutions of Latvia.

Cronbach's alpha coefficient assessing reliability of the test shows a good internal consistency ($\alpha = 83$).

Kolmogorov-Smirnov Test results on non-compliance of empirical division with the norm (p =.000) determined the use of nonparametric methods for acquisition of secondary data.

Empirical data processing methods using SPSS software were applied to provide quantitative data processing methods:

- Mann-Whitney-U Test for determination of statistical significance of differences between two independent samples;
- Kendall correlation analysis for determination of relationships between indicators.

III. RESULTS AND DISCUSSION

The results of the Mann-Whitney U Test show that there are statistically significant differences in the demand and supply of digital learning depending on the profile of the respondents (See Table 1).

Representatives of formal education have rated interactive and on-demand learning higher than respondents of non-formal education. The offer of various media platforms in formal education for the acquisition of engineering content is sufficient, binding and appropriate for the target audience, which motivates educators to use it in a creative way in the millennium generation teaching process. Formal education at school has got the characteristics of a hierarchical system, characterized by the results to be achieved at each level of education and by expanding the amount of knowledge to be acquired in the time dimension. However, with higher education, the students' choice to improve in the academic or professional direction is more distinct.

On the other hand, representatives of non-formal education tend to appreciate situational and authentic learning more highly. As non-formal education is mostly related to interests, as well as to intrinsic motivation to acquire new knowledge, improve their skills in order to raise competitiveness, then it has got certain advantages in specific knowledge acquisition in a relatively short time, but formal education is often constrained by institutional bureaucratic conditions. The format of non-formal education is

more flexible, offering the opportunity to achieve results in a shorter period of time.

Table I Results of the Mann-Whitney U Test: Significant Differences Formal and Non-formal Education Representatives

Digital Learning Criteria	Results of Mann-Whitney U Test	Higher evaluated by	Lower evaluated by
Interactive	U=12085.000 **p=.000**	Formal education representatives Mean Rank 309,36	Non-formal education representatives Mean Rank 230,33
Learner-centred	U=10826,000 p>.05	Formal education representatives Mean Rank 296.80	Non-formal education representatives Mean Rank 272.84
Situational	U=12111.000 **p=.000**	Non-formal education representatives Mean Rank 299.48	Formal education representatives Mean Rank 232.90
Collaboration	U=11068,000 p>.05	Non-formal education representatives; Mean Rank 270,73	Formal education representatives Mean Rank 247,39
On-demand	U=12602.000 **p=.001**	Formal education representatives Mean Rank 290.42	Non-formal education representatives Mean Rank 244.12
Authentic	U=12555,500 **p=.000**	Non-formal education representatives Mean Rank 281,99	Formal education representatives Mean Rank 225,04

In its turn, there are no statistically significant differences in the assessment of student-cantered learning and cooperation - educator's support is essential in both formal and non-formal education. The possibilities of using different media platforms motivate them to use them creatively in formal and non-formal education; the educator's support in learning promotes cooperation; an active and purposeful activity in real life situations enhances the intrinsic motivation.

Teachers and academic staff tend to evaluate higher such criteria as interactive exercises, situational learning, learning on-demand and authentic learning in comparison to the pupils and students (p=.000). Pupils and students' responses, on the other hand, indicate that there is a great demand for more diverse and interesting use of media, including age-appropriate learning materials, as well as for modelling and problem-solving in real-life situations and in a particular context.

Students have ranked higher the interactive and situational learning, as well as learning on-demand than pupils (p=.009). But pupils have a tendency to evaluate higher the cooperation and authentic learning. In the context of learner-centred learning, pupils have emphasized the teacher's support, but students - their

own responsibility; modelling was equally important for both groups of respondents.

Teachers assessed higher the learning and cooperation in class than the academic staff, which tend to evaluate higher the authentic learning, teaching on-demand and interactive learning (p=.031).

As a result of Kendall correlation analysis, a statistically significant correlation between the digital learning criteria has been found (see Table 2).

Table II Kendall Correlation Analysis: Statistically Significant Correlation between the Digital Learning Criteria

Criteria of the digital learning	Interactive	Learner-centred	Situational	Collaboration	On-demand
	r =.75, p <.001.				
	r =.81, p <.001.	=.77, p <.001.			
	r =.63, p <.001.	r =.79, p <.001.	r =.82, p <.001.		
	r =.70, p <.001.	r =.67, p <.001.	r =.71, p <.001.	r =.72, p <.001.	
	r =.69, p <.001.	r =.63, p <.001.	r =.68, p <.001.	r =.64, p <.001.	r =.61, p <.001.

An active and purposeful activity, which is based on the real-world learning models, as it is directed towards certain problem-solving which the contemporary youth encounter in their daily life and in the surrounding social environment, motivates creative application of different technologies and media, promotes collaboration and responsibility for their learning.

Application of technologies, using smart devices, initially is most often related to application of different media resources offered by the entertainment industry. As smart technologies play an increasingly important role in everyday life, car building, logistics and elsewhere, the high level of digitalization sets requirements not only to be able to manage the smart technologies as users of the product on offer, but be the multiplicators of the new technology development and knowledge themselves. In order to be able to implement knowledge transfer, cooperation between specialists from different fields of activity is necessary, where a representative of

each industry is responsible for the quality of the performance of their assigned duties. For instance, in the building industry with a high export capacity, specialists of engineering industry, designers, marketing specialists, logistics and transport specialists are needed, who are familiar not only with the smart technologies of their industry, but due to the digital learning in formal and non-formal education have developed transversal skills to be able to work in team, to cooperate and be motivated, be responsible for their learning which ensures competitiveness of the company and the whole industry in the global market.

Application of various media platforms in engineering acquisition promotes learning as a social activity, raises intrinsic motivation and responsibility, as well as application of social media.

Getting involved in a dialogue with the representatives of similar interests, skills and knowledge are already being transferred in the informal environment in order to acquire the skills and abilities that ensure inclusion in the social environment where digital skills are essential. The knowledge acquired in the informal environment, as a result of a skilful pedagogical activity, can be adapted in the acquisition of engineering sciences in teamwork which is similar to the acquired type of socialization provided by the accumulated experience in the informal environment. In group work, for instance, during some project development in the learners' environment the intrinsic motivation is raised to prove one's individual skills, but common goals develop responsibility. For example, during the Covid-19 pandemic, the youth invent and offer more rational solutions to solve the tasks formulated by teachers/ lecturers, using the possibilities offered by social media which had already been applied in the informal knowledge circulation.

Monitoring of factors influencing environmental habitats in open water reservoirs can be performed according to a certain algorithm, using human workforce, but floating data acquisition laboratories can also be used, which have been given a task to obtain, process different data and transmit them from the monitored environment at certain coordinates through global positioning systems to the research institution. Such an idea has been implemented at Faculty of Science and Engineering of Liepaja University, implementing the project "Application of GPS Technologies for Environmental Monitoring." To implement the idea, knowledge in biochemistry, environmental sciences, physics is necessary, one has to be familiar with radio engineering, knowledge and practical skills as of constructors are required.

Learning as a social activity with the teacher's support offers opportunities for authentic learning, modelling, engaging content and the use of materials.

Teaching staff of higher educational institutions, cooperating with school teachers, engaging students and pupils in a unified educational process, can transfer the acquired knowledge and experience in engineering sciences through modern media both in such public events as Science Nights and in the digital environment, preserving the evidence of the achieved outcomes, which encourage other pupils and students to collaborate, experiment, accumulated new knowledge and apply it in a creative way to solve practical tasks. Socially significant future-orientated educational measures, such as projects supported by Liepaja Municipality, implemented by the teaching staff of Liepaja University in work with talented pupils, who acquire programming elements, developing digitally

controlled mechanical models, create multi-media optical installations etc., can be considered as successful. Spatial visualization in architecture and urban planning has become a widespread technique on a daily basis, which is being adapted by new researchers as an analogous model in order to implement their creative intentions in the offer of new computer games or also to develop different software related to robotics.

Situational studies are associated with student-centered and interactive learning.

Distance learning methods, which in comprehensive schools was a sporadic phenomenon, during the global pandemic has become as a norm. The process of the students' scientific research work development and their work presentation online is a clear example. Due to the unexpected situation both the teachers and learners' creative abilities have been unlocked. The situation of pupils' SRW is characterized by both the topics related to the analysis of the consequences of the pandemic, which affected the condition of culture, economic life, social welfare, and mental health. At the same time social skills and technologies have been acquired in order to document the empirical data obtained as a result of surveys and interviews and to ensure appropriate data protection. Thanks to engineering achievements, video interviews, electronic signature or computerized data processing have become reality. Also, measurements of sports and physiological condition of the body can be measured with electronic smart devices, which promote physical activities and their monitoring, but the corresponding data analysis, based on a certain methodology, opens an opportunity for scientific studies in medicine, sports pedagogy, etc.

The teacher's support encourages pupils to apply social media in a creative way.

The open public space of social media for most of the youth is an approbated digital environment which ensures high publicity to a wide range of users in a very short time, but the uploaded information remains for a long time. Adherence to socially responsible ethical principles is important. Positive examples are related to the acquisition of natural sciences by posting videos depicting the processes happening in nature, integrating quizzes or other game elements in order to acquire new knowledge. For instance, on the FB platform the teacher, a specialist of Liepaja environmental sciences, frequently uses filmed materials on different natural phenomena, on eco-system's functioning etc., which is not only an authentic study resource, but also an encouraging way for pupils to carry out observations, research and exchange of thoughts remotely. In prototyping laboratories engineering students in cooperation with scientists and industry specialists develop both environmentally friendly packaging packages and automatically controlled devices for the disinfection of premises, etc. innovations.

Application of an exciting content and materials, which motivate participation and creative use of social media in interactive learning, influence the application and cooperation of different media platforms in a positive way, as well as raise pupils' motivation and responsibility to get involved in an active and purposeful activity. The creative industries, exhibitions of virtual artwork, applying engineering solutions - illuminating environmental objects, transferring the images to be projected to various formats, reviving frozen photos, etc. open opportunities for the commercialization of inventions to the technology, art, advertising market. Outstanding examples of engineering and their achievement demonstration are the creative solutions of New Media Studies of Liepaja University, using sound waves, turning the oscillations created by them into artwork. The knowledge and skills acquired through millennium generation's digital learning are an essential prerequisite and important resource for the integration of smart technologies in various essential areas of life; they are especially significant for the offer of creative technological solutions in relation to engineering, as well as the creation and transfer of knowledge, mutual communication, creation, preservation and transfer of new cultural products.

IV. CONCLUSIONS

The research results confirmed the ideas suggested by other studies – the internet as a virtual learning environment offers authentic materials, meaningful interactions [16] and socialization opportunities [17], and "the digital-material tools employed represent a valuable resource for students' learning process" [18] in formal and informal education environment of engineering.

At different stages of education formal and non-formal education create the synergy effect during the engineering acquisition period which ensures sustainable development of engineering sciences and technologies, promotes the increase of competitiveness potential and facilitates the development of economic sectors.

Currently in Latvia, the digital learning offerings partly correspond to the pupils' demand, but in the process of education content reform and implementing the competence-based approach, the following transversal skills are developed: digital and critical thinking, problem-solving, creativity, entrepreneurial ability, self-guided learning, cooperation, and civic participation. Digital learning is a powerful resource in engineering for improving of all of them in accordance with the demand of the labour market.

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Ecological Worldview Formation of Engineering Students in the Context of Foreign Language Training

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Abstract - **The educational space of a non-linguistic university makes it possible to conduct a purposeful process of forming the ecological worldview and culture of future specialists in the logic of their professional development. According to the authors, the eco-oriented content of teaching a foreign language can make a great contribution to the implementation of this mission due to the great general cultural and educational potential of this discipline. The paper offers a comprehensive theoretical substantiation of the problem under study, reveals the essence, structure and methodology of the ecological worldview formation of engineering students. The authors make an attempt to model the educational process on the basis of interactive pedagogical technologies, the use of which allows students of non-linguistic areas to solve communicative problems on the basis of environmental topics. The totality of data obtained as a result of the experimental work carried out by the authors confirms the effectiveness of students' ecological worldview formation through the inclusion of environmental-oriented content in the system of language training at the university.**

Keywords - ecological worldview, engineering students, foreign language training, pedagogical technologies.

I. INTRODUCTION

Within the framework of the new paradigm of education for sustainable development, which is a new type of education that permeates all subject areas of natural, technical and humanitarian sciences, the content of university education is changing significantly. Environmental education, being a part of the content of higher education, is designed to solve the problems of the formation of an ecological information society and to reveal the main aspects of the interaction of people, society and nature. The main goal of environmental education of students is to form an environmental-oriented personality with developed ecological worldview. The issue of the formation of the ecological worldview of future specialists in the educational environment of a technical university is one of the urgent tasks of the higher education system in various aspects and in the training of all specialists. It acquires special significance in relation to the students of technical areas of training who, by their professional activities, exert the greatest anthropogenic load on the environment. In this regard, engineering students must receive a deep ecological background for successful professional activity [1], [2].

Obviously, the effectiveness of environmental education increases significantly with the integration of environmental knowledge into all possible disciplines, but a leading role in this process is played by the disciplines of the natural science cycle. Also, a special contribution to the formation of an ecological worldview and consciousness is made by subjects of the humanitarian cycle, including a foreign language.

However, when analyzing scientific and pedagogical literature, we came to the conclusion that there is an insufficient number of studies devoted to identifying the potential of the discipline "Foreign languages" for the ecological and professional development of engineering students and the development of methodological support for this process. In our opinion, a thorough study of this problem is very important and urgent.

Thus, the purpose of our research is to identify the features and content of the structural components of the ecological worldview and to describe the technology of working with engineering students in teaching English, aimed at developing an ecological worldview.

As theoretical research methods, we used the analysis of scientific and pedagogical literature on the problem and modeling the educational process for the development of an ecological worldview among engineering students within the discipline "Foreign languages". The empirical part of the study consists in generalizing the experience of applying interactive pedagogical technologies for teaching a foreign language, aimed at students' awareness of environmental problems, as well as in organizing, conducting, processing and interpreting the results of experimental teaching using methods of observation, interview, testing, questioning and analysis of students' products of speech activities.

II. MATERIALS AND METHODS

As mentioned above, environmental education, due to its relevance, is the subject of close study of specialists in various fields. Scientists agree that the main goal of environmental education is the formation of an ecological worldview among students and society as a whole, based on the unity of scientific and practical knowledge, a responsible and positive emotional-value attitude towards their health, the environment, improving the quality of life, and meeting human needs [3], [4], [5], [6]. Thus, an environmental worldview is becoming more and more in demand in society.

We understand by the ecological worldview of a future specialist, a graduate of a non-linguistic university, the integral part of his personality, based on ecological consciousness, ecological style of thinking and activities, which are projected onto his professional activity. Since the ecological worldview is part of the scientific worldview, it has the same aspects and components as the scientific worldview, but they are specific. The

components of the ecological worldview include: 1) the system of socio-natural knowledge, 2) ecologocentric views and beliefs and their corresponding values and ideals, 3) skills and abilities of environmental protection, manifested in ecologically sound behavior, which is characterized by the transition of ecological knowledge, ecological thinking into everyday behavior.

Based on the above, we distinguish three main components of the ecological worldview: 1) *cognitive,* 2) *axiological*, and 3) *activity. The cognitive component* performs an explanatory and informational function of forming a worldview that corresponds to the modern level of science, historical practice and the intellectual requirements of students. The functions of *the axiological component* are to develop ideas about universal human and environmental values; development of the qualities of a cultural personality in young people in the field of relationships with nature. The functions of *the activity component* consist in the integration of the worldview and consciousness in practice, that is, in the process of interaction with nature; the formation of an active nature conservation and nature-creating position in the individual; practical environmental activities of future specialists.

As experts note, purposeful pedagogical activity on the formation of an ecological worldview and culture among future specialists during the period of study at a higher professional school can be considered as one of the best periods for such activities, since student age is considered the most sensitive for the development of reflexive abilities, understanding the world around students and their own place in it. In addition, the educational environment of the university is capable of providing a moral and developing atmosphere for the organic combination of professional and environmental consciousness, the assignment of the values of environmental culture and their translation into personal values and life guidelines [7], [8], [9].

It is obvious that the effectiveness of the ecological worldview formation increases significantly with the integration of environmental knowledge into all possible disciplines, mainly, in mastering the disciplines of the natural-scientific cycle.

It should be mentioned that environmental education is also reflected in the content of teaching a foreign language at a university and is expressed in an environmentally oriented training topics of a problematic nature. Taking into account the obligatory implementation of fragments of environmental education in a compulsory program, we can expect from students that they know the general terminology on the topic "environmental education" and possess the conceptual and categorical apparatus in this area.

In our opinion, in the context of the strategic goal of forming the ecological worldview of students, the main tasks of a foreign language teacher are: 1) the formation of

sustainable motivation of students to environmental topics; 2) increasing the ecological and cultural level of students, 3) the formation of a student as an ecologically convinced personality in the human and professional sense; 4) optimal use of the content and educational potential of the discipline "Foreign languages" for the development of students' ecological lifestyle.

It should be emphasized that an effective means of implementing environmental education in foreign language training is the use of modern pedagogical technologies, such as game modeling, case studies, brainstorming, discussions, debates, project activities, etc. The use of modern educational technologies in the educational process develops the students' skills and abilities of systemic thinking, awakens in students the desire to search for new ideas, encourages creativity and collective interaction, contributes to the formation of readiness for their own optimal interaction with nature [10].

Within the framework of this research the English language teachers of the Department of Foreign Languages for Non-linguistic Areas of Pskov State University summarized the experience of using interactive technologies aimed at integrating environmental content into the language training of future engineers. In our activities with students of engineering educational programs we try not only to state the ecological problems that exist in their professional field but also make them contemplate over the actions they can do to escape or minimize them. Students' emotionally-colored reaction to the topics they argue about is success on the way to being ecologically aware.

Experimental training, carried out by the foreign language teachers, aimed at the formation of the ecological worldview of engineering students. The experiment involved 100 students of the Institute of Engineering Sciences of Pskov State University, enrolled in the following undergraduate programs: Construction, Informatics and Computer Engineering, Information Technology, Automobiles and Automotive Industry, Technosphere Safety, Electrical Engineering and Power Engineering, Mechanical Engineering.

The most relevant topics of environmental education were identified, based on brainstorming with students. These are some examples: "Can nature revenge people because of waste?", "What can we do to save the planet?", "Limited resources and unlimited wishes", "Promotion of renewable energies", "Employment sector of clean energies", "How much do we consume?", "Pollution or economic stability", "Ecotourism", "Free-market environmentalism", "Vehicle fuel economy standards".

In accordance with versatile environmental topics, preliminary work was carried out to master lexical units through didactic games (*Domino "Matching ecological definitions"*, description of terms in pairs / groups, *"Guess what I mean"*, compilation of mind maps, *Word Bingo, Charades, Word Jeopardy*, games to develop attention, memory and responsiveness - *Pelmanism and Snap*). In addition, Quizlet, Anki and Worditout applications were actively used.

A prerequisite was the use of speech and creative exercises in the process of studying environmental topics. Let us consider some examples of tasks and forms of work with environmentally friendly content: 1) *Working with a glossary "ecological problems"*, which lays the foundation for the further construction of speech exercises. 2) *Making a weather map*. Students are invited to analyze climate change in a certain territory of Russia over the past 5 years, and then, taking into account individual data, draw up a climatic map of the country. 3) *"Eco-projects fair"*. - fulfillment of an individual project assignment on the history of charitable organizations for environmental protection. 4) *Multimedia quiz "Are you ecological enough?"* in which students test their knowledge on this topic and discuss ways to deal with the environment in a sustainable manner. 5) *Presentation* of modern energy saving technologies and renewable energy sources. 6) *Environmental video journey "How climate affects architecture"* introduces students to different types of architecture and the impact of climate on them. 7) Students' work on individual projects for the preparation of *the Eco-house exhibition.* Students can describe existing green home options or suggest ideas of their own. 8) *Debates "Do you agree with Greta Thunberg?"*- the teams present their positions on climate change, political reshuffle and youth engagement in this context. 9) *Ecological dilemmas (conversation cards)* - students are invited to solve problems on an environmental theme with the choice of one of the options. 10) *The game "Take a position" – "Let's all go green", "Say no to plastic"* - students need to determine their position and take an appropriate place in the discussion. 11) *Discussions "Eco-cities should be built"* and *"How do you treat the Earth?"* 12) *Sociological survey "How green are you?"* 13) *Brainstorming "How ecology affects you?"* 14) *Role play "Why throw away? Why not recycle?"* 15) *Discussion game "Sustainable / Unsustainable"* during which students discuss a number of important topics for society (for example, vaccination, vegetarianism, etc.) from the point of view of a binary approach. This format contributes to the development of critical thinking skills and setting the vector for preparing for a debate. 16) *Presentation "Climate behind headlines"*- a selection of English-language articles on the topic of climate change, the discussion of the role of headlines and the effectiveness of eco-language in modern media.

Let us offer two fragments of lessons which aroused keen interest among students. Tables 1 and 2 illustrate the training organization algorithm in more detail.

Table 1. Activity Algorithm of Project Work

Project work
Students' electronic waste recycling options

1. Warming up: the mind map "Ecological problems in the sphere of IT Engineering".
2. Group discussion (part 1): "What is E-waste?" Compare your definitions with those given in Britannica [https://www.britannica.com/technology/electronic-waste]. Are they different?
3. Group discussion (part 2): Why is it important to recycle E-waste? Is it illegal to throw away electronics? How should we recycle electronics? What are the disposal methods?
4. Read the article "E-waste disposal methods and how to do it?" [https://www.sellyt.com/blogs/e-waste-disposal/] and list the approaches towards eliminating electronic waste.
5. Watch TedTalk video "Recovering value: how I became an electronics recycler" [https://www.youtube.com/watch?v=sg18KmcTYXA] and answer the question "How did the speaker start her e-waste recycling company?"
6. Find the information about electronic waste recycling options at the university. Share the information with your project group.
7. Project work: develop electronic waste recycling options for students of your university and make multimedia presentation.

The second fragment of the environmental lesson was aimed at students of engineering educational programs with a language level of B2 (upper-intermediate). The lesson introduced learners to some of the main issues related to extended producer responsibility (EPR). The Extended Producer Responsibility (EPR) policy was first introduced by Thomas Lindhqvist in a report to the Swedish Ministry of Environment in 1990 [11]. A careful assessment of benefits of EPR is considered to be an important issue.

Table 2. Activity Algorithm of Project Work

Students' project work on
Extended Producer Responsibility Policy (EPR)

1. Pair work: discussing the information about the companies known for their ecological responsibility; making a list of their activities and drawing a mind-map; brainstorming newly-acquired vocabulary.
2. Reading the article on EPR policy and making a list of conventional waste management techniques.
3. Group discussion "How do producers affect consumers? What are the rights and responsibilities of producers?" Sharing the information with other project groups.
4. Group work: brainstorming on how to design improvements of products and their systems, reuse or recycle them in an environmentally friendly and socially desirable manner.

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5. Presentations of the best tips on the topic followed by general discussion.
6. Home assignment: project implementation on the topic "Policies used by the companies for promoting cleaner production" followed by a multimedia presentation.

By the end of the lesson students were able to 1) understand important causes of producer's responsibility and some solutions; 2) extend their understanding of lexis connected to environmental issues; 3) learn a number of simple collocations for talking about environmental issues as well as the use of speech patterns for giving advice and recommendations, use environment-related phrases, idioms and expressions of certainty when discussing events likely to happen.

Students focused on revising, learning and using vocabulary related to the environmental issues through a variety of engaging activities which helped them to improve speaking and listening skills. Activities also focused on reading and writing. The main emphasis was placed on the development of speaking skills. It should be noted that speaking activities are essential for English language classes, as students develop their communicative competence, become more versatile, fluent and adaptable. Being confident communicators in English is one of the most important skills, as these objectives for the students are written in each curriculum of university education.

III. RESULTS AND DISCUSSION

Let us consider the process of experimental teaching and analyze its main results. Experimental training included two stages. At the first stage, a survey of students called "Ecological awareness" was conducted. As it has been stated before, the formation of an ecological worldview is represented in three components: cognitive, axiological and activity level. In order to understand the level of ecological awareness and worldview of engineering students we have developed a questionnaire oriented on these components.

There were several criteria which affected the basis of the questionnaire: 1) for the cognitive component: understanding of the importance of ecological issues, the ability to highlight crucial problems in students' places of living; 2) for the axiological component: evaluation of self-readiness to improve ecological situation, estimation of social efforts in this field; 3) for the activity level: ability to perform ecologically oriented actions, take part in citizenship activities raising awareness of ecological problems. The questions were organized it three groups – by the number of components under consideration: cognitive (1, 2, 3), axiological (5, 6, 9) and activity level (4, 7, 8).

The questionnaire included the following questions: 1) How do you assess the environmental situation in your place of residence? 2) How do you assess the

environmental situation in the world as a whole? 3) Do you consider yourself an environmentally responsible person? 4) Are you ready to show your civic position on environmental crimes, for example, when someone poisons the water or burns garbage in your neighborhood? 5) Do you think climate change affects people's health? 6) Can you name more than two ecological organizations that are familiar to you? 7) What activities can improve the environmental situation in your place of residence? Options for answers were: individual responsibility, civic participation in environmental issues, increasing the punishment for environmental crimes, involving managers of industrial enterprises in solving environmental problems. 8) How often do you sort rubbish in your household? 9) Do you consider your level of environmental awareness sufficient?

While conduction a survey we used the Survey Monkey platform: students received a link to the survey and passed it either in class or remotely. This approach is eco-friendly itself – you do not need to make a large number of printouts. The service we selected allowed us to analyze the answers of 100 respondents. We did not set the task of checking the level of knowledge regarding facts, figures and concepts in the environmental sphere, since, firstly, this material is in any case presented in the course of practical lessons in a foreign language, and secondly, it was the personal attitude to environmental issues that allowed for us to form a methodological component of classes with the implementation of environmental topics more specifically.

During the second stage, based on the results of the survey, an algorithm was developed for working with students using interactive forms and methodological techniques for the formation and development of students' awareness of environmental problems. In the course of the second stage, a list of some topics of current relevance was identified. Then, during one semester, students were taught using interactive technologies, some examples of which we presented above.

The training was intensive in nature and focused on the formation of environmental awareness, consciousness, culture and, as a result, was supposed to contribute to the development of the ecological worldview of students. At the end of the experimental training, we conducted a second survey of students based on the questionnaire that we used at the initial stage. Then we carried out a comparative and statistical analysis of the survey data at the initial and final levels. Our goal was to see the difference in numbers, and, therefore – in students' attitude towards ecological topics.

Let us present a general analysis of the questionnaire results. When assessing the ecological state of their region, the number of students who defined it as rather satisfactory increased by 20 % at the end of the experiment. This increase indicates a deeper and more

correct evaluation of the region's environmental problems by the students at the final stage of the experimental teaching.

In the process of discussing environmental issues, students became more critical of the overall assessment of the environmental situation around the world. Therefore, the number of respondents assessing the environmental situation in the world as generally unsatisfactory increased by 18% at the final stage. The increase in positive answers to the question "Do you consider yourself an environmentally responsible person?" was also significant. 21 % more students responded that they consider themselves environmentally conscious and responsible and can personally affect the environment. Answering the question "Are you ready to show your civic position on environmental crimes?" 23% of students changed their initial opinion about the correctness of non-interference at the sight of committing environmental violations and recognized the need for an active prevention of environmental crimes. As a result of project work during the experimental training the majority of students enlarged their knowledge of ecological organizations and recognized the need for sorting rubbish in the household (the increase is 15% and 17% respectively). The students positively assessed all the options that can improve the environmental situation in their place of residence. But it should be noted that the number of students who considered individual responsibility to be the most important has increased by 11%. A 13% increase in the number of respondents who prioritized civic participation in environmental issues was also defined.

The answers to the question "Do you consider your level of environmental awareness sufficient?" showed the following results: at the beginning of the experiment: 25% of respondents answered "Definitely, yes", "Rather, yes" - 34%; "Rather, no" - 20%; "Definitely, no" - 21%. At the final stage: 52% of respondents answered "Definitely, yes", "Rather, yes" - 34%; "Rather, no" - 14%; "Definitely, no" - 0%. These significant changes in the assessment of the formation of environmental awareness, made by the students themselves as a result of environmentally oriented teaching, testify to the effectiveness of the selected environmental content and teaching technologies aimed at environmental education of students.

The answers in questionnaire were stated in comparison with the ecological worldview component levels: "Definitely, yes" – highly developed components, "Rather, yes" – medium developed components, "Ratner, no" – low level. "Definitely, no" – pretty low level.

The results of the statistical analysis of the initial and final data based on the survey results are presented in Fig. 1 and 2. We can state a significant increase in indicators corresponding to the levels "highly developed" and

"medium", as well as a decrease or disappearance of responses indicating a low and pretty low level. The most pronounced are positive changes at the cognitive and axiological levels, which indicate deep positive transformations in the minds of students that have occurred at the level of understanding and assessing the importance of environmental issues for ensuring sustainable development of society. Thus, the style of professional environmentally sound activity is manifested in a future engineer in a stable set of environmentally sound professional views, moral principles established by a specialist in the course of his work.
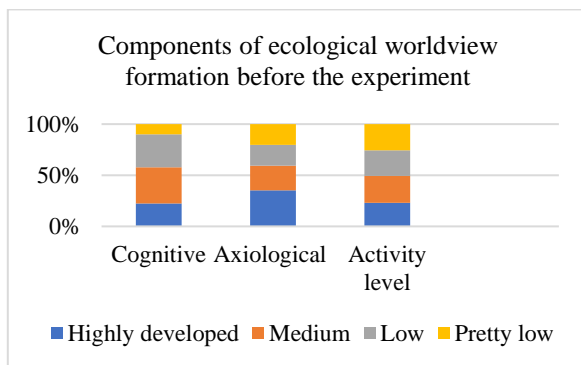
Fig. 1. The results of evaluating the level of ecological worldview development at the initial stage.
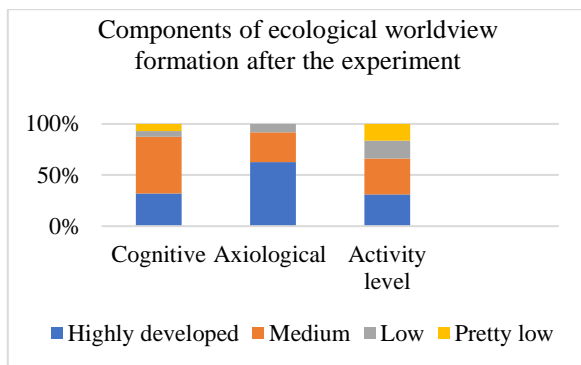
Fig. 2. The results of evaluating the level of ecological worldview development at the final stage.

In the course of a reflexive analysis of the results of experimental teaching, students identified the main characteristics inherent in a person with an ecological worldview, namely:

− conscientious observance of eco-oriented moral and ethical principles, attitudes, rules and skills of natural behavior;
− possession of environmental awareness, which involves the acquisition of environmental values that become life guidelines;
− a creative approach to organizing one's life with the maximum realization of one's natural abilities and

inclinations, the choice of an eco-friendly life strategy.

Taking into account the results obtained, it can be concluded that the issues of environmental safety can and should be successfully integrated into the subject content of the language training of engineering students. At the same time, a foreign language teacher implements, in addition to an educational function, an upbringing function, and creates conditions for further study of environmental aspects in the professional activities of students.

IV. CONCLUSIONS

Summing up, it should be noted that environmental education is designed to form a socio-ecological worldview of undergraduate students. The fact that a future engineer has an ecological worldview means that in his professional activities he will use resource-saving technologies, will strive to harmonize his relations with the environment, make professional decisions that would cause minimal harm to the environment. Thus, the ecological worldview is harmoniously embedded in the professional culture of the future specialist, complements and enriches it.

A foreign language can serve as a tool for educating an environmentally oriented engineering student who is aware of the interdependence of the world and the need for international cooperation in solving global problems of mankind. Accordingly, in the subject content of a foreign language at the university, more and more attention is paid to the problems of forming the ecological thinking of students, they are offered various tasks related to both the problems of environmental protection of nature and the ecology of relationships between people.

Experimental learning based on eco-oriented content using effective interactive pedagogical technologies, carried out by the authors of this study, showed obvious positive dynamics in the development of the ecological worldview of engineering students.

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Formation of Competencies of Specialists in the Field of Welding Through the Possibilities of Distance Online Training

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Abstract - **Today the new challenges in the world assign a key role to the distance online education in the formation of knowledge and competencies. The development of Internet technologies provides opportunities for much better distance online education. The use of various digital platforms increases the efficiency and improves the way of delivering information to the students. Different types of multimedia applications improve the perception of the learning material. The subject of this report is the development of a methodology for distance online training of welding specialists at the Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Centre "Acad. A. Balevski" at BAS.**

Keywords - ***welding, distance online training, internet, remote learning, online learning, e-learning, modern education.***

I. INTRODUCTION

The need for coordinated and generally recognized training of welding specialists was realized in 1991 when the European Harmonized System (EHS) for training of welding personnel was launched. Its basic principles are realized through a system of general, mandatory, operational procedures and curricula. The streamlined organization for application of EHS proved so fruitful that it was adopted by the International Institute of Welding (IIW) [1].

Welding in the sense of BSS EN ISO 3834: 2006 is a "special technological process". Ensuring reliable, quality and cost-effective production requires well-trained staff. The training in the field of welding is based on the synchronization with the European requirements and traditions imposed by the application of EHS, which is an initiative of the European Welding Federation (EWF). Currently, Bulgaria is a full member of the two main international institutions in the field of welding, IIW and EWF [1].

Distance learning methods were first applied in teaching at the University of South Africa in 1946. Later, in 1969 the British Open University defined a model for integrating pedagogical methods and multimedia technologies into distance learning. Historically, the forerunner of distance learning realized through some kind of technology was the correspondence learning, which started in Europe and the USA in the mid-19th century. It is designed as training for persons who do not attend classrooms and use mail as a means of delivering education materials. In general, distance learning can be described as learning in which learners and teacher are in different places and communicate with each other through computers or other means of communication. Here is an example definition of this way of learning: "We have distance learning when the teacher and the learners are physically separated and when technology (sound, picture, print, etc.), often in combination with direct communication, is used to make a connection between the two parties." [2-11]

Today, the development of computers allows knowledge to be presented electronically and multiplies the speed of working with information. The information technologies allow this information to be stored, transmitted and disseminated over long distances at any time. These technologies provide new alternative means for

learning that were unthinkable a few decades ago. Particularly, the achievements of online technologies allow to develop new teaching methods and means of communication that can provide knowledge without the limitations of the traditional on-site training. These new technologies contribute a lot to the development of distance online learning. Currently, due to the existing global pandemic, many educational organizations face various problems related to the onsite learning. Some of these problems can be solved through distance online training.

The Center of Welding at IMSETCH-BAS provides training for welding practitioners, specialists and inspectors.

II. METHODOLOGY OF THE COURSE FOR DISTANCE ONLINE TRAINING OF WELDING SPECIALISTS

The concept of "methodology of the course" is related to the process of planning all components of training (curriculum, learning activities, resources, teaching aids, assessment) in their sequence, internal interconnectedness and dynamics, aimed at achieving educational goals. The methodology is realized at two levels: macro- and micro level [12].

At macro level, the planning of the course as a whole is realized: objectives, content, expected results, assessment both of the trainees' achievements and the quality of the course, time schedule (calendar time), instructional time, etc.

At micro level the instructor plans each activity individually (organization, structure and content) and the links between the individual activities so that their sequence leads to the realization of the objectives of the course.

When transforming a course from on-site into online one, we have to consider the characteristic features of distance online learning, which can generally be divided into six steps [12-16]:

- I step, "Diagnosis of the entry level of trainees": involves analysis of the profile of the trainees, the access to technologies, the expected number of trainees.
- II step, "Formulation of training objectives": related to the formation of competencies and skills in a virtual environment.
- III step, "Selection and structuring of educational content": solving issues related to the technologies for presentation of educational content - visualization, dynamization, interactivity, multimedia; how certain learning content can be mastered online; with what technologies to implement the learning activities.
- IV step, "Design of learning activities": designing and describing in detail all the tasks

and activities in accordance with the capabilities of the online learning environment.
- V step, "Design of the information-resource provision of the course": the teacher specifies the quality, quantity and depth of the selected information necessary for the formation of competencies by the trainees.
- VI step, "Assessment of trainees' achievements": solving issues such as methodologies for online assessment, assessment software [12-16].

III. DEVELOPMENT OF DISTANCE ONLINE COURSE FOR TRAINING OF WELDING SPECIALISTS.

The main objective of the course is to prepare qualified welding specialists for the industry. The training is up-to-date and corresponds to the International Harmonized System for training of welding specialists. The accession of Bulgaria to the European Union and the introduction of pan-European requirements for quality assurance of welded joints (regulated in a series of standards) set serious tasks of legal, legal-standardization, structural-organizational and technical nature, which require synchronizing the training of welding personnel with the European requirements and traditions.

The welding specialists acquire:

- Specialized knowledge in the field of welding;
- Knowledge of the capabilities of modern methods and technologies for welding and their application in modern industrial production;
- Knowledge of control and testing of welded structures;
- Knowledge for independent solution of constructive and technological issues related to the production of welded structures and products;
- Knowledge for the responsibility in manufacture of welded structures and products.

The course was designed at macro level in the following sequence:

- Planning the course structure;
- Defining the learning objectives of the course;
- Defining the expected learning outcomes;
- Main topics of the curriculum;
- Time schedule (calendar time) - start and end of the course;

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- Instructional time for teaching and learning activities;

- Number of trainees;

- Prerequisites for enrollment in the course;

- Assessment: types of assessment methods; the way of forming the final grade of the course; identification of plagiarism.

For the purpose of distance online training course for welding specialists, the Microsoft Teams platform was selected and purchased as part of Microsoft 365 products (Fig. 1).
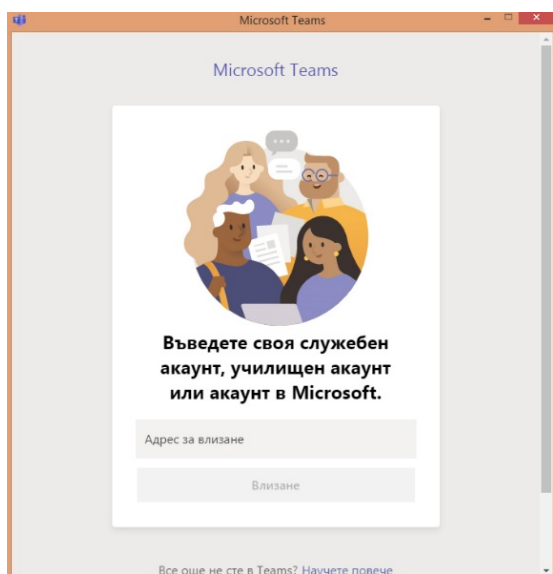

Fig. 1. Microsoft Teams platform for distance online learning.

All teachers and trainees were provided with users' accounts and access to Microsoft Teams. A team of teachers was organized to conduct the course (Fig. 2).
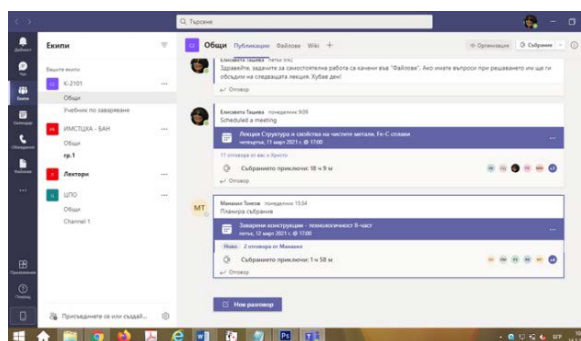
Fig. 2. Team K-2101 to conduct the online training course of welding specialists.

The structure and topics for conducting the course were developed in accordance with the objectives of the training (Fig. 3).
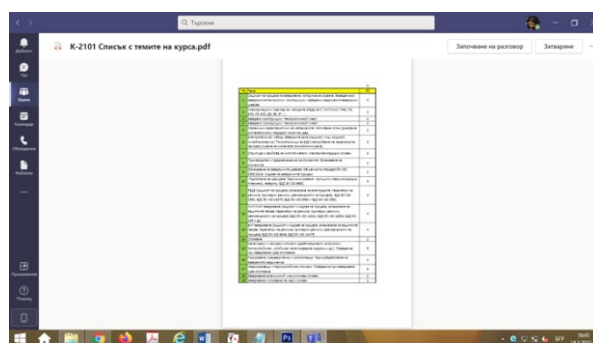
Fig. 3. Structure and topics for conducting the online training course for welding specialists.

The time schedule was developed and uploaded in the calendar of the platform (Fig. 4).
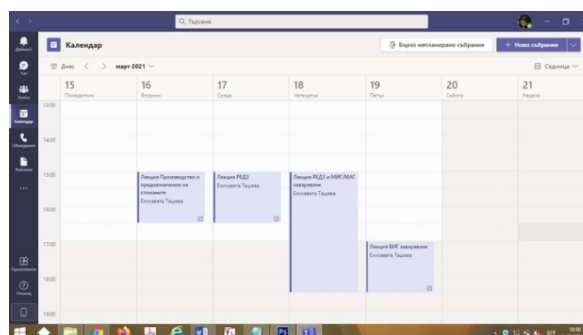
Fig. 4. Time schedule for conducting the course.

All delivered lectures are recorded and uploaded on the platform to facilitate the trainees in their individual preparation (Fig. 5).
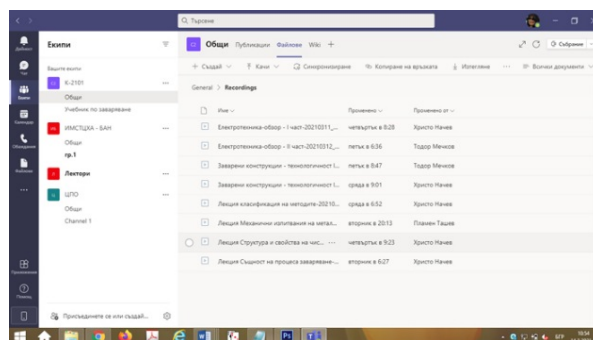
Fig. 5. Video lectures recorded and uploaded on the platform.

Videos illustrating the lecture material are also uploaded on the platform Microsoft Teams (Fig. 6).
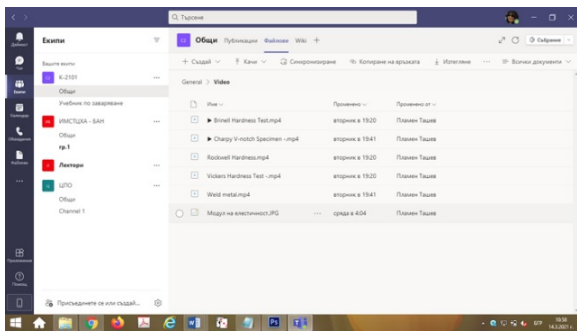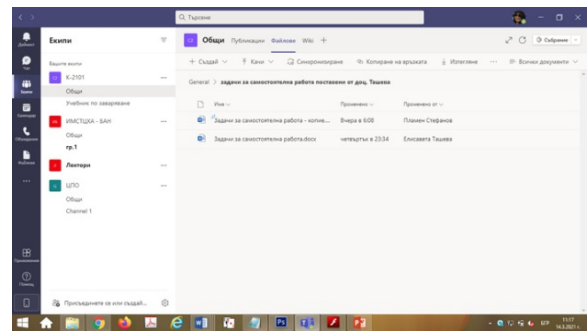
Fig. 6.   Illustrating video materials.

The electronic textbook "Welding", which is written mainly by teachers leading the course is also uploaded on the Microsoft Teams platform (Fig. 7).
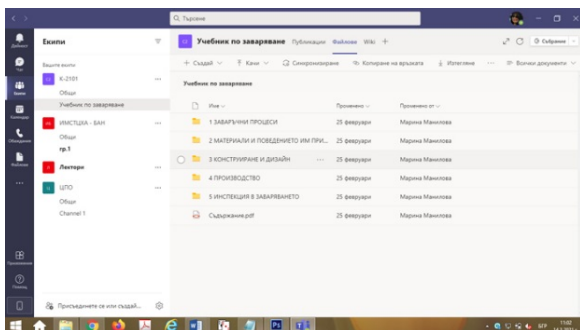

Fig. 7.   The electronic textbook "Welding".

At the micro level, each teacher has developed lectures considered with the topics of the course, which in addition to theoretical material contain many examples (pictures and videos) illustrating the material taught. (Fig. 7).
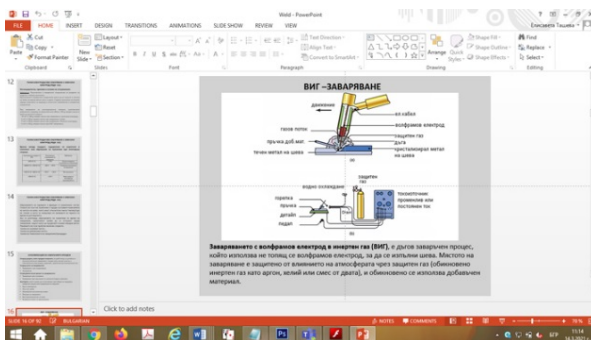

Fig. 8.   Lecture material.

Tasks for independent work and preparation of the trainees are also developed (Fig. 9).

Fig. 9.   Tasks for independent work and preparation

IV.   CONCLUSION

The distance online learning offers some very good opportunities for the learners to acquire knowledge at their own pace while providing them with a direct connection with the teacher without time and place restrictions. It reduces the costs required for transport, accommodation and maintenance in another locality. It is especially suitable for the training of active people directly involved in industry. With regard to the teachers, the main advantage is the possibility to update the teaching material, the use of multimedia tools for interactive teaching.

Of course, the distance online learning has its drawbacks, such as the need for additional training to work with the Microsoft Teams platform, and it cannot completely replace the practical training of welding specialists.

For successful formation of competencies of specialists in the field of welding it is recommended to combine both forms, distance online and on-site training.

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