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Dynamic Simulation Model for Sustainable Municipality Development in Vidzeme Region, Latvia

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Abstract. Authors in this research paper publish the results of system dynamic simulation modelling in the field of sustainable development planning, monitoring and evaluation for all 26 Latvia Vidzeme region municipalities. As the most notable research outcome, authors created original socio-technical system dynamic simulation model in STELLA modelling environment valid for sustainable development evaluation purposes.

After successful verification and validation process of this model authors reached the significant results for improved methodology of dynamic systems evaluation process reliability of sustainable development in Vidzeme region municipalities. Methodology, proposed by authors roots into the quantitative statistical data analysis and system dynamic process simulation modelling.

Keywords: sustainable development, modelling, system dynamics, municipality.

I. INTRODUCTION

Vidzeme region municipalities in Latvia still use very limited arsenal of scientifically based and reliable scientific methods and tools for planning and evaluation of sustainable development process within their administrative territories. It creates a situation when formally achieved results of municipalities long-term sustainable development planning and evaluation are not fully reliable because all analytic outcomes and results are created mostly by use of simplified pre-designed templates and political decisions. In many cases, there are used simplified qualitative research methodologies in the form of general questionnaires and non-structured interviews, but very limited are applications of quantitative statistical data analysis or algorithmic socio-technical systems dynamic process simulation modelling.

Sustainable regional development has been defined by researchers in various ways but the core components in the most of definitions are almost the same: sustainable economy, sustainable society and sustainable environment [1, 2, 3, 4, 5].

From Year 2009 In Latvia came into the legal force new administrative territorial division of municipalities. Therefore, Vidzeme region is now divided into 26 municipalities: 25 rural districts and 1 city municipality (Fig. 1).

As stated in Latvian legislation all municipalities are obliged to develop determined set of sustainable development strategic planning documents. The highest priority document is "Sustainable development strategy for X municipality". These strategies had been developed by all municipalities in Vidzeme region for period of 20-25 forthcoming years. The operative level sustainable development planning documents are "Development program for X municipality". These programs had been developed for all municipalities in Vidzeme region for 5-7 forthcoming years [6]. Accordingly, authors stated the main aim of research as follows: to create socio-technical dynamic simulation model for sustainable development evaluation process in Vidzeme region municipalities.

Fig. 1. Map of Vidzeme region municipalities [6]

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Detailed studies of sustainable development strategies and planning documents in all 26 municipalities provided the basic framework and an input data set for further analysis and with purpose to create socio-technical dynamic simulation model for sustainability evaluations.

II. METHODOLOGY

To be sure that the development process of municipality proceeds in a sustainable way, it is necessary to keep steady balance among various economic, social and environmental factors. One of the leading sustainable development determination and evaluation methodology in the world nowadays is "Triple Bottom Line" (TBL) framework methodology analyzed by many researchers all over the world [7, 8, 9, 10, 11].

At the first stage of this research TBL method was applied an adapted to serve specific objectives of research (Fig. 2).

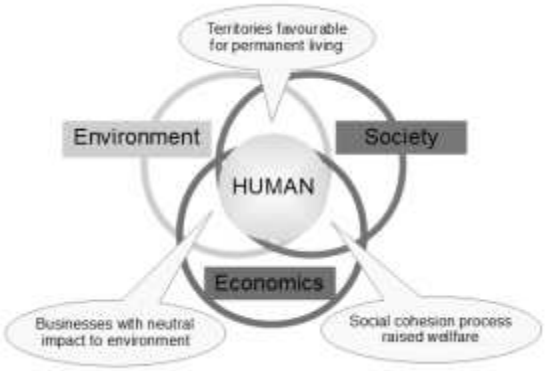

Fig. 2. Theoretical framework of applied "Triple Bottom Line" methodology

At the second research stage all existing sustainable development systems for 26 municipalities in Vidzeme region had been matched on their compliance with "Triple Bottom Line" methodology theoretical framework (Table I).

Table I
Compatibility of municipality sustainable development systems with TBL methodology framework

Municipality	**Fully TBL**	**Partially TBL**	**Undefined TBL**
Aluksne			undefined
Amata		partially	
Ape	fully		
Beverina	fully		
Burtnieki		partially	
Cesvaine		partially	
Cēsis	fully		
Ergli		partially	
Gulbene	fully		
Jaunpiebalga		partially	
Koceni		partially	
Ligatne	fully		
Lubana	fully		
Madona	fully		
Mazsalaca		partially	
Naukseni	fully		
Pargauja	fully		
Priekuli		partially	
Rauna	fully		
Rujiena		partially	
Smiltene	fully		
Strenci		partially	
Valka		partially	
Varaklani		partially	
Vecpiebalga	fully		
Valmiera		partially	

As drawn from analysis above in 25 from 26 municipalities their already published sustainable development strategies indicates systemic frameworks fully or partially compatible with "Triple Bottom Line" methodology theoretical framework. In partially compatible frameworks there are minimum 67% percent compatibility (at least 2 from 3 TBL dimensions are equal) and maximum 75% percent match (3 from total 4 indicated dimensions are equal to TBL). At this stage, had been proved that choice of specific TBL methodology is optimal decision for further statistical data analysis and dynamic simulation modelling.

The third stage of research covered selection of appropriate system dynamics simulation modelling tools. General theories of system dynamics describe that for such complicated and integrated dynamic systems as municipalities, intensive use of socio-technical systems modelling is one of the optimal solutions [12, 13, 14, 15]. In this research, as specific tool for modelling purposes was chosen STELLA (ver. 9.0.3) modelling software.

In the fourth stage of research statistical data retrieval and analysis issues had been systematized. Only data from official databases of Latvian Central Statistical Bureau, Office of Citizenship and Migration Affairs, Ministry of Environmental Protection and Regional Development, State Employment Agency, Treasury Republic of Latvia, Vidzeme Planning Region and respective municipalities were used for data statistical analysis.

Sustainable development evaluation process in municipalities can be characterized as trend analysis thus as the most appropriate statistical analysis method were used "trend" and "forecast" functions from PSPP statistical data analysis tool (Fig. 3).

Period	Number of inhabitants			
1	19358			
2	19121			
3	18806			
4	18501			
5	18020			
10		Equation	Forecast	Trend
11			16124	
12			15795	
13			15465	
20			**13158**	13158

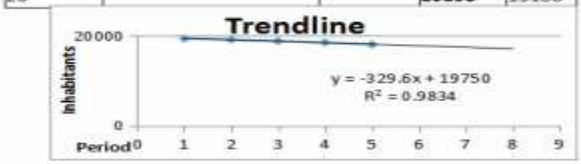

Fig. 3. Number of inhabitants forecast (trend) analysis (Aluksne)

At the final research stage were selected 9 specific factors (3 from economic dimension influence factors, 3 from social dimension influence factors and 3 from environmental dimension influence factors) for socio-technical modelling purposes. Then were created theoretical sustainability evaluation model to be implemented in STELLA modelling software (Fig. 4).

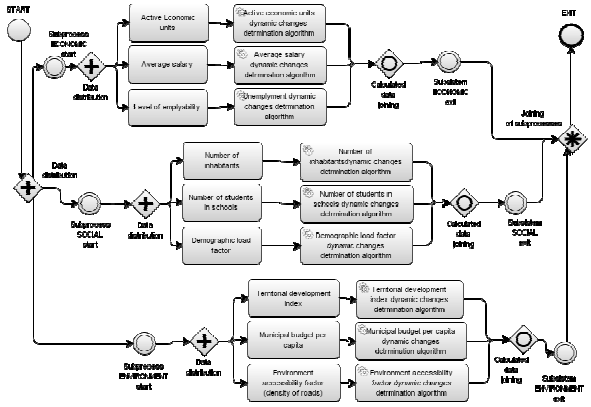

Fig. 4. Theoretical sustainability evaluation model (in BPMN 2.0 notation)

As one of the limitations for this model could be mentioned still insufficient incoming data flow from statistical databases because new administrative structures for Vidzeme region municipalities were created only in Year 2009. That means, that indicators and factors in all three dimensions have maximum 6 years long previous incoming data stream and predicted trends calculated for the next 15 years. Of course, it concerns only data analysis and produced results reliability but nor the model structure or data management options.

III. RESULTS AND DISCUSSION

From all analysed sustainable development strategies, development programs and special territorial planning documents of Vidzeme region municipalities (in total 56 documents) there were retrieved 484 indicators at least once mentioned in these documents with purpose to evaluate sustainability performance. From total number, there were selected 178 unique indicators but only 42 indicators which are measurable within calendar year interval. From them 31 indicators are valid and specific for all 26 local municipalities in Vidzeme region. Finally, there are only 27 indicators, mentioned in strategies and planning documents as minimum 3 times. These 27 indicators were used in this research for test modelling purposes. Most of retrieved quantitative indicators belong to the economic dimension and/or social dimension but just few of them has connection with environmental dimension. Accordingly, there were assigned higher specific weight (0,5 from 1,0 in total) to economic dimension indicators for modelling purposes. Social dimension indicators have medium assigned specific weight (0,3 from 1,0 in total) and environmental dimension indicators have lowest assigned specific weight (0,2 from 1,0 in total).

After multiply test runs with different sets of indicators, authors input into the final socio-technical simulation model version (ver 1.0) the following ones:

[E1] Number of active economic units registered in municipality (dominating economic dimension);
[E2] Average salary of people declared in municipality (dominating economic dimension);
[E3] Unemployment rate of people declared in municipality (dominating economic dimension);
[S1] Number of inhabitants in municipality (dominating social dimension);
[S2] Number of pupils and students in schools located in municipality (dominating social dimension);
[S3] Demographic load factor per municipality (dominating social dimension);
[V1] Territorial development index of municipality (dominating environmental and economic dimensions);
[V2] Municipal budget per capita (dominating environmental, economic and social dimensions);
[V3] Environment accessibility (density of roads) (dominating environmental and social dimension).

All selected indicators are sufficiently backed up with reliable data series from last 4-7 years in official statistical databases. Some other significant indicators for environmental dimension evaluation was impossible to implement into proposed model (like amount EU, state and local budget funds allocated specifically for environmental programs or number of households with direct access to the centralized sewage and waste management systems) due to lack of sufficient data flows for all 26 municipalities of Vidzeme region.

Complete socio-technical system dynamic simulation model in STELLA modelling environment (Fig. 5) consists from 3 main processes and 9 sub processes where total value of sustainability growth trend is calculated as a single trendline.

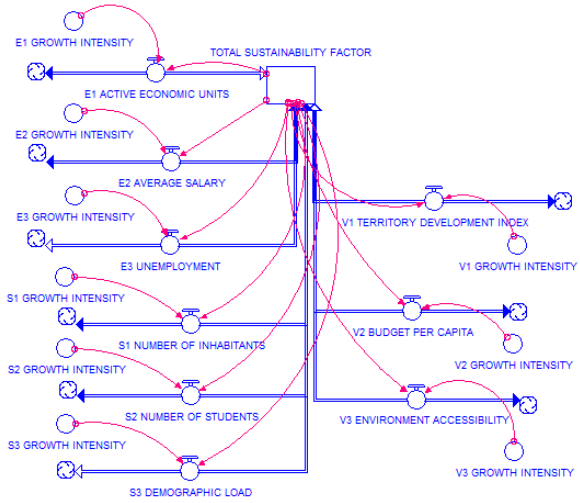

Fig. 5. Sustainability dynamic simulation model (in STELLA modelling environment)

At the next model development stage, all 26 forecasted sustainability growth trends for municipalities of Vidzeme region were calculated by use of differential equitation:

TOTAL_SUSTAINABILITY_FACTOR(t) = TOTAL_SUSTAINABILITY_FACTOR(t - dt) + (E1_ACTIVE_ECONOMIC_UNITS + E2_AVERAGE_SALARY + V1_TERRITORY_DEVELOPMENT_INDEX + V2_BUDGET_PER_CAPITA + V3_ENVIRONMENT_ACCESSIBILITY + S2_NUMBER_OF_STUDENTS + S1_NUMBER_OF_INHABITANTS - E3_UNEMPLOYMENT_RATE - S3_DEMOGRAPHIC_LOAD) * dt
INIT TOTAL_SUSTAINABILITY_FACTOR = 100

With 7 predefined inflows (higher values corresponds to better growth trends):

(1) E1_ACTIVE_ECONOMIC_UNITS = TOTAL_SUSTAINABILITY_FACTOR*E1_GROWTH_INTENSITY*50/3/100
(2) E2_AVERAGE_SALARY = TOTAL_SUSTAINABILITY_FACTOR*E2_GROWTH_INTENSITY*50/3/100
(3) S1_NUMBER_OF_INHABITANTS = TOTAL_SUSTAINABILITY_FACTOR*S1_GROWTH_INTENSITY*30/3/100
(4) S2_NUMBER_OF_STUDENTS = TOTAL_SUSTAINABILITY_FACTOR*S2_GROWTH_INTENSITY*30/3/100
(5) V1_TERRITORY_DEVELOPMENT_INDEX = TOTAL_SUSTAINABILITY_FACTOR*V1_GROWTH_INTENSITY*20/3/100
(6) V2_BUDGET_PER_CAPITA = TOTAL_SUSTAINABILITY_FACTOR*V2_GROWTH_INTENSITY*20/3/100
(7) V3_ENVIRONMENT_ACCESSIBILITY = TOTAL_SUSTAINABILITY_FACTOR*V3_GROWTH_INTENSITY*20/3/100

And with 2 predefined outflows (lower values corresponds to better growth trends):

(1) E3_UNEMPLOYMENT = TOTAL_SUSTAINABILITY_FACTOR*E3_GROWTH_INTENSITY*50/3/100
(2) S3_DEMOGRAPHIC_LOAD = TOTAL_SUSTAINABILITY_FACTOR*S3_GROWTH_INTENSITY*30/3/100

As initial value in the beginning of Year 2016 were given 100 sustainability factor units and simulated further potential positive or negative growth trends and calculated trendline specific sustainability factor values within period from Year 2016 till Year 2030 (15 years, in line with the period designated in sustainable development strategies of municipalities). If final total value of sustainability factor goes below 100 units then this municipality had been regarded as *"unsustainable"* (there were no such cases in Vidzeme region municipalities). If final total value of sustainability factor reached level from 100 till 250 units then this municipality had been evaluated as *"low sustainability prospective"*. If final total value of sustainability factor reached level from 250 till 750 units then this municipality had been evaluated as *"low/medium sustainability prospective"*. If final total value of sustainability factor reached level from 250 till 750 units then this municipality had been evaluated as *"medium sustainability prospective"*. If final value of sustainability factor reached level from 750 till 1250 units then this municipality had been evaluated as *"medium/high sustainability prospective"*. If final total value of sustainability factor reached level above 1250 units then this municipality had been evaluated as *"high sustainability prospective"*.

The weakest sustainability performer in Vidzeme region is Jaunpiebalga municipality as drawn up from simulation modelling results (Fig. 6, 7, 8). This municipality demonstrates total sustainability factor growth score corresponding to "low/medium sustainability prospective" (approx. 500 units).

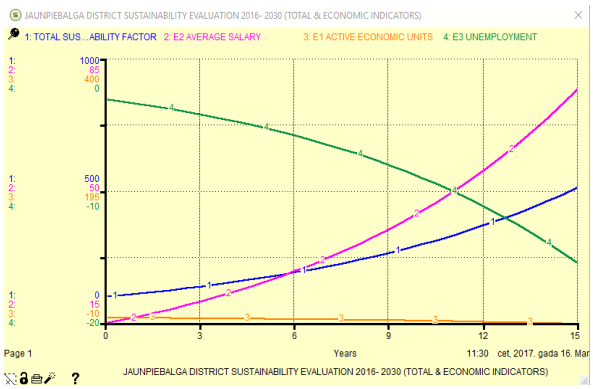

Fig. 6. Jaunpiebalga municipality sustainability evaluation (total & economic dimensions' evaluation)

Jaunpiebalga municipality in economic sustainability dimension indicates positive trends for "unemployment" factor (decrease) and "average salary" factor (increase) but negative trend for "active economic units" factor (decrease).

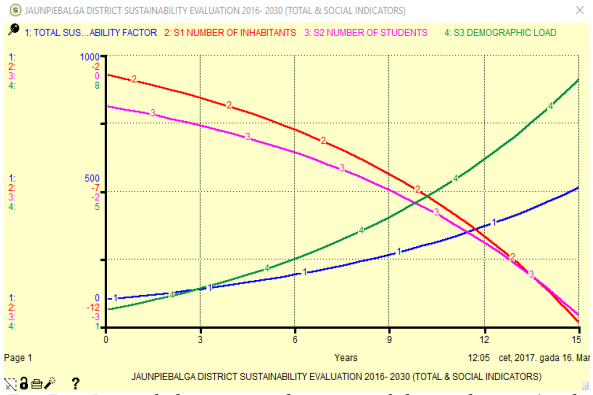

Fig. 7. Jaunpiebalga municipality sustainability evaluation (total & social dimensions' evaluation)

Jaunpiebalga municipality in social sustainability dimension demonstrates only negative trends over time for all factors- "number of inhabitants" factor (decrease), "number of students in schools" factor (decrease) and "demographic load" factor (increase).

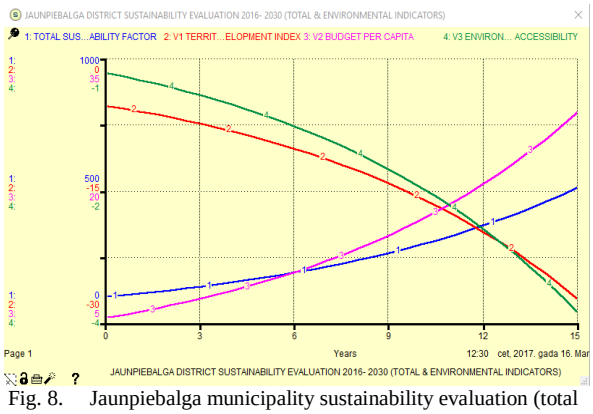

Fig. 8. Jaunpiebalga municipality sustainability evaluation (total & environmental dimensions' evaluation)

Jaunpiebalga municipality in environmental sustainability dimension displays positive trend for "budget per capita" factor (increase) but negative trends for "territory development index" factor (decrease) and "environment accessibility" factor (decrease).

Data analysis discovers the major risk of sustainability for Jaunpiebalga municipality as decreasing sustainability for social dimension. Designed simulation model for all social factors compounded has specific weight of only 30% from total 100% therefore economic and environmental dimensions compensate negative social dimension and total sustainability factor value is still positive and fits into "low/medium sustainability prospective" group.

In comparison, further the same analysis provided for the best performer in Vidzeme region- Valmiera City municipality regarding STELLA dynamic simulation modelling results (Fig. 9, 10, 11). This is only one municipality in Vidzeme region which demonstrates evaluated sustainability growth trend as "high sustainability prospective".

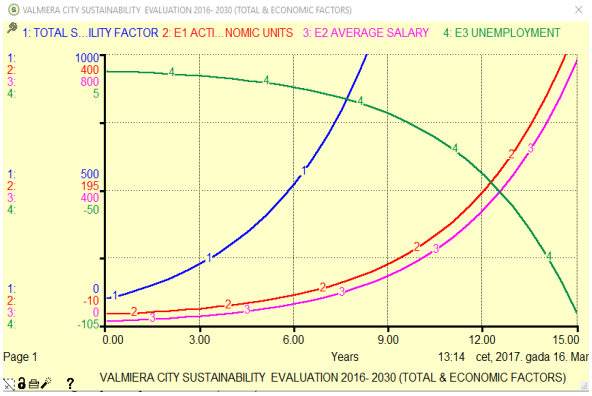

Fig. 9. Valmiera City municipality sustainability evaluation (total & economic dimensions' evaluation)

Valmiera City municipality in economic sustainability dimension indicates extremely positive trends for all three selected factors- "active economic units" factor (increase), "unemployment" factor (decrease) and "average salary" factor (increase).

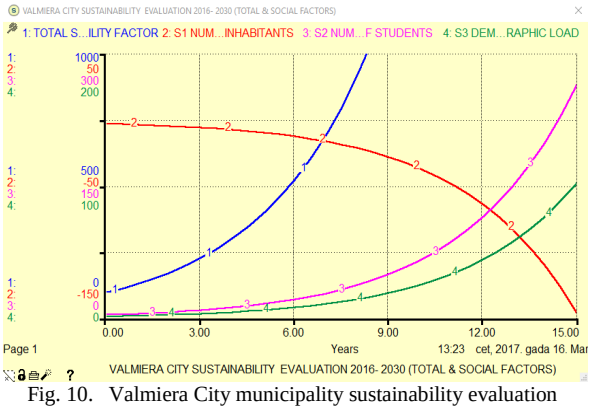

Fig. 10. Valmiera City municipality sustainability evaluation (total & social dimensions' evaluation)

Valmiera City municipality in social sustainability dimension demonstrates negative trends over time for two factors- “number of inhabitants” factor (decrease) and “demographic load” factor (increase) but positive changes for factor “number of students in schools” factor (increase).

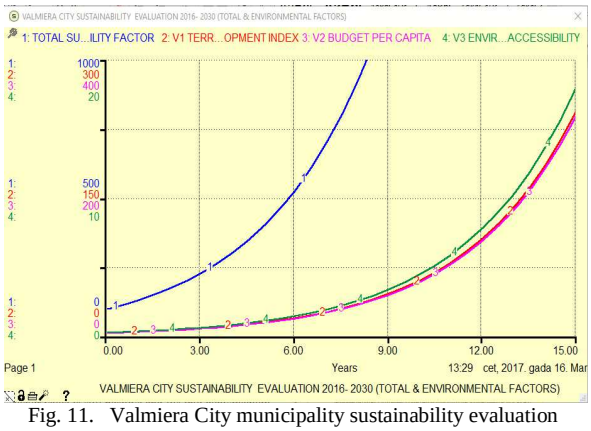

Fig. 11. Valmiera City municipality sustainability evaluation (total & environmental dimensions’ evaluation)

Valmiera City municipality in environmental sustainability dimension demonstrates positive trends for all three factors “territory development index” factor (increase), “budget per capita” factor (increase) and “environment accessibility” factor (increase).

In fact, specific real situation analysis shows that sustainable development situation in Valmiera is even better than it is calculated from official statistics because number of permanent inhabitants in the City is growing, despite official statistics which relies only on data about number of officially declared inhabitants. Incoming flow of young people at the working age also in positive manner influences another still negative factor for Valmiera City municipality, respectively, “demographic load”.

Similar analysis with created STELLA dynamic simulation model was provided for all 26 Vidzeme region municipalities. The overall results of sustainable development trends in Vidzeme are mostly positive (TABLE II). There are no municipalities in the area with “unsustainable” or “low sustainability” prospective. Seven municipalities in Vidzeme region have evaluation “low/medium sustainability prospective”, 14 municipalities have evaluation “medium sustainability prospective”, four municipalities have evaluation “medium/high sustainability prospective” and one- Valmiera City municipality has evaluation “high sustainability prospective”.

Table II
Evaluation results of Vidzeme region municipalities sustainable development prospective

Municipality	Low sustainability prospective	Medium sustainability prospective	High sustainability prospective
Aluksne	NO	**YES**	NO
Amata	NO	**YES**	**YES**
Ape	NO	**YES**	NO
Beverina	NO	**YES**	NO
Burtnieki	NO	**YES**	NO
Cesvaine	NO	**YES**	NO
Cēsis	**YES**	**YES**	NO
Ergli	NO	**YES**	NO
Gulbene	NO	**YES**	NO
Jaunpiebalga	**YES**	**YES**	NO
Koceni	NO	**YES**	**YES**
Ligatne	NO	**YES**	NO
Lubana	**YES**	**YES**	NO
Madona	NO	**YES**	NO
Mazsalaca	**YES**	**YES**	NO
Naukseni	NO	**YES**	NO
Pargauja	NO	**YES**	NO
Priekuli	NO	**YES**	**YES**
Rauna	NO	**YES**	NO
Rujiena	**YES**	**YES**	NO
Smiltene	NO	**YES**	**YES**
Strenci	**YES**	**YES**	NO
Valka	NO	**YES**	NO
Varaklani	**YES**	**YES**	NO
Vecpiebalga	NO	**YES**	NO
Valmiera	NO	NO	**YES**

IV. CONCLUSION

Produced results by new sustainable development evaluation dynamic simulation model for Vidzeme region municipalities are close to results published by other researchers dealing with GDP per capita or GDP per sq. km growth analysis in Latvia [6, 16].

Current Latvia state policy allows full freedom for municipalities in their sustainable development strategic planning, monitoring and evaluation thus now we have 26 completely different strategies in Vidzeme region with incompatible methodologies and indicators. There should be accepted unified sustainable development strategic planning methodology framework at the central government (ministry) level.

Designed dynamic simulation model has very high eventual scalability and elasticity level for further adaptations and improvements, for example, it is easily possible to replace, add or remove sustainability indicators or add scripts for automatic data retrieval from official statistical databases.

V. ACKNOWLEDGMENTS

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Analysis and Selection of Web Service Technologies

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Abstract. The main objective of this article is to provide insights on how applications can interact with each other on the Web using Web services. The article is devoted to Web services and their basics, as well as to technologies such as REST-compliant (RESTful) and arbitrary (XML, SOAP, WSDL, UDDI, XML-RPC) that are used to implement them.

Keywords: SOAP, Web service, REST.

I. INTRODUCTION

The Internet has become a significant factor in business and public life. With the use of Internet technologies many problems can be solved. However, the Internet combines many different platforms and the information is saved in the various data sources. Linking of heterogeneous data communications as well as providing a method which allows obtaining it in a convenient form for further processing is an actual problem. The concept of Web services is designed to solve this problem of heterogeneous systems based on open standards association and integration [1], [2].

Web service is a service that is available on the Internet through a special program. For example, the most common services are search engines, web hosting (services that enables people and organizations to make their websites accessible via
.

II. MAIN IDEA

A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. We can identify two major classes of Web services:

- REST-compliant Web services, in which the primary purpose of the service is to manipulate XML representations of Web resources using a uniform set of "stateless" operations; and
- Arbitrary Web services, in which the service may expose an arbitrary set of operations [3].

the World Wide Web), e-mail, an information storage (files, bookmarks), calendar, etc. An important feature of the Internet service is that the service is not dependent on the Internet service provider, browser or computer – it can work with data anywhere in the world where there is Internet access. Web services are based on open standards and protocols (SOAP, XML-RPC, REST, etc.). Web service is a way of how applications can interact with each other in the Web. Applications can use different platforms and be written in different programming languages. Thanks to the fact that Web services are developed to ensure machine collaboration in the Web (Machine-to-Machine approach) each service interface can be described using a machine-readable format

Fig. 1 shows the overall Web service architecture. There can be three instances identified that interact within a Web service:

- service requestor;
- service provider;
- service broker.

The service provider sends the WSDL file to the UDDI (Universal Description Discovery & Integration). UDDI is an open source project that enables organizations to publish a Web service description (WSDL) so that it could be found by other organizations and integrated into their system. Service requester contacts the UDDI to find out what data provider he needs and then contacts the service provider via SOAP protocol. The service provider validates the service request and sends structured data in an XML file, using the SOAP protocol. This XML file would be validated again by the service requester using an XSD file.

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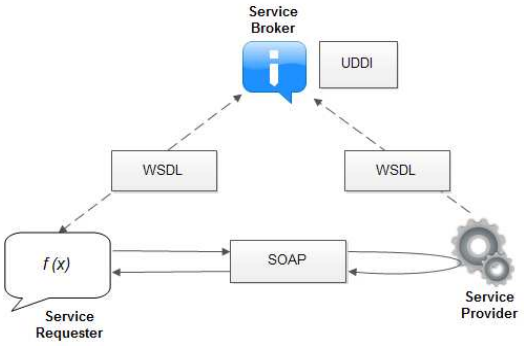

Fig. 1 Web service architecture.

III. WEB SERVICE TECHNOLOGIES

Web service architecture includes a lot of layers and related technologies. There are many ways how to visualize these technologies, as there are many ways how to build and use Web services. **Error! Reference source not found.** represents one of the technology families. XML, WSDL, SOAP, XML-RPC and UDDI technologies will be considered more detailed.

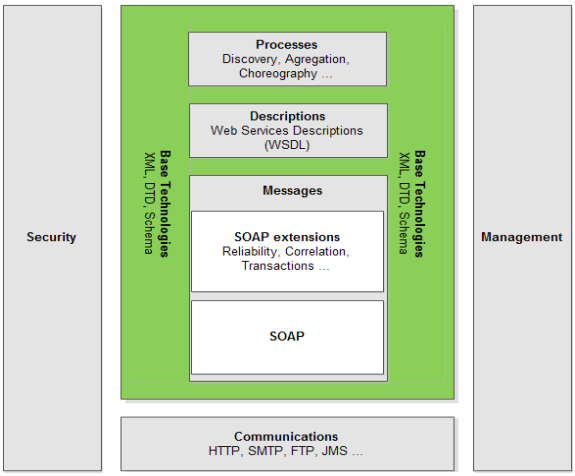

Fig. 2 Web service architecture stack.

A. XML

XML stands for *eXtensible Markup Language* which was recommended by the World Wide Web Consortium (W3C) on February 10, 1998. The XML specification describes XML documents. XML was designed as a formal language with a simple syntax that programs and humans can use to create and handle documents that will mostly be used on the Internet. The language is called extensible because it does not define the markup used in the documents: the developer is free to create the markup in accordance with the needs of a problem domain, being limited only by the syntax rules. A combination of simple formal syntax, convenience to the users and scalability, as well as being based on the Unicode encoding which is applied to represent the content of the documents, led to widespread use of XML, as well as using many other derivative specialized XML-based languages in different software tools. XML-document is a plain text file in which data elements are created with the help of special markers, which define the sequence and nesting of the document structure and its content. The main advantage of XML documents is that with a relatively simple way of creating and processing (plain text can be edited by any test processor and processed by standard XML parser) they allow to create structured information, which is well understandable to computers.

XML does not do anything by itself. The XML format was created to structure, store and transport information. Below is a note from John to Eve, which was saved as XML.

```
<note>
  <to>Eve</to>
  <from>John</from>
  <heading>Question</heading>
  <body>Do you know what is XML?</body>
</note>
```

The note contains information about sender and recipient. It also has a title and a message body. But still this XML document does not do anything. XML is only information that is "wrapped" in tags. Developer should write software to send, receive, store and display the message which is shown in Fig. 3 [4].

Note
To: Eve
From: John
Question
Do you know what is XML?

Fig. 3 Example of a note.

B. WSDL

WSDL stands for *Web Services Description Language* which was recommended by the World Wide Web Consortium (W3C) on June 26, 2007. This standard was developed by IBM, Microsoft and webMethods. Each of these three companies had their own approach in developing of a standard for describing Web-services: IBM created NASSL, Microsoft developed SCL and webMethods company came up with WIDL. WSDL is based on XML and describes Web services as endpoint nodes or port groups. Abstract port and message definitions are separated from specific implementations. This allows the use of these definitions again elsewhere. The port is defined by associating a binding to a specific Web address. WSDL is often used in combination with SOAP and XML Schema to provide Web service availability on the Internet. When connecting to a Web service, a client program can read the WSDL file and determine which operations are available. Each WSDL document contains several items which belong to one of the following categories as shown in Fig. 4 (category names as in WSDL 1.1 and

WSDL 2.0 specifications are given in the parentheses) [5], [6]:

- Service (Service / Service) - service can be considered a system function that is available with the help of web protocols.
- Port (Port/Endpoint) - the port defines a web service address. Typically, it is a string containing a HTTP URL address.
- Binding (Binding / Binding) - defines the interface and SOAP binding type (Remote Procedure Call/Document). Binding section also defines operations.
- Port Type (portType/Interface) - describes the Web service operations that can be executed and messages for operation execution.

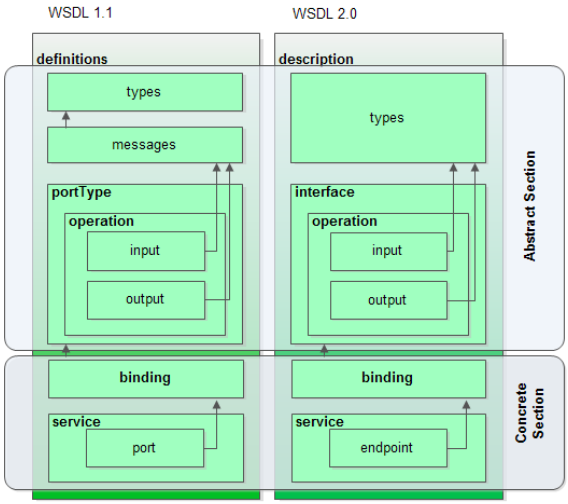

Fig. 4 WSDL 1.1 and WSDL 2.0 schematic diagram of concepts.

The main structure of a WSDL document looks like this:

```
<definitions>
<types>
  data type definitions
</types>
<message>
  definition of the data being communicated
</message>
<portType>
  set of operations
</portType>
<binding>
  protocol and data format specification
</binding>
</definitions>
```

C. SOAP

SOAP stands for *Simple Object Access Protocol* which was recommended by the World Wide Web Consortium (W3C) on June 24, 2003 (version 1.2). SOAP is an application communication protocol which is based on XML. SOAP is a format for sending and receiving messages. The main advantage of SOAP is that it is platform independent so it provides a way to communicate between applications running on different operating systems, with different technologies and programming languages. SOAP can be used with any application layer protocol: SMTP, FTP, HTTP, HTTPS, and others.

SOAP specification defines a messaging framework that includes the following components [7], [8]:

- SOAP processing model - describes the rules that define processing of a SOAP message.
- SOAP extensibility model - defines SOAP features and modules.
- SOAP underlying protocol binding - a framework which describes exchange of SOAP messages between SOAP nodes.
- SOAP Message Construct - describes SOAP message structure.

SOAP messages are using XML format which makes them easy to transfer, read and process. Fig. 5 shows that SOAP message consists of an envelope which is basically a container. The envelope contains a header and a body. The header contains information about how the recipient should handle received SOAP message. SOAP message body part contains information which is necessary for instruction execution.

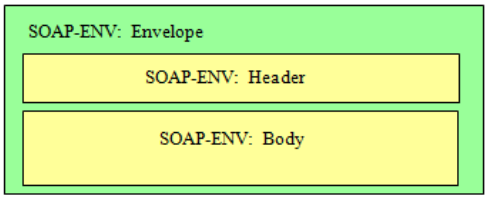

Fig. 5 SOAP message structure.

SOAP message skeleton looks like this:

```
HTTP/1.1 200 OK
Content-Type: application/soap+xml;
charset=utf-8
Content-Length: 299

<?xml version="1.0"?>
<soap:Envelope
xmlns:soap="http://www.w3.org/2003/05/soap-
envelope">
  <soap:Header>
  </soap:Header>
  <soap:Body>
  </soap:Body>
</soap:Envelope>
```

D. XML-RPC

XML-RPC stands for *Extensible Markup Language Remote Procedure Call* - remote procedure call standard/protocol which uses XML to encode its messages and HTTP as a transport

mechanism. Fig. 6 shows that XML-RPC is a bridge between service requestor and service provider. In spite of the fact that XML-RPC is the ancestor of SOAP, it differs with its outstanding ease of use. XML-RPC as well as any other interfaces of Remote Procedure Call (RPC) defines a set of standard data types and commands that the programmer can use to access the functionality of a different program located on another computer in the network. XML-RPC is not intended to solve global tasks as SOAP but it is widely used in Web development.

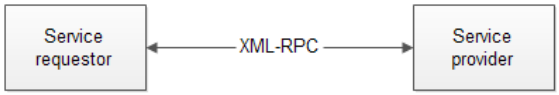

Fig. 6 XML-RPC conception.

Table I represents some of the characteristics that define differences between XML-RPC and SOAP. Data shows that data types in both protocols are the same. But in XML-RPC it is not possible to specify names for arrays, structures (all structures and arrays are "anonymous") and developer-defined encoding.

In light of current pace of development of technologies and standards, especially the Web, the point - the ease of development and practical application is becoming more important.

Table I
Comparison of SOAP and XML-RPC main characteristics

Characteristics	XML-RPC	SOAP
Scalar data types	+	+
Structures	+	+
Arrays	+	+
Named arrays and structures	-	+
Developer defined encoding	-	+
Developer-defined data types	-	+
Detailing of errors	+	+
The ease of development and practical application	+	-

Most programmers and specifications developers agree that:

- if there is a need for a system that is dealing with complex logic, transferring large complex data structures, if there is a need for complete information about the client and request should contain instructions about its processing – it is preferable to use SOAP;
- if data are relatively simple and applications must run on multiple platforms and languages, if performance is important and system logic does not require complicated commands - it is preferable to use XML-RPC [9].

E. UDDI

UDDI stands for *Universal Description Discovery & Integration*. UDDI is a cross-platform software based on XML. It is an open source project sponsored by OASIS, which allows organizations to publish descriptions of Web services (WSDL) for them to be searched by other organizations and integrated into their systems. It also determines how services or applications communicate over the Internet. UDDI was originally proposed as a primary Web service standard. It is designed for surveying by SOAP messages and for providing access to Web Service Description Language (WSDL) documents that describes bindings of protocols and message formats required to interact with Web services listed in its directory.

In Fig. 7 is shown how a business publishes services to the UDDI registry. Then a client finds the service in the registry and receives service binding information. Finally, the client uses received information to invoke the service. A business or a company can register three types of information into a UDDI registry.

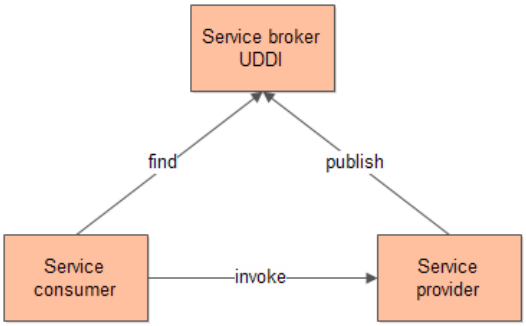

Fig. 7 UDDI registry.

Registration in the UDDI consists of following components:

- white pages - address, contact and known identifiers;
- yellow pages - industrial categorization based on standard taxonomies;
- green pages - technical information about the services available in the business.

White pages provide information about the service provider, for example a company name or description of services (probably in several languages). Using this information, it is possible to find a service that some information is already known about.

Yellow pages contain the classification of a business based on standard taxonomies. Since a business can provide a number of services there may be several yellow pages (each describing a service) related to a single white page (giving general information about the business).

Green pages are used to describe the method of gaining access to Web services and information about linked services. Part of the information is

associated with Web services - such as address of the service and its parameters as well as links to interface specifications. Other information is not directly related to the Web service - it includes e-mail, FTP, CORBA, and service phone numbers. Since a Web service can have multiple bindings (as defined in its WSDL description) it may have multiple green pages because each binding will need access to various pages [10].

F. RESTful

REST stands for *Representational State Transfer* - architectural style of interaction between distributed application components in the network. REST is an alternative to RPC. The term "RESTful" is used for Web services that are based on REST architecture. REST is not a standard by itself, majority of RESTful implementations use standards such as HTTP, URL, JSON and XML. Although World Wide Web is based on this concept - the term "REST" was introduced only in 2000 by Roy Fielding who is one of the HTTP protocol founders.

REST offers HTTP-methods for developers to use. This basic REST design principle establishes an unambiguous equivalence between such operations as create, read, update and delete (CRUD) and HTTP-methods. According to this equivalence:

- to create a new resource on the server is used POST;
- to access a resource is used GET;
- to update a existing resource or create a new resource on the server is used PUT;
- to delete a resource is used DELETE [11].

Fig. 8 shows that REST is based on client-server interactions. The client application makes a request that is translated to a RESTful HTTP request. This request is started like any other HTTP transaction – from a client to a server. The server processes the request and responds accordingly.

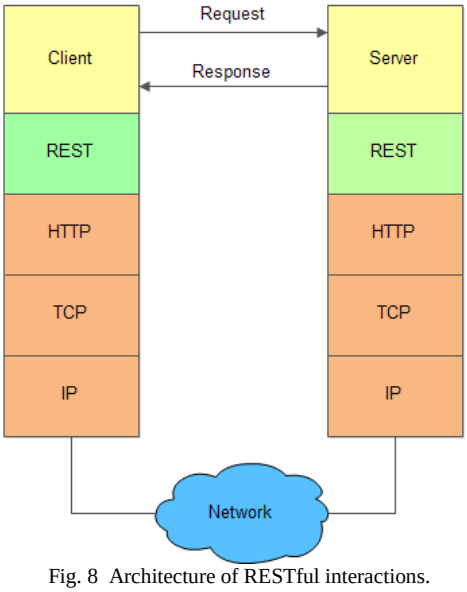

Fig. 8 Architecture of RESTful interactions.

IV. RELATED WORK

In our earlier work, we proposed various PHP programming framework [12] (CakePHP2, CodeIgniter, Symfony2, Yii, Phalcon) popularity overview and comparison using various criteria. Based on this study obtained data two frameworks were selected for deeper analysis - Symfony2 and PhalconPHP. There was offered a description of the architecture and main features of selected frameworks (routing, template engine, etc.). During framework comparison a performance test was developed with a goal to determine performance and effectiveness of frameworks for the same task. For performance testing a „Ticket Reserving System" cashier list section was selected. Tests were performed using ab.exe (Apache Benchmark) tool that comes along with the Apache Web server. Based on the comparison results, recommendations were made which allows Web developers to select a framework for the creation of a real Web project.

Although both Web service technology classes can be used for Web systems development, paper authors decided to develop Web site improved version using the REST architectural style. REST architecture choice is based on the fact that the protocol separates the user interface from the server and data storage, which improves interface portability to other types of platforms and increases the scalability of the project. Also the key aspect of REST architecture is that it's stateless (without status saving). This feature makes RESTful architecture secure and helps to improve the scalability.

Firstly, in order to improve the developed website capabilities, it was decided to use a Web service that will provide access to information about currency exchange rates. Currently the feature to book tickets is implemented on the website and registered users can see the prices for each performance. However, if a user from different country registers on the website, he will be more comfortable to look at the prices in his national currency. The Web service currencylayer.com was used to provide the information about currency exchange rates to the website. This Web service allows to use real-time REST API and retrieve the exchange rate history of the worlds 168 currencies and precious metals in the JSON format that is compatible with any application. Secondly, in order to improve the developed website capabilities, it was decided to use a Web service that will provide access to the information about the weather. Such opportunity will allow theatre visitors to prepare for unexpected weather changes. In order to implement such a feature, the Web service owm.io/weather-api was used, which aims to collect data on weather conditions around the world and make them more open and accessible to everyone.

V. CONCLUSIONS AND FUTURE WORK

The paper provides information about Web service basics and main technologies. In the paper REST-compliant (RESTful) and arbitrary (XML, SOAP, WSDL, UDDI, XML-RPC) Web service technologies that can be used in development of a Web system are described, also the description is provided about two Web services - currencylayer.com and owm.io/weather-api that were used to supplement developed website capabilities, and provide access to information on exchange rates and weather. The selected Web services are based on a REST architectural style, which nowadays is used more and more often in web-based technologies.

To continue the research, it is necessary to improve the Web system [12] which was developed using Symfony2 and PhalconPHP frameworks further by implementing Web services described in this paper to apply theoretical knowledge in practice.

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Ontology-Based System Development for Medical Database Access

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Abstract. Medical research is a complex multi-disciplinary task involving specialists from different fields and professions, not only medical professionals. Medical databases are structured by information technology experts, but the contents must be tailored to the medical field. When the medical staff defines the information they use, terminology from their particular field of expertise is employed. This leads to misunderstandings between the maintainers and developers of information technology solutions, and the users of those solutions. When the time comes that a user, who is a medical professional, requires very specific data from the database, the chance of obtaining the data incorrectly is very high. By defining specific concepts and relationships between the data, in an explicit shared specification, some of the above problems can be avoided. The developed ontology-based data access system, described in this paper, provides a tool to store, manage and use definitions of common terminology and their mappings to the database. It is also capable of reasoning about the relationships between terms and indicates inconsistencies of term definitions, if any are present. By defining these interconnected terms in the ontology and by working through the system, all experts and software tools, who use the data, are able to use and reuse these terms to obtain data in a reliable and predefined way. This paper discusses the development and implementation of the ontology-based data access system, the ontology describing the medical data and the data mapping system, linking data from the database to concepts and virtual ontology individuals.

Keywords: Database analysis, intelligent system development, ontology.

I. INTRODUCTION

There are cases when an information system can be built using standardized blocks and known approaches. In the case of a small online store or a similar field, the technology and development steps can be known even before development starts. In some other cases, minimal analysis of the field is required and after finalizing the users' specifications of the information system, development can begin. However, there are fields where development is much more difficult. Specifications cannot be fully determined beforehand or can change over time. Medical research, or any research can be such a field. In the case of medical research, the procurer of the system may envisage the need to catalogue some medical procedures and a fixed pipeline of analysis for the research. However, the procedures, the order in which the procedures are commissioned, the types of analysis, the desired participants and many other aspects may change over time. There are no fixed approaches for such situations. Furthermore, any knowledge about the domain may exist only within the currently used system in a derived state. Any knowledge that went into the development may be found in the documentation. However, the documentation exists only in the form of informal text meant to be read by humans. Frequently, only the original developer truly knows how the system works.

The uses of the data structures in the existing system are only truly known to the developer. They might also have changed over time. Understanding the significance of database columns may not be sufficient to understand the data. Some columns might not be used anymore. Some values might be outdated. New structures replace the old ones, while still maintaining some aspect of the old system. This all leads to confusion and makes maintenance and improving of the system increasingly difficult.

Another aspect to be considered is that databases for scientific research may be accessed not only by administration personal, but also by researchers to analyse the data. These requests for data may be very different. Different researchers are interested in different data. This means that standard reports or data extraction solutions may not be possible to implement, since the requests for data are constantly changing. Providing all the data without structure and context will lead to misunderstandings, or the inability of the researcher to do anything useful with the data. Providing a standardized report solution may work for a limited time and only for a certain repeating task.

That all necessitates using knowledge in the system. When knowledge about the domain and the system's inner working is embedded into the system itself, it becomes accessible and usable by both different human users, software agents, and different modules of the information system itself. This paper

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describes the development of an ontology-based system for extending an existing ontology-less information system, for the medical field. This is done by adding ontology reasoning capabilities to information access. The ontology allows for the storage of knowledge about the field to make it possible to retrieve data from a complex relational database in a simple and intuitive way. Information retrieval becomes paired with reasoning.

II. EXISTING SOLUTIONS

Using ontology as a knowledge extension is not a new idea; it is employed in many different fields [1] - [3]. The use of related semantic meaning to mostly plain data offers additional opportunities desired by both system users and developers. Using ontologies in the medical field has gained popularity in recent years [4] – [7]. This is partly due to medical information being often complex in structure and using complex terminology. There already exist multiple solutions for accessing databases using ontologies or other semantic technologies [8]. Although, ontologies are offering two levels of descriptions, the TBox and the ABox, it is apparent that separating these levels can be beneficial. This can be achieved by using the ontology only to describe terminology and higher conceptual relations and applying it to data, stored separately. However, we find that the existing solutions are lacking in certain aspects, mostly due to the way the knowledge is stored [9]. Many of these solutions require that the database is built from ground up to the specifications of the solutions. These solutions propose a triple store database. These are specific databases meant for the storage of subject-predicate-object triples. These triples are the smallest unit used to describe the concepts of the ontology. Although, these solutions are capable of storing and retrieving information using ontology knowledge, they are very difficult for the task of adding knowledge-based support for an existing software solution. Restructuring the existing database in this way is often not viable. This is due to all previously developed solutions being tuned to the database technology and data structures. Also, converting a database into a network of related data, as is the case with triples, the retrieval of data, as it is possible in relational databases, becomes more complex and resource intensive. This would raise the usage of resource not only for any new software solutions, but also for any existing solutions.

Another shortcoming is the complexity of retrieving and using the knowledge. The current way of retrieving knowledge from an ontology is to use SPARQL queries over the RDF data [10]. Having an ontology describing the data can offer additional advantages over classical data description solutions. However, if the complexity of correctly obtaining data increases with the addition of ontology, it is less likely to be used by the average user. SPARQL queries are not simpler than SQL queries, in fact they are in many aspects more complex. In order to make the addition of ontology to an existing solution an improvement, we prioritize ease-of-use and ease-of-integration.

The developed solution described in this paper is able to connect and use an existing database to obtain data on which to perform induction and deduction reasoning, without making any changes to the database or requiring any additional compliancy. The developed solution extracts data using simple SQL queries, making it no different from any other software module accessing it. Many existing solutions are based around the usage of the language and conformity to all linguistic aspects of ontologies. Many solutions will put their conformity to RDF at the centre of the solutions. This is due to the most popular ontology language OWL being and extension of RDF and RDF schema. The proposed solution aims at making it easy for the user and developer to use ontology specific capabilities, by concentrating on what makes an ontology an ontology, instead of viewing an ontology as an additional meta-layer to RDF. The descriptive and reasoning capabilities of an ontology are interesting in themselves and could be used to perform tasks in a stand-alone way. Ontologies describe the class layer of individuals, relations between them and the attributes of properties themselves. This can be used to create usable descriptions without making use of lower level structures. However, this requires that the ontology used with the system is created in a certain way. The development of the system is tuned to its use.

III. DEVELOPMENT OF THE SYSTEM

System development starts with the analysis of the field aimed at creating an ontology for it. There are multiple types of ontologies. Some ontologies are very abstract and describe high-level concepts, such as time and what a place is. There are more specific ontologies describing a certain domain or field of interest. At the lowest level, there are application ontologies, defined for a certain application only. In the case of the developed system, the ontology is a combination of a domain ontology with database specific mappings and based on the structure of the database. Since the primary use for the ontology will be to access the database and all information is obtained from the database, forming the ontology around the structure and content of the database is not only unavoidable, but also an opportunity to shape the ontology in a useful way. A downside to this is that the ontology is not a pure domain ontology. All concepts are viewed through the context of the database. If some unit of information exists in the database and describes some real-world object, some concept describing such units must exist in the ontology. On the other hand, if some concept exists in the ontology, but there is no data in the database,

which could be used to instantiate an object of this concept, the existence of such concept in the ontology can be questioned.

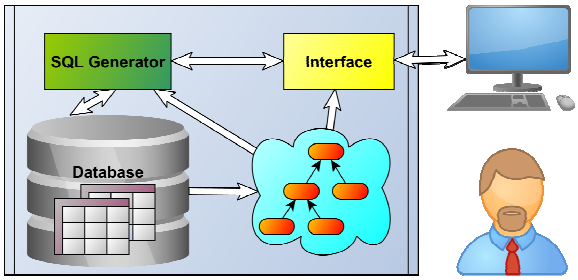

Fig. 1. System structure

Having developed the ontology, the system is capable of reading and constructing a memory model of the ontology. In this case, a new solution has been built from scratch. It reads an ontology described in OWL/XML and constructs a concept-network based ontology in its memory.

Figure 1 shows the systems schema. The system consists of the pre-existing database, the ontology, an interface module and a SQL generator. The database is analysed and an ontology is created. The created ontology is used in both the SQL generator and the interface module for selecting required concepts. The selected concept together with the definitions provided in the ontology are used by the SQL generator to obtain data. All related concepts of the obtained database records are found and provided to the user through the interface.

A. Database analysis

The first step in developing an intelligent system for an already existing solution is to analyse the inner workings of the existing solution. In this case, there was an already established database for the project. The database contains all the data relevant to the project. The database is structured around a central table containing data about participants in the medical study. Participants are defined as people who at some point agreed to participate in the study. This table contains the names, addresses and other personal information about these people. It also contains fields classifying them as different kinds of participants. One field describes their status. They can be active participants or can have been excluded from the study, for some reason. Another field describes their subtype. Participants are divided into the main group and a control group. Further still, since the study had multiple stages, the participants were further divided into participants of the current main study and participants of the previous pilot study.

When the participants first joined the study, they were given questionnaires. Each questionnaire had its own database table containing the respondents' answers. Each respondent will have either 1 or no corresponding record in each of these tables. If the respondent was excluded from the study, there will be a record for the respondent in the main table, without a corresponding questionnaire record.

Other tables describe medical procedures. Most procedures are divided into two tables. One table holds records for a distinct procedure at a specific date. Another table will hold multiple records related to the procedure. There are usually records for obtained samples (blood samples, biopsies) and some data about medical results if the samples have been analysed.

It is important to understand how the database table is used and what data it describes. It is also important to conduct a more technical analysis of the data contained in the database. Direct access to the database was not given, and only views were used for data extraction. Since all tables were accessed through table views, some important definitions were lost. Since the developed system should make use of the views instead of the tables directly, almost all information about the database structure had to be obtained from the accessible data. By using methods described in an earlier paper [11], it was possible to obtain information about distinct values and key pairs. A meta description of the database was created. In the case of a well-maintained database, such step would not be required. It would be possible to obtain such data from the definitions and the meta data of the database.

The result of the analysis is that an ontology describing the content of the database must be able to reference certain data values and relationships between tables. Each database record can be viewed as an individual of the table class. The meaning of the table class is not necessarily readily available. The only thing that can be said for sure, is that a database table is a grouping concept for its records. For example, the database of the described project has the participants table. However, it would be wrong to equate the concept of the database table to the concept of a participant. This is due to the table having records which are not real participants. Therefore, the concept of a real participant would be a sub concept of the concept describing the database sable.

B. Ontology building

Once the database is well understood, the ontology for the system can be built. There exist many different approaches to building ontologies. These approaches are described in many papers [12]. When an ontology is being created from a specific domain, often terminology is analysed. There is no wrong way to create an ontology, however, there is no guarantee of the ontology being usable, or usable for the specific task. By basing ontology development directly on a database, and for the task of ontology-based data access, the likelihood of the concepts being usable and used in the task is higher. By knowing what data are stored in the database, what groups are described by the data and understanding

the meaning of the data, it is possible to define concepts describing these groups.

The ontology is first filled with concepts describing records from tables. For each table, a corresponding table-concept is created. As described earlier, these concepts have a very specific use. They do not necessarily describe the thing they were named after and it would also be wrong to use these concepts as descriptions of database technology. Instead, these concepts are used as grouping concept for the records and are also used as mappings. When the SQL generator encounters a concept, having a database table name, it knows that this table will be used in the query. Many times, an ontology based on a database will start to describe the database more, than describing the field. Often ontologies based on databases will automatically contain generated concepts and properties based on tables and fields. This should not be considered correct for the purposes of this system. In order to create the needed link to the database, fields will be addressed, but only the most necessary fields, not all of them. This means that the knowledge engineer defines the mapping to the database as needed, instead of using all possible mappings. This is helpful to keep the ontology small enough to be understandable by humans.

For the database, the system has been developed for, the following ontology concepts have been defined. Based on the status, concepts for active participants, excluded participants, decided participants, main study participants and pilot study participants have been defined. These concepts are given a definition based on a database value. For example, the participants of the main study are defined as records of the participants table with a value of “Main” in the data attribute correlating to the table field holding this information.

Database tables can be found in the names of the special class concepts. Field names can be found in the data properties of the ontology. They are used to define complex classes. The third kind of mapping between the ontology and the database are object properties. Object properties describe relations between individuals. In a database, these are primary and foreign key mappings. In the ontology, special object properties are defined. In order to handle mapping, annotations are used. A special annotation property is defined to indicate database mapping. Using these annotation properties, the database tables and fields, participating in the relationship, are defined.

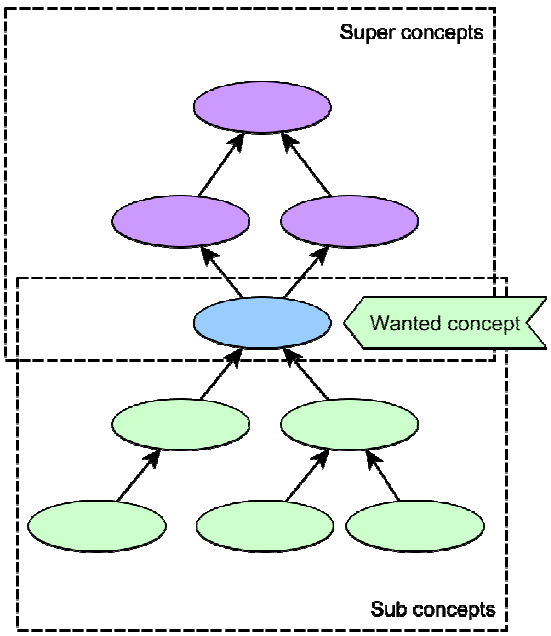

Fig. 2. Related concepts

The purpose of the system is to extend knowledge. Therefore, it is not enough to have these base types. They are only used to define mappings. The real knowledge has to be added to the ontology as sub and super classes of the mapping classes and properties.

C. Development of ontology reasoner

The developed ontology can now be used to access the database, but before that can happen, a reasoning system must be developed capable of using concepts, their descriptions and relations to perform the necessary reasoning for correct access to the database. Ontology reasoning at its core is based on extending the existing hierarchy of concepts. Each concept (class, object property, data property, datatype) is assigned some position in a pre-established hierarchy. This hierarchy can be extended when analysing complex concepts. The developed solution searches for special cases and adds new hierarchical relations, based on these cases.

Once the hierarchy has been fully extended, it can be used for classification. When a new instance of a concept is added to the ontology, complex concepts can be used to determine, whether this new instance can be classified as any of them. No additional reasoning is required, since the hierarchy already connects the new instance to all other concepts. The only additional reasoning required is to check if the individual belongs to multiple internally disjoint classes. If this happens, the ontology is inconsistent and must be checked.

D.SQL generator

The SQL generator is a direct extension to the reasoner. The developed reasoner makes it possible to traverse the relationships between concepts. It is necessary for the SQL generator, so that it may use only the most necessary tables and fields. It must generate a SQL query to obtain the needed data, without extracting the entire database.

As described before, multiple concepts and data properties are directly based on database tables and fields. Some object properties describe table key restrictions. Generation of SQL statements is directly related to the search for these concepts and properties. When a concept is selected (Figure 2), the concept hierarchy is used to traverse it in the search for these values. To determine the necessary fields

and table to classify any data with the selected class, only the subclasses need to be considered. If a database record can be classified as any of the subclasses (including the selected class), the record belongs to the selected class. If it cannot be classified as any of the subclasses, the relationship is unknown, at best. By traversing all subclasses the SQL generator looks for tables and fields referenced in the names of the concepts and relations (in the case of complex concepts). They are added to a list of distinct tables and fields. This is the smallest set of data, which has to be obtained for positive classification. Next, all super classes of the select concept should also be considered. By doing the same operation of gathering database references from the super classes, additional tables and fields may be found. The purpose of these new tables and fields is not positive classification. They are needed to test consistency. Any data that have to belong to the selected class must satisfy the inherited restrictions of the super concepts. In order to keep the set of selected data as small as possible, addition of other tables is restricted in the second step.

E. Concept selection interface

The user is presented with an interface for the selection of the desired concepts. By traversing the ontology only named classes are selected to be shown to the user. The user may select multiple concept and an "AND", "OR", "NOT" relationships and grouping between these concepts. Working together, the ontology reasoner and SQL generator can extract the smallest amount of data corresponding to these ontology concepts. The user query represents a new complex concept, which is a combination of existing concepts. The reasoner can determine the new concepts position within the existing concept hierarchy. The SQL generator obtains the data, and reasoning is performed. After the classification is done, the data may be presented to the user. In addition to selecting the desired data, all related classifications are also shown to the user. This makes the data more descriptive.

It is difficult to visualize this data. There may be multiple object relations between tables. If provided in table form, some additional approaches for visualization may need to be used.

IV. CONCLUSIONS

The described system can add ontology knowledge to an existing system or solution, because it is built in addition to it and does not require any changes to the established order. It works by mapping database tables and field to ontology concepts. The developed system provides an additional way of accessing the data in the database. Instead of using SQL queries, combinations of existing concepts can be used. Data access becomes more intuitive. This can also be helpful to the developer of the system. Knowledge about the type of information stored in the database is also added to the system. Having an ontology, the concepts important to the system have to be stated explicitly. When problems with development or the functionality arise, it is possible to investigate the definitions of the concepts to recall their meaning. In case of insufficient definitions, the definitions of concepts can be extended and improved. Improvements, in these cases, can be performed by changing the ontology and not program code. This can be beneficial to development. The described system enhances the capabilities of the system by adding new possibilities in a none-intrusive manner.

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Potential Function Method Approach to Pattern Recognition Applications

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Abstract. Potential function method was originally offered to solve the pattern recognition tasks, then it was generalized to a wider range of tasks, which were associated with the function approximation. Potential function method algorithms are based on the hypothesis of the nature of the function that separates sets according to different classes of patterns. Geometrical interpretation of pattern recognition task includes display of patterns in the form of vector in the space of input signal that allows to perceive the learning as approximation task. The paper describes the essence of potential function method and the learning procedure is shown that is based on practical application of potential methods. Pattern recognition applications with the help of examples of potential functions and company bankruptcy data analysis with the help of potential functions are given.

Keywords: potential functions, pattern recognition, bankruptcy prediction.

I. INTRODUCTION

It is known from physics that the distribution of electrical charge potential (depending on the distance to the charge) is determined by the formula:

$$p = a\frac{q}{r^2} \quad (1)$$

where a – coefficient;
q – charge size;
r – the distance from the given point to the charge.

Geometrical interpretation of distribution of potentials is shown in Fig. 1.

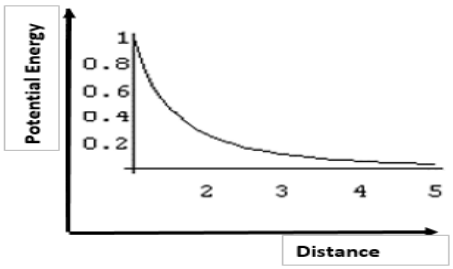

Fig.1. Distribution of potential

Thus, the potential value can serve as a starting point of the distance to the charge. When the electric field is made by a number of charges, the potential of each point of the field is equal to the amount of the potentials created by each of the charges in this point. If charges form a compact group, then the maximum value potential will take the charge internally and respectively decrease, falling away from that group.

The algorithm of the potential function method is based on the hypothesis about the function character that separates sets according to different classes of patterns [3], [5], [11]. Further description of the algorithm is given in the pattern recognition context. Assume that there are two compact groups of charges in the space. In the one group the charges are negative but in the other positive. Fig. 2 represents these groups and the set potential distribution curve.

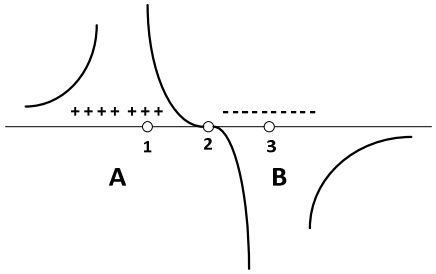

Fig.2. Potential groups

Each point of the space is closer to the set whose potential at that point is larger. Any point can be associated with specific set depending on the total potential sign at that point. Hence, the total potential curve is at the same time set separating curve. Say, point 1 has positive potential, so it can be ascribed to set A; point 3 has negative potential and it can be ascribed to set B; point 2 has zero potential on the boundary of sets.

Similar assumptions can be laid down in the pattern recognition basis by connecting vectors of learning patterns with certain potential functions. Let us consider the idea of potential function method on the basis of two-class separability.

Suppose that classes A and B do not intersect, i.e., in set X at least one separation function $\Psi(z)$ exists which assumes positive values (corresponding to class A) and negative values (corresponding to class

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B). In general case there may be many such separation functions.

In the process of learning, points in space X are sequentially shown and it is declared to which class these points belong. Provided that this information is only available, it is required to determine the separation function within the finite number of steps. Then it would be possible to ascertain the conformity of test set points to class A or B depending on the separation function sign at those points.

II. LEARNING PROCEDURE, BASED ON THE POTENTIAL FUNCTION METHOD

Solving of that task deals with the following procedure: if some point x_k appears in the course of learning, potential function $K(x, x_k)$ is associated with it, which is set over the whole set X and is dependent on $x_k$as a parameter ("potential function"). In the process of learning, to point collection $x_1, x_2, \ldots$ a collection of potential functions corresponds $K(x, x_1), K(x, x_2)$ ... used to determine function $\Psi(x, x_1, x_2, \ldots$ by means of certain rules. These rules are determined so that $\Psi^*(x, x_1, x_2, \ldots)$ would tend to some of separation functions. The procedure when separation function is successively constructed using the functions, which are shown by space points, is called potential function method [5].

In order to ensure learning of that type, it is first necessary to restrict choice of space X and of function class $\psi(x)$. Otherwise, points may appear in testing whose membership class is misclassified. The restriction is determined so that in space X existence of such functions $\psi_i(x))i = 1,2, \ldots)$ is accepted at which it is possible for each pair of separable sets to find such a N under which separation function could be assigned as follows (description of variables see below):

$$\Psi(x) = \sum_{i=1}^{N} c_i \varphi_i(x) \qquad (2)$$

Let us introduce some important basic concepts. To each point $x \in X$ there corresponds point $z \in Z$ with co-ordinates $z_i = \varphi_i(x)$. Using formula (2), the separation function $\Psi(x)$ in space Z can be represented as linear function $\sum_{k=1}^{N} c_k z_k$. Since

$$\Psi(x) = \sum_{k=1}^{N} c_k z_k \qquad \left\{ \frac{> 0 \ldots x \in A}{< 0 \ldots x \in B} \right\} \qquad (3)$$

then points in space Z that belong to different classes are separated by hyperplane

As a potential function, we will use the function of two variable arguments:

$$K(x, y) = \sum_{i=1}^{\infty} \lambda_i^2 \varphi_i(x) \varphi_i(y) \qquad (4)$$

where $\varphi_i(x)$ $(i = 1,2 \ldots .)$ a system of linear independent functions (see condition (2) above);

λ_i – integer numbers different from 0.

In what follows we will assume that $\varphi_i(x)$ and $K(x, y)$ are restricted at $x \in A \cup B$. Variable y will be interpreted using the points that appear in the process of learning.

Suppose that in the course of learning, points $x_1, x_2, \ldots, x_k$ appear and each of them belongs either to set A or to set B. Let us assume conditionally that positive values belong to set A but negative values belong to set B. In learning, after the first point x_1 is shown, function $K_1(x)$ is constructed that is equal to the potential at point x_1 taken with the sign of the corresponding set, i.e.:

$$K_1(x) = \begin{cases} K(x, x_1) & if \ \ x_1 \in A \\ -K(x, x_1) & if \ \ x_1 \in B \end{cases} \qquad (5)$$

Further algorithm execution is based on induction. Assume that after the $r - th$ appearance, potential $K_r(x)$ is created. Suppose that at the next $(r + 1) - th$ learning step, point $x_r + 1$ appears. As a result of that, four cases can occur:

$x_{r+1} \in A$,	$K_r(x_{r+1}) >$	(a)
$x_{r+1} \in B$,	$K_r(x_{r+1}) <$	(b)
$x_{r+1} \in A$,	$K_r(x_{r+1}) <$	(c)
$x_{r+1} \in B$,	$K_r(x_{r+1}) >$	(d)

In cases (a) and (b) the sign of the set to which x_{r+1} belongs and the sign of $K_r(x_{r+1})$ coincide, which means that the algorithm correctly classifies point x_{r+1}. In this case it is assumed that $K_{r+1}(x) = K_r(x)$.

In cases (c) and (d) there is an error as the sign of the set and the sign of K_{r+1} do not coincide. "Error correction" is accomplished as follows:

- in case (c) it is assumed that $K_{r+1}(x) = K_r(x) + K(x, x_{r+1})$ and
- in case (d) it is assumed that $K_{r+1}(x) = K_r(x) - K(x, x_{r+1})$.

The learning algorithm described above can be used in this way: during learning, when the $s - th$ point appears, function $K_s(x)$ is constructed. After a sufficiently long learning, the process is interrupted but function $K_s(x)$ is supposed to be a separation function. As a result of testing, after a new point x^* has appeared, the value of $K_s(x^*)$ is calculated and this point is ascribed to class A or B depending on the sign of $K_s(x^*)$.

The results of practical implementation of the method are discussed below.

III. PATTERN RECOGNITION WITH POTENTIAL FUNCTION APPLICATIONS

A. Experiment I. Artificial data

Let us consider the application of potential function method in pattern recognition tasks. Statistical data on automotive diagnostic measurements were taken as the learning data. The following measurements were made:

- mileage;

- towing capacity;
- exhaust gas;
- relevant class.

Classification is as follows:

- 1- norm;
- 2- ring wear;
- 3- cylinder group wear;
- 4- cylinder wear.

Learning set consists of 4 classes of 15 patterns in each class. After learning the testing is carried out using the given data, for which the relevance to a particular class was previously known. The recognition accuracy should be the result of testing.

The potential function takes the form of a function (see Fig. 3):

$$\varphi(R) = \frac{\lambda}{1+\alpha R^2} \qquad (6)$$

where α - learning parameter;

R – the distance between the point where the potential is calculated and the point of learning set;

λ - the value of potential that is assigned to the point in the process of learning (weight).

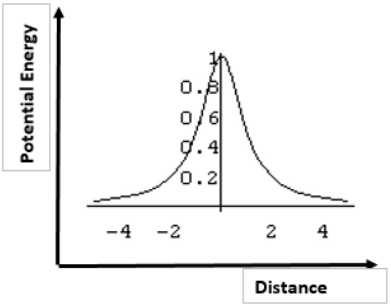

Fig. 3. Potential function within [-5,5]

The learning procedure is as follows:

1. We introduce learning set patterns of all four classes W_1, W_2, W_3, W_4.

2. We take all the patterns in turn (starting with the first X_1) and determine the corresponding class to this pattern:

a) determine the distance squares from the learning subordinated pattern to all others. Indicate classes of patterns with:

$$\begin{aligned} Class1 &\quad x_1,\ x_2, \dots, x_{15} \\ Class2 &\quad y_1, y_2, \dots, y_{15} \\ Class3 &\quad z_1, z_2, \dots, z_{15} \\ Class4 &\quad v_1,\ v_2, \dots, v_{15} \end{aligned}$$

It has to be calculated:

$$R^2_{x_1x_1}; R^2_{x_1x_2}, \dots\dots\dots\dots R^2_{x_1x_{15}}$$
$$R^2_{x_1y_1}; R^2_{x_1y_2}, \dots\dots\dots\dots R^2_{x_1y_{15}}$$
$$R^2_{x_1z_1}; R^2_{x_1z_2}, \dots\dots\dots\dots R^2_{x_1z_{15}}$$
$$R^2_{x_1v_1}; R^2_{x_1v_2}, \dots\dots\dots\dots R^2_{x_1v_{15}}$$

b) We calculate out the potential functions:

$$\varphi_{x_1x_1}, \varphi_{x_1x_2}, \dots\dots\dots\dots \varphi_{x_1x_{15}}$$
$$\varphi_{x_1y_1}, \varphi_{x_1y_2}, \dots\dots\dots\dots \varphi_{x_1y_{15}}$$
$$\varphi_{x_1z_1}, \varphi_{x_1z_2}, \dots\dots\dots\dots \varphi_{x_1z_{15}}$$
$$\varphi_{x_1v_1}, \varphi_{x_1v_2}, \dots\dots\dots\dots \varphi_{x_1v_{15}},$$

using the formula

$$\varphi_{x_1x_n} = \frac{\lambda_n}{1+\alpha R^2_{x_1x_n}}$$
$$\varphi_{x_1y_n} = \frac{\lambda_n}{1+\alpha R^2_{x_1y_n}}$$
$$\varphi_{x_1z_n} = \frac{\lambda_n}{1+\alpha R^2_{x_1z_n}}$$
$$\varphi_{x_1v_n} = \frac{\lambda_n}{1+\alpha R^2_{x_1v_n}}$$

c) we calculate the average value of the potential created by the patterns of each class with respect to the learning pattern:

$$\psi_{w_1x_1} = \frac{1}{N_{x_n}} \sum_{i=1}^{N_{x_n}} \varphi_{x_1x_n}$$
$$\psi_{w_2x_1} = \frac{1}{N_{y_n}} \sum_{i=1}^{N_{y_n}} \varphi_{x_1y_n}$$
$$\psi_{w_3x_1} = \frac{1}{N_{z_n}} \sum_{i=1}^{N_{z_n}} \varphi_{x_1z_n}$$
$$\psi_{w_4x_1} = \frac{1}{N_{v_n}} \sum_{i=1}^{N_{v_n}} \varphi_{x_1v_n},$$

where $N_{x_n}, N_{y_n}, N_{z_n}, N_{v_n}$ - the number of patterns in each class (in this case – 15 patterns in each class)

d) We compare the values of $\psi_{w_1x_1}, \psi_{w_2x_1}, \psi_{w_3x_1}, \psi_{w_4x_1}$ and the learner pattern is attributed to the class which creates the greatest potential for this pattern.

3) We set the pattern recognition accuracy i.e. compare the resulting class value with the previously known.

4) If the pattern is recognized correctly (classes match) - move to the next pattern.

5) If the image is not recognized correctly, we increase the "weight" value by 1 and move to the next pattern.

6) After the last pattern recognition the first learning cycle ends. We start a new cycle - again

repeat learning points 2,3,4,5 (starting from the first and ending with the last pattern). Learning shall be done as long as all the patterns are recognized correctly at the current cycle - resulting class values coincide with the previously given.

7) We save the resulting values for each pattern (which will be required for the testing phase).

8) At the given value the learning is completed.

For each pattern to be tested we do the activities listed in the second point, and the pattern is applied to one of the four classes. Comparing the computed value of the class with previously known - we find out whether the pattern is recognized correctly or incorrectly.

We take the next test pattern and so on. At the end of the testing we process the results obtained, for example, the number of incorrectly recognized patterns, etc.

As a learning sample the following data were taken (60 patterns - 4 class of 15). Learning coefficient α changed within [0.005; 1.000].

Analyzing the learning and testing results, it can be concluded that the algorithm converges at all α values, but the number of learning cycles decrease with increasing of α value. At $\alpha > 0.03$ the learning is performed in the first step. Table I shows the number of learning steps and the number of unrecognized patterns at different values of α coefficient.

Table I.
LEarning steps and Unrecognized patterns

α	Learning steps	Unrecognized patterns
0.01	3	12
0.02	2	7
0.04	1	8
0.05	1	8
0.06	1	8
0.07	1	8
0.08	1	8
0.09	1	8
0.1	1	8
0.2	1	8
0.3	1	9
0.4	1	9
0.5	1	9
0.6	1	9
1.0	1	9

The Fig. 3 shows number of learning steps dependence on α, Fig. 4 – number of unrecognized patterns dependence on α.

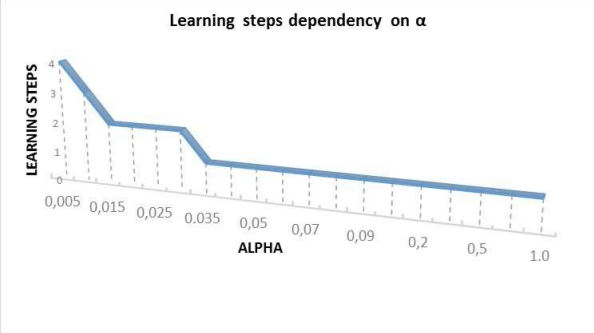

Fig. 3. Learning dependency on α

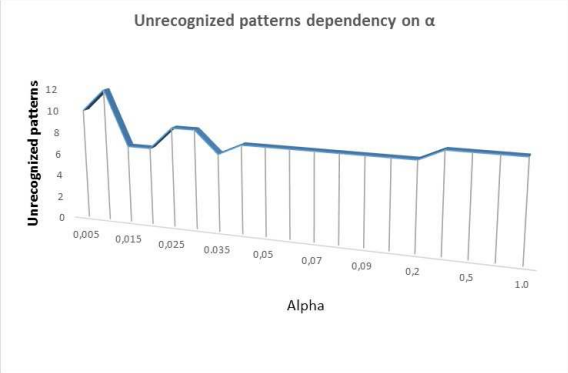

Fig. 4. Unrecognized patterns number dependency on α

The result of the experiment - correct pattern recognition is performed for 92.5% of all tested patterns (9 patterns remained unrecognized: 3 from class W_2, 5 from class W_3, and 1 from class W_4).

Thus, 100% recognition in the result of data experiment is obviously not possible for the reason that classes overlap, and hence it is not possible to construct a "good" separating function.

B. Experiment 1I. Bankruptcy data

Bankruptcy diagnostics is a directed financial analysis system whose area is crisis situation control at the enterprises. In the analysis of the general financial situation of the company a separate group of financial ratios is made, using which it is possible to reason about the threat of bankruptcy [6], [7], [10], [12], [14].

The task of this experiment is to examine bankruptcy data by potential function method ability to correctly perform classification - bankrupt or non-bankrupt (only two-class separability).

The data on firm bankruptcy were taken from [13], [15]. For the purpose of experiments, balance sheet data of 63 companies were used (46 - bankruptcy and 17 - not bankruptcy). It was decided to calculate the following financial ratios on the basis of the data available and further use them in all the experiments:

- R2: Cash Flow / Current Liabilities;
- R3: Cash Flow / Total Assets;
- R7: Current Assets / Current Liabilities;
- R9: Current Assets / Total Assets;
- R31: Working capital / Total assets.

In the first part of the experiment, the effect of learning parameter on the duration of learning (epochs) was examined. As a learning set, the bankruptcy data were used. A sample of the same firm bankruptcy data served as a test data. Learning parameter α varied within the limits [0.1, 2.0]. Learning results are given in Fig. 5.

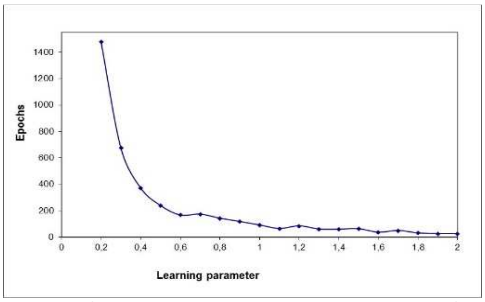

Fig.5. Graph of parameter's dependence on the number of epochs

By analyzing the results of learning, one can conclude that the algorithm converges at all the α values assigned but the number of learning cycles goes down as α value increases.

In the second part of the experiment, testing and analysis of learning algorithm execution depending on the value of potential, were performed. It was found that after the learning the points of the given test set were identified correctly, i.e., α values calculated in the course of learning enabled one to determine correctly the input data class: bankrupt or not bankrupt. After application of potential functions in the algorithm, the initial α values are equal to 0. If a point is not classified correctly during learning, the value of that parameter, is increased by 1. As a result of the experiment it was found that in bankruptcy data set there were 7 points for which correction of parameter α was performed most frequently during learning. Table II represents these points and the number of corrections performed at different α values. Note that at the rest α values the situation does not change essentially.

Table II.
Experimental results (misclassified cases and its λ parameter)

	α=0.3	α=0.4	α=0.5
Cases/λ	4/249	4/148	4/92
	8/274	8/153	8/94
	14/357	14/206	14/168
	26/393	26/212	26/112
	37/424	37/228	37/140
	50/482	50/265	50/165
	59/104	59/60	59/90

The correspondence is shown in the graphic form in Fig. 6.

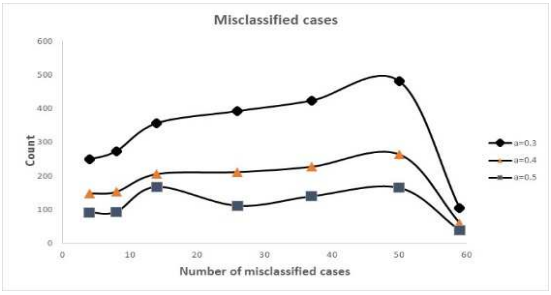

Fig.6. Misclassified cases dependence on the count of parameter λ

So, at these bankruptcy data misclassified cases for the case of potential functions are 4, 8, 14, 26, 37, 50, 59. Hence, a conclusion can be made that potential function method can be used for bankruptcy data analysis, such as neural networks [1], [2], [4], [8], [9], [13]. However, one has to be careful in interpreting the results.

IV. CONCLUSIONS

We have presented potential functions implementation possibility in bankruptcy prediction (the experiments have been performed in the Matlab environment). The experiments have shown that these methods can be viewed as alternatives to traditional bankruptcy prediction methods. Popular neural network models need significant parameter debugging resources to achieve valid results, whose correctness could be checked with traditional methods.

It can be concluded that different methods yield different results and they have to be analyzed carefully.

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The Pedagogical Potential of Information and Communication Technologies in the Formation of Ethnic and Cultural Awareness of Younger Schoolchildren

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Abstract. Modern social and cultural environment of educational institutions are characterized by multi-ethnicity, as well as the ambiguous attitude of one social group to the members of different cultural and ethnic communities. Therefore, one of the most important tasks is the education of children in the spirit of peace and respect for all nations and peoples; formation of communicative skills and ability to interact with the representatives of different nations and religions. Achieving this goal is possible thanks to targeted multicultural education, which targets are defined by state strategy in the field of inter-ethnic harmony and harmonization of interethnic relations. The authors emphasize the formation of ethnic and cultural awareness of younger schoolchildren: reveal the essence and structure of ethnic awareness, the diagnostics results of the formation level of its components with the primary schoolchildren, consider the possibility of using information and communication technologies in the classroom and in extracurricular activities.

The article reveals the pedagogical potential use of Internet resources in the creation of presentations, movies, virtual tours, virtual museums, thematic projects, Web-based quests and virtual newspapers. The features of the individual and group work organization and joint work with teachers and parents are considered.

Keywords: ethno-cultural awareness, educational process, primary school pupil, information and communication technologies.

I. INTRODUCTION

A characteristic feature of our time is the coexistence of people in a multicultural society. The peculiarity of Russia is that it has a population of more than a hundred indigenous peoples living in different territories since ancient times. Based on this, the most important task of modern pedagogy becomes the formation of personality, which has ethnic and cultural awareness, ready for intercultural interaction and cooperation, respect for the representatives of different ethnic groups and their cultures [11, 13, 14, 15].

Content analysis of research on this issue leads to the conclusion that the concept of "ethno-cultural awareness" and "ethno-cultural competence" are not identical. Ethno-cultural competence is formed throughout life and manifests itself in skills and models of intercultural communication (TV Poshtareva, AB Afanasyev, VG Krys'ko) [1,6,10]. At primary school age formation of its substantial bases - ethnic and cultural awareness is expedient (AR Georgyan, SV Mazharenko, SA Goncharov, LM. Kostin, IA Khomenko, LA Tkachenko) [2,8,12].

According to the definition given by PY Sokolova, by ethno-cultural awareness of primary school pupils is understood "integrative personal education, which consists in the adoption and understanding by primary school pupils a certain set of ethno-cultural ideas, concepts and knowledge to reveal positive, emotional and value-tolerant and respectful, peculiar to this age, attitude to the representatives to various ethnic groups and their cultures in the process of intercultural interaction"[11, p. eleven].

The scientist believes that the formation of ethnic and cultural awareness of primary school pupils should be carried out consistently, step by step, including mastery of ethno-cultural ideas, concepts and knowledge.

One of the means of formation of ethnic awareness of children of primary school age are information and communication technologies have become an integral part of education and allowing the maximum to implement the principles of clarity, accessibility and age-appropriate. It should be noted that one of the priorities of the new educational standards is to focus on the active use of information

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and communication technologies in education of younger schoolchildren. They involve the use of digital resources, online tools to access information and its usage to implement educational purposes.

The article focuses on the formation of ethnic and cultural awareness of primary school children in the course of acquaintance with the culture of the peoples living in the Nizhny Novgorod region.

II. MATERIALS AND METHODS

Having presented the theoretical foundations of the study, it is taken an attempt of the possibility to empirically substantiate pedagogical use of information and communication technologies in the formation of younger schoolchildren ethnic and cultural awareness comparing the results of diagnostic section of its components formation with the students in the control and experimental classes.

Defining the level of formation of ethnic and cultural awareness in young school-age children, we relied on the criteria: knowledge, existence and nature of interest, respectful and tolerant attitude towards representatives of various ethnic groups.

For each criterion qualitative characteristic of its establishment was given. Layered characteristic criteria are presented in Table 1.

Table 1
Levels of formation of ethno cultural criteria Primary school pupils awareness

Criteria	Levels
1) Knowledge of the field of culture of the peoples living on the territory of Nizhny Novgorod Region (Russian, Mordvinians, Tatars, Chuvash)	*High level* - availability and possession of ethno -cultural knowledge. *Middle level* - partial ownership of ethno-cultural knowledge. *Low level* - lack of understanding and a lack of ethnic and cultural knowledge.
2) The interest in the knowledge of the diversity of cultures and the acquisition of new information of ethno-cultural character.	*High level* - there is a stable demand for knowledge of ethno-cultural diversity and positive motivation to interact in a multicultural society. *Middle level* - manifestation of situational character in the knowledge of ethnic and cultural diversity and interaction with representatives of other nations. *Low level* - lack of willingness and needs in knowledge and interaction with representatives of other ethnic groups.
3) Respectful, tolerant attitude towards representatives of various ethnic groups and understanding of common culture.	*High level* - a manifestation of positive emotional responses to representatives of other ethnic groups in real situations. *Middle level* - fragile manifestations of positive emotional responses to representatives of other ethnic groups in real situations. *Low level* - lack of positive emotional responses to representatives of other ethnic groups in real situations.

To study the level of the criteria formation outlined above, the following methods were used: a questionnaire, which questions are based on questionnaires by EA Angarhaevoy, MB Kozhanova, SV Mazharenko, TV Poshtarevoy, PY Sokolova; monitoring, modification sociometry "Treat candy" (EK Suslova), the diagnostic task "Letter to a friend from other town" (based on diagnostic tasks by OV Dybina [4]).

III. RESULTS AND DISCUSSION

The empirical part of the study consisted of three phases. The aim of ascertaining stage of pedagogical experiment was to identify the level of formation of students' awareness of ethnic and cultural criteria at 3 "A" and 3 "B" classes. Experimental work took place on the basis of MBOU "School № 15", MBOU "School № 12" MBOU "School № 1" of Arzamas Nizhny Novgorod region. In the experiment, 138 students were involved. Control groups were set up for the implementation of the experimental purposes (CG), consisting of 69 students of class 3 "A", and the experimental group (EG), which also includes 69 pupils of 3 "B" class.

Diagnostics results of knowledge formation in the field of the peoples culture living in the Nizhny Novgorod region testify the low level for the majority of students (KG - 48 people, accounting for 69.6%, EG - 45 (65.2%)). Minor group consisted of students with an average level of knowledge (CG - 12 (17.4%), EG - 12 pupils (17.4%)). High level of knowledge was demonstrated only by 9 respondents CG - 13%, and 12 people EG, which accounted for 17.4% (see Figure 1.).

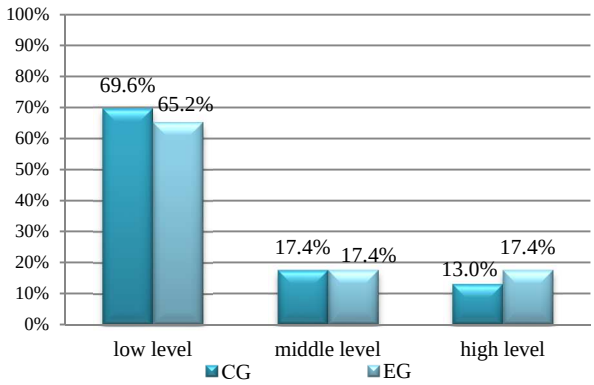

Figure 1. Maturity of knowledge from the field of the peoples culture living on the territory of Nizhny Novgorod region in the beginning of the experiment

In the context of the study of the presence of interest in the knowledge of cultures and the acquisition of new information diversity of ethno-cultural nature was detected motivation to acquire new knowledge and cross-cultural communication and interaction. Availability of motivation reveals the answers to the questionnaire.

The analysis results of the responses testify to the interest of all students (100%) in both groups in the study of folklore, crafts, celebrations of the peoples living on the territory of the Nizhny Novgorod

region. 30.4% of respondents CG (21 pupils) and 34.8% of EG (24 pupils) believe that to understand each other to the representatives of different nations help familiarity with their culture, folklore and traditions.

Analysis of students' responses to the survey questions (Do you want to learn the culture of their own and other peoples? Do you want to travel to another country?) revealed that a stable demand for knowledge of ethno-cultural diversity and positive motivation to interact in a multicultural society is characteristic of the 60 CG (87%) and 61 pupils EG (91.3%). Lack of desire and the need for knowledge and interaction with representatives of other ethnic groups were found in CG 9 pupils (13%) and EG 6 children (8.7%).

Determine the nature of the interest to know the ethnic and cultural diversity and positive motivation to interact in a multicultural society also contributed to the diagnostic task, "Letter to a friend from out of town." The interest in the knowledge of the diversity of cultures and the acquisition of new information, ethno-cultural character was found in almost half of the respondents (54 people CG - 78.3% and 48 EG - 69.6%), the rest of the students (15 persons CG-21.7% and 21 EG pupils - 30.4%) did not wish to write a letter, chat with a peer from another city. This situation made it possible to identify the students who agreed to interact with other people and children who have refused cooperation. Summary of results of the survey and the methodology presented evidence of the presence of children with situational interest in the knowledge of ethnic and cultural diversity and interaction with representatives of other nations. For these groups of learners is characterized by an average level of interest in the knowledge of the diversity of cultures and the acquisition of new information of ethno-cultural nature (9 pupils CG - 13% and 15 pupils EG - 21.7%).

The results identifying the level of interest in the formation of knowledge of the cultures diversity and the acquisition of new information of ethnic and cultural character are shown in Figure 2.

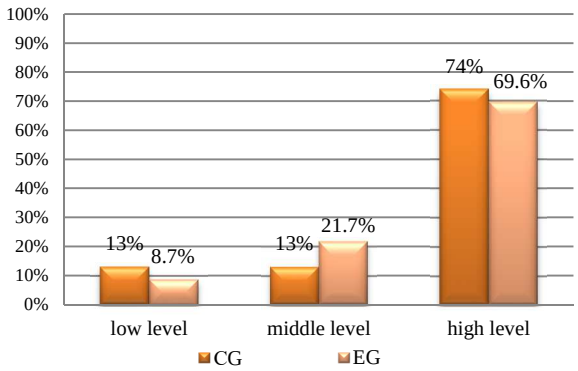

Figure 2. Levels of formation of interest to the knowledge of the cultures diversity and the acquisition of new information of ethno-cultural nature at the beginning of the experiment

The level of development of a respectful, tolerant attitude towards representatives of various ethnic groups and understanding of common groups was estimated on the basis of questionnaires and methodology "Treat candy."

Analysis of the resulting survey data showed that more than half of primary school respondents refer with pride and love to their native land (54 CG children - 78.3%, and the EG 60 children - 87%) and Russia (60 CG-87 children %, 63 students from the EG -91.3%). Note that among the respondents no one responded negatively and adversely about his native land and Russia.

The survey results allow to state that the majority of respondents (48 people CG - 69.6%, 54 persons EG -78.3%) believes that people of different nationalities are to live in peace, as the friendship between the peoples can help to bring peace on earth. The rest of the students (9 pupils CG - 13% and 15 pupils EG - 21.7%) believe that friendship between ethnic groups does not always help to bring peace on earth.

Most students expressed a desire to make friends with children of Tatar, Mordovia and Chuvashia nationalities (51 CG of respondents - 73.9%, and the EG 60 - 87%). However, some children did not choose as friends of other ethnic groups (18 CG of respondents - 26.1%, and EG 9 people - 13%), explained by the fact that they are not ready to communicate with the representatives of those nations, of which they know nothing.

Further, the diagnostic work, in order to identify the nature of the relationship to the children of other nationalities, we had a method of "Treat candy." Each child was asked to choose the person with whom he shared his candy. Children had to choose pictures that depicted children of Tatar, Chuvashian, Mordovian and Russian nationalities. Pupils were announced the names and nationality shown peers. Most children were happy to have completed the task, sharing sweets, and regardless of gender and nationality. Sweets were distributed to everyone equally. Usually, the students began handing out candy to those illustrations that were closest to them. Thus, we can say that the ethnicity of children depicted in the illustrations was not important for most of the children in the distribution of sweets.

Some children behaved selfishly, leaving most or all of the candy themselves. They gave preference to one ethnic group and refused to share the candy with the children of other nationalities.

Summarizing the results, we can conclude:

- 54 pupils CG and EG - 60, that is 78.3% and 87% of children, respectively, are friendly in their actions to all children in the illustrations, so depicted nationality of the child is not important for them;

- 9 pupils CG and EG 3 pupil, which is 13% and 4.3%, respectively, selfish, self-centered on their desires;
- 6 pupils CG and EG 6 pupils, this is 8.6% of the children treated only some of the children of certain nations.

So, in the ascertaining stage of the experiment a low level of formation of respectful, tolerant attitude towards representatives of different ethnic groups and understanding of common cultural is characterized by 13% and 4.3% of respondents in control and experimental groups (respectively - 9 children and 3 child CG EG), average-to 8.6% of respondents in each group (for 6 children), high – for 78,3% and 87% of respondents in control and experimental groups (respectively - 54 children and 60 CG EG children).

The results of the study of development respectful, tolerant attitude towards representatives of various ethnic groups and students' understanding of common sense are shown in Figure 3.

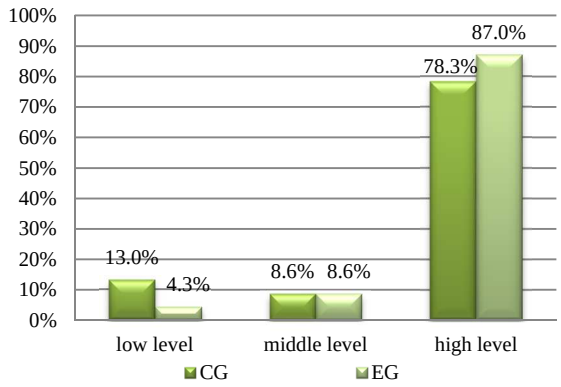

Figure 3. Level of development of respectful, tolerant attitude towards representatives of various ethnic groups at the beginning of the experiment

Carrying out of diagnostics has allowed to receive overview of the development level of the main components of ethnic and cultural awareness of primary school children. It should be noted that most of the younger students have an interest in the study of other cultures, in interaction with the representatives of other nationalities. However, further work is needed to build knowledge and develop a respectful, tolerant attitude towards representatives of various ethnic groups.

During the second phase of the experimental work the introduction of experimental class students to the culture of the peoples living in the Nizhny Novgorod region was carried out [3]. Formation of ethno cultural representations started with such means as: folk tales, folk toys, ornaments, dance, etc. Boosting children's interest helped work with the multimedia project "Russian Museum: Virtual Branch" that enabled visually introduce children to the history of Russian fine art and art of other peoples, their history and culture.

Children have been held a virtual tour on the theme "A friendly family of nations", "Nizhny Novgorod Region World peoples crafts", "The Magic of the national ornament" and others. Web quests have been proposed to consolidate the knowledge to students, in which they had to reproduce the knowledge about the elements ornaments Russian costumes, Mordovian, Tatar, Chuvash peoples, to make the national costume of the different elements to determine the nationality of the passage of a literary work (the fairy tale "The wolf and the goat" (Russian) "Eight leg's dog" (Mordovia), "Shah - cock" (Tatar) "," The Fox and the Woodpecker "(Chuvash)), household items. This educational tool was used in all phases of lessons and educational activities, as well as for the organization of independent work of students. It is important to note the role of the family. As part of the job quest require collaboration of the child and his parents, adults were indirectly involved in the educational process [5, 9].

During the lessons on the subject "The world around us" students performed a presentation of group projects "Russian (Mordovian, Tatar, Chuvash, etc.) the nation in the family of peoples of Russia". According to the results of the project groups of students a virtual newspaper was created, the content of which reflects the cultural elements of the peoples living in the Nizhny Novgorod region. The results of the children's work was reflected on the website of the educational project "Letopisi.ru".

To generalize and systematize the knowledge gained has allowed the children to work with electronic resources Dipity service - Ribbon time at which significant events in the history of the peoples are reflected in chronological order [7].

In the final stage we repeated diagnostics which was conducted using research methods presented earlier.

The chart below reflects the results of re-formation of the diagnostic cut-off levels of the above components of elementary school pupils of ethnic awareness.

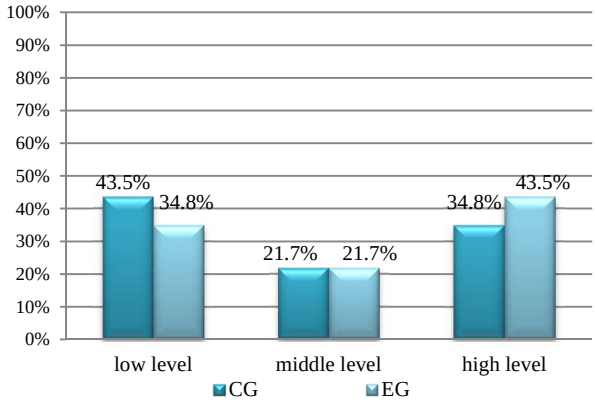

Figure 4. Maturity of knowledge from the field of culture of the peoples living in the Nizhny Novgorod region at the end of the experiment

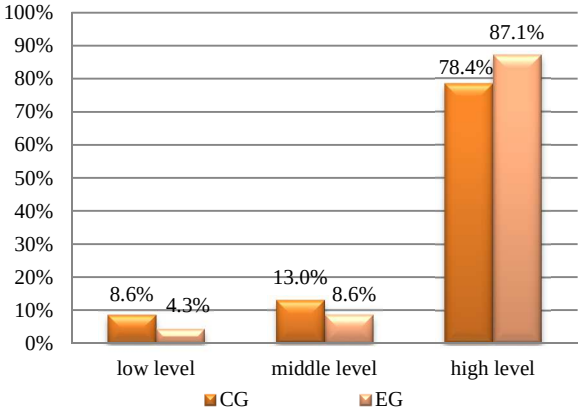

Figure 5. Levels of formation of interest to know the diversity of cultures and the acquisition of new information, ethno-cultural nature at the end of the experiment

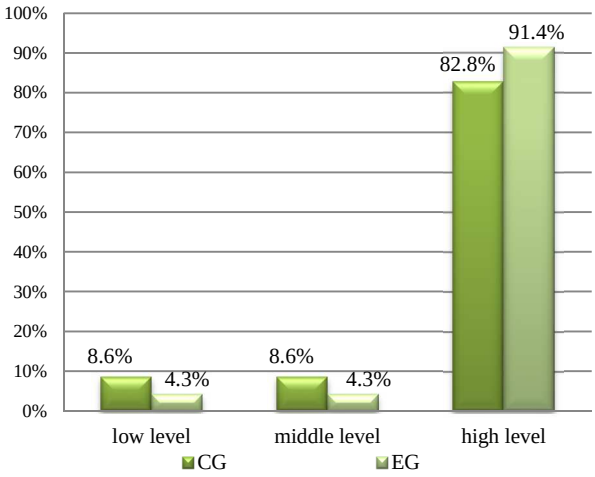

Figure 6. The level of development of a respectful, tolerant attitude towards representatives of various ethnic groups at the end of the experiment

IV. CONCLUSION

Thus, on the basis of the data presented, we can conclude that the positive dynamics in the formation of students' awareness of ethnic and cultural components, which demonstrates the effectiveness of the work was carried out with the use of information and communication technologies for the implementation of various educational and educational problems.

During pedagogical experiment observed the experimental class students were interested in the study of culture as their own and other cultures, understanding of the unity and uniqueness of cultures, the desire of many students to communicate with representatives of other nationalities and positive emotional value to display it.

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Rule Based Adaptation: Literature Review

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Abstract. Rule based adaptive systems are growing in popularity and rules have been considered as an effective and elastic way to adapt systems. A rule based approach allows transparent monitoring of performed adaptation actions and gives an important advantage of easily modifiable adaptation process. The goal of this paper is to summarize literature review on rule based adaptation systems. The emphasis is put on rule types, semantics used for defining rules and measurement of effectiveness and correctness of rule based adaptation systems. The literature review has been done following a systematic approach consisting of three steps: planning, reviewing and analysis. Targeted research questions have been used to guide the review process. The review results are to be used for conducting further research in the area of rule based context-aware adaptive systems. This paper accents the potential of using rules as means to perform adaptive actions in enterprise applications taking into account contextual factors as well as points challenges, difficulties and open issues for planning, developing, implementing and running of such systems.

Keywords: rules, rule based adaptation.

I. INTRODUCTION

Rule based adaptation systems have become very popular in last decades. In rule based adaptation systems adaptation actions are performed in form of rules – statements that tells system what is or what is not allowed or what should be done in particular situation. Rules have been considered as effective means for performing adaptive actions in different systems. The rule based adaptation systems have advantages of readability, transparency, elegance and they are easy modifiable by simply adding, removing or modifying rules [1]. Tran et al. in [2] emphasize that the most important advantage of using rules are the fact that rules can be managed and controlled by humans. Rubart in [3] also considers the ability of managing rules by both – humans and system components as an advantage.

The goal of this literature review is to explore the existing scientific literature on rule based adaptation systems. The sub goals are to explore the potential of using rules as means to perform adaptive actions in enterprise applications as well as to identify the shortcomings and open challenges for such systems.

The rest of the paper is structured as follows: section II describes the literature review methodology and research questions. Section III shows the results of the conducted literature review structured according to research questions defined in section II. Section IV gives some conclusions and observations about the analyzed literature.

II. MATERIALS AND METHODS

A literature review has been divided into three stages: planning the review, conducting the review and reporting the review [4]. In order to initiate the literature review, a literature review protocol has been developed (see figure 1). The review protocol ensures systematic and iterative approach for developing literature review by defining how each step of the review will be performed [5].

Following research questions (RQ) have been defined in order to guide analysis of literature:

- *RQ1: For what kind of software entities rules have been applied?*
- *RQ2: What types and semantic forms of rules have been used?*
- *RQ3: Application domains where rule based systems are used?*
- *RQ4: What kind of rule performance measures are used?*
- *RQ5: What are open challenges and potential solutions?*

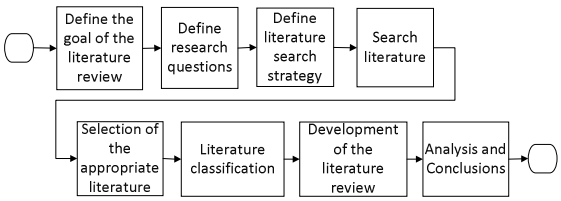

Fig. 1. Literature review protocol.

The literature search strategy includes following conditions:

- Research papers are searched in scientific data bases accessible for the authors: *IEEE, ScienceDirect, The ACM Digital Library, Springer Link*.
- *Key* words used for the search process: *adaptation rules, rule based adaptive systems, rule based systems, event-action rules.*

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- Publication years are limited from 2000 – 2017.
- Research paper types are limited to: *research papers, conference proceedings, periodicals, doctoral dissertations, technical reports and books.*

In total 112 papers were found from which 45 papers were selected for further analysis and inclusion into literature review.

The literature review results will be used as a base for further research in the area of rule based context-aware adaptive systems, thereby research questions have been defined based upon the specification of the approach to be developed.

III. RESULTS AND DISCUSSION

The literature review has been structured based on the research questions defined in section II. Due to the space limitations, only the most important results are described and summarized in this paper.

A. *RQ1: For what kind of software entities rules have been applied*

Rule based adaptation can be applicable for different type of systems and different adaptable software entities. One of the most popular adaptable entities is users interface. López-Jaquero et al. in [6] emphasize that adaptation rules allow to evolve the users interface in accordance with the evolvement of systems' users.

Rule based adaptive systems mostly focus on one particular type of software entities, e.g. processes, graphical users interface components etc. We assume that systems consist of standardized objects, such as classes, forms, procedures etc. These objects are referred as software entities and each of them can be context dependent. Rules can be defined for different kind of software entities. Following types of adaptable software entities in adaptation systems were identified in current investigations:

- **Process adaptation** – adaptable entities are processes or process schemas [7] - [8].
- **Workflow** and **service flow** adaptation - workflow and service flow technologies are widely used in complex processes in web applications to reach the flexibility. Workflow as an adaptation entity is described in [9] and service flow is described in [10].
- **Content adaptation** – adaptable entities are content parts such as pictures, text, command buttons etc. [11] - [12].
- **GUI/AUI adaptation** – adaptable entities are graphical users interface parts or audio interface parts. Often adaptation in this level is performed for complex GUI, especially in heterogeneous systems [13] - [14] and for systems used by users with disabilities [15] - [16].
- **Software configuration adaptation** – software as a whole can be configured based upon the received context information [12].
- **Features adaptation** – features can be both functional and technical components of the software, e.g. browser, desktop, Bluetooth [1].

The wide range of different software components adaptation performed in a form of rules proves the flexibility and usefulness of the rules.

B. *RQ2: What types and semantic form of rules have been used?*

Some papers discuss the rule based adaptation but do not specify the semantic form of rules used in proposed approaches. The most popular semantic form of rules used in rule based adaptation systems is Event-Condition-Action (ECA) rules with a typical form of *IF-THEN-(ELSE)*. Some authors have used a derivate form of ECA rules, e.g. Muller et al. in [9] uses form WHEN (event) WITH (condition) THEN (control action) VALID-TIME (time period), including condition about time period in which this control action is valid. The time parameter has been taken into account also in [7] and [17]. In [15] an extra parameter – description is used for better understandability of the rule. In [18] RuleML is used as the most suitable language for medicine related adaptive systems. This language ensures equally good readability for both – humans and machines. Some authors use their own rules languages or have adjusted existing rule languages for their specific needs. In [19] a combination of 4 languages is used for event based software components adaptation. One of the ways how to describe rule semantic and rules language components is a rules metamodel [6]. The identified semantic forms of rules used in rule based adaptation systems are summarized in Table I.

Table I
Identified semantic forms of rules used in rule based adaptation systems

Semantic form	Description	References
Event-Condition-Action rule	Defined in form IF-THEN-(ELSE).	[7], [9] - [10], [16], [20]
Association rules	Are used to describe the relationships between elements or variables	[21]
RuleML based behavioral rules	Language contains elements, individual constants, data values and complex expressions.	[18], [22]

Rules in rule based adaptation systems also can be classified based on the adaptation entity and situations when adaptation actions are performed. Such classification is summarized in table II.

Table II
Identified rule types used in rule based adaptation systems

Rule type	Description	References
Content analysis rules	Used to gather the information about objects, such as the size of command button can be calculated based on the number of characters used in command button.	[11], [15]
Content adaptation rules	Derived from the facts about the user. Content adaptation rules can be distinguished by the adaptable content type – text changes, pictures changes etc.	[11]
Corrective rules	Used to adapt the application in case if applications current configuration is not viable in current conditions.	[23]
Enhancing rules	Used to improve the existing activities which may work anyway but might work better. It can be achieved by changing the non-functional properties of the activity or by providing a new functionalities	[23]
Fuzzy rules	These rules are able to choose the most appropriate parameters based on heuristics. Fuzzy rules can contain IF-THEN structure.	[24] - [25]
Integration rules	Used to represent the business logic for integrating the components in a declarative manner at a high level of abstraction. They can be expressed in a form of ECA rules.	[19]
Monitor rules	Used to verify the service oriented systems behavior, systems services quality and context information that affects the services used in the system and the system itself.	[17], [26]
Production rules	These rules are more appropriate for context-aware adaptation systems – rules are suitable for reacting to newly received context information.	[12]
Matching rules	These rules are used in matching processes and they consists of several parts – pattern, action, relevance function and an optional check function.	[8]

C. RQ3: Application domains where rule based systems are used?

Rule based adaptation systems are widely used in different area domains what reaffirms the benefit of such systems. In the literature reviewed, rules have been applied for the following domains: travel scenarios development systems [10], [23], different web applications, e.g. online auction site [27], medicine related systems [9], [18], smart building systems [28], specifically adjustable systems for people with disabilities [15], [29], mobile device applications [30] and others.

The usage of rules is not limited to adaptive systems. Rules are also used in data cleaning systems [31], software configuration management systems [32] and expert systems [25].

D. RQ4: What kind of rules performance measures are used?

In order to evaluate the quality of rules and the quality of the performed adaptive actions, several measures have been identified in analyzed literature:

- **Confidence value** has been calculated based upon collected users' feedback about the executed rule. Each time when positive feedback is fixed, rule's confidence value is increased. In the case of negative feedback, a new appropriate rule can be generated or other more appropriate rule from the existing rule set can be chosen and its confidence value is increased [20].
- **Rule Weight** [35], and **Priority** [34] measures can be used when several rules fit for one context situation – then a rule with the highest weight or priority can be executed.
- **Check function** is used when the rule is executed. It allows to evaluate the quality of executed adaptation action initialized by the rule [8].
- **Similarity degree** [35] and **Average Fitness Value** [36] are used to measure the quality of automatically generated adaptation rules.
- **Case based reasoning** cycle can be used to evaluate the rules quality and improve the rules by searching similar rules from which new rules can be generated [33].
- Executed adaptation actions initialized by the rules can change systems metrics, e.g. response time, process execution time etc. These **system metrics** can be used to evaluate the quality of the executed adaptation rules [34].
- **Users' preference** can be fixed during the execution of recommended adaptive action – if user choose to execute the recommended action or prefers to execute another action [1].

Most of the Rule based adaptation systems use one particular approach for evaluating the quality of the adaptation rules or executed adaptation actions, thought combination of different approaches and rules quality measurements can ensure more accurate evaluation process and results.

E. RQ5: What are the open challenges and potential solutions?

Despite the fact that rule based adaptation systems are popular and they provide many advantages, there are also a number of limitations. For instance, Zhao [33] emphasizes that adaptation rules are often defined in advance with insufficient knowledge about executable actions what leads to poor performance of the rules when the system is in dynamic environment does not behave as expected. Following challenges of using rules have been identified:

- More than one rule fits one context situation: potential solutions are (1) to assign a static of

dynamic priority to rules and to execute the rule with the highest priority [23], [34]; (2) rules can be executed in non-deterministic order [23]; (3) if possible, rules can be combined and executed simultaneously [34].

- A set of rules contains rules with equal IF part and different THEN part. Such rules are called conflicting rules [24]. Throughput can be taken into account and a rule with the highest throughput can be executed. In [20] conflicting rules can be clustered into one cluster and ranked according to their usage frequency. In [9] such problem can be solved by combining the executable actions, but in most cases there will be incompatibility, so there are no method for solving this problem completely.
- In an automatic rules generation process, a large number of rules can be generated. The challenge is to extract worthy rules. It can be solved by a two-step solution – in the first step duplicate rules can be identified. In the second step those who have equal IF part and different THEN part can be processed [20] as described previously.
- During the lifetime of adaptive system, a large amount of adaptation rules can gradually arise. To address this concern, Virgilio et al. [12] defines the optimization strategy based on a rule clustering technique. Rules clustering in clusters based on the type of affected context allows to manage the rules and to apply an effective rules search process.

Existing literature proves that open challenges still exists for using rules in adaptive systems, thereby there is a potential for improvement of such systems and approaches.

IV. CONCLUSIONS

This paper presents the shortened form of the results of the literature review on rule based adaptation systems. The literature review results are divided into research questions and each research question leads to some insightful observations and conclusions.

The literature review highlight popularity and broad applicability of rules for adaptation of systems. Rules are used to adapt software entities of different kind, type and granularity level what indicates that rules are flexible and uniquely means how to perform adaptive actions. Nevertheless, some shortcoming and open challenges of using rules were identified during the literature analysis.

The results of the literature research summarize important information about the adaptation rules and rule based adaptation systems and this information will be further used to develop a new approach for adaption of context-aware software entities using rules.

V. ACKNOWLEDGEMENTS

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Experience of Obtaining the Plan of Experiments, with Using Models of Interaction of Charged Particles

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Abstract. In this article a method of obtaining an experiment plan in a fragment of multidimensional space is analyzed and improved. The method is based on an assumption that particles will distribute evenly in an infinite space with constant charged particle density. To obtain the experiment plan, the infinite multidimensional space is replaced with a hypercube whose surface models influence of the surrounding infinite space. Software is developed and practical results in obtaining experiment plan in two-dimensional space are acquired. Two-dimensional space allows developing of a methodology and algorithm for obtaining experiment plan while providing a simple visualization of the solution. Acquired results in two-dimensional space give an opportunity to create methods for obtaining experiment plan in a hypercube of multidimensional space.

Keywords: Experiment plan, charged particle interaction, Latin cube, Hypercube, Uniform distribution.

I. INTRODUCTION

Computerized mathematical modeling and metamodeling constitutes an increasingly important role in the development of technical objects and systems. An indispensable part of computerized modeling is the experiment plan [1].

The classic experiment planning method anticipates all variables, except one that is changed during the experiment, to be recorded beforehand, which is the basis of univariate experiments. To use univariate experiment for general research in multivariate processes, a large amount of experiments must be performed. This type of approach is not advisable while researching multivariate systems due to the amount of experiments necessary. To perform multivariate experiments it is necessary to use static experiment planning methods. Algorithms and different mathematical methods are necessary, while formalizing research action and choosing the strategy that gives an opportunity to make important decisions after each series of experiments, to lower the amount of possible experiments.

Experiment plan obtaining is often based on Latin hypercube methods [2] and [3]. Latin hypercube is usually used to acquire experiment plan for an experiment with two to four independent variables. As a result of the rapid development of technology it has become necessary to obtain experiment plan for experiments with eight, ten or even more independent variables. With such a large number of variables Latin hypercube method loses its efficiency. Consequently, it is necessary to research and develop other approaches for obtaining experiment plan [4].

In the end of last century a scientist from Riga Polytechnic Institute - V. Eglājs - suggested that charged particle coordinates in equilibrium state could be used as an experiment plan (in finite space) [5].

II. MAIN ASSUMPTIONS

Article [5] describes how an experiment plan can be obtained by modeling particle interaction in a hypercube whose surface models influence of the surrounding multidimensional infinite space. Figure 1 shows research schema for two-dimensional (square) case.

Replacing the infinite space with a square whose surface imitates the influence of the surrounding space causes a methodic mistake, which needs to be minimized. In this article two methods for replacing the infinite space are analyzed [5]:

- Wallpaper – part of the space, which infinitely repeats itself (Fig. 2. a).
- Mirror – part of the space, which does not allow charged particles to leave the space by creating mirror images of the particle (Fig. 2. b).

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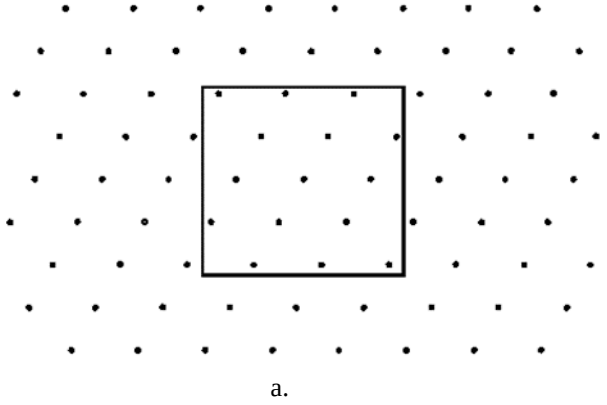


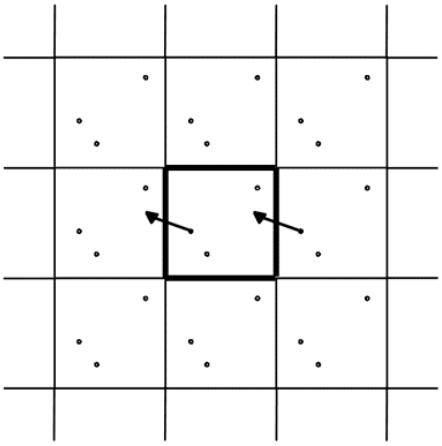
a.

b.

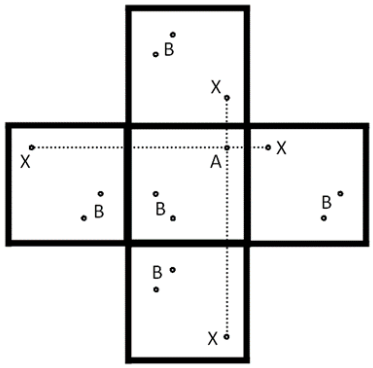
Fig 1. Research schema [6]. a. Square as a fragment of an infinite two dimensional space. b. Square and its perimeter area that imitates the influence of the surrounding infinite space.

III. CALCULATION SCHEMA

A calculation area is chosen which contains a certain number of electrons. Around the perimeter of the chosen area identical areas with matching particle (phantom) positioning are placed. One or more phantom rings can be placed around the calculation area. Phantom particles move analogous to the corresponding particle in the calculation area.



a.



b.

Fig. 2. Replacing of an infinite two-dimensional space with a square and an imitator of the effects of the surrounding space [7]**.** a. Replacement method "Wallpapers", b. Replacement method "Mirror"

Figure 2 shows that if as a result of calculation a particle is pushed out of the calculation area it becomes a phantom, while another particle (phantom) enters the calculation area replacing the particle that was pushed out.

IV. SINGLE CHARGED PARTICLE DISPLACEMENT CALCULATION SCHEMA

Calculations are made for each particle by determining the particles coordinates at its equilibrium state as shown in Figure 3.

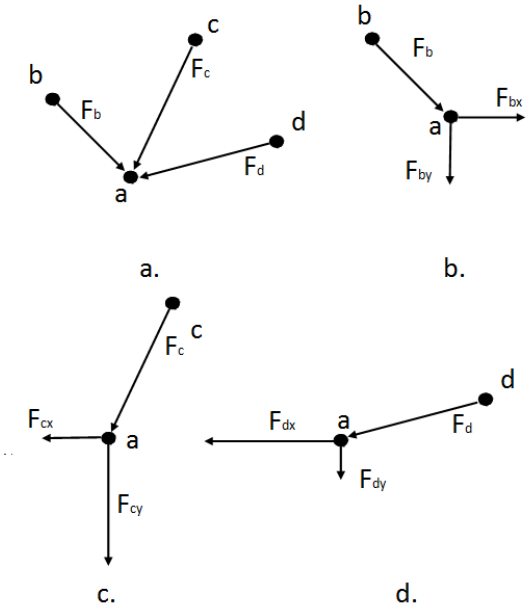


Fig. 3. Finding the equilibrium state of a charged particle [8]

To determine the new coordinates for the particle *a*, we need to find and calculate the following:

- All forces that affect the particle - F_b, F_c, F_d. (2. att. a)

$$F_{ai} = C\frac{1}{r_{ai}^2}, \text{ where} \qquad (1)$$

- a – charged particle;
- C – coefficient;
- r_{ai} –distance between particle a and particle i (b, c, d);
- Forces are divided into components x and y – $F_{bx}, F_{by}, F_{cx}, F_{cy}, F_{dx}, F_{dy}$. (Fig. 2. b, c, d);
- Cumulative force F_x is calculated for the particle:

$$F_x = F_{bx} + F_{cx} + F_{dx} \quad (2)$$

- Cumulative force F_y is calculated for the particle:

$$F_y = F_{by} + F_{cy} + F_{dy} \quad (3)$$

- Absolute cumulative force that is affecting the particle:

$$F = \sqrt{F_x^2 + F_y^2} \quad (4)$$

- Particle is moved a certain distance l, for example, half of the distance to its nearest neighbor;
- The new coordinates of the particle are determined by dividing displacement of the particle into its vector components.

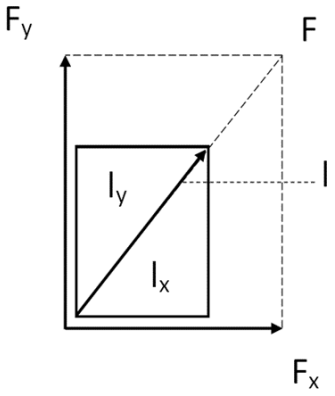


Fig. 4. Determining displacement l_x and l_y

$$l_x = \frac{F_x}{F} * l \quad (5)$$

$$l_y = \frac{F_y}{F} * l \text{ , where} \quad (6)$$

- l_x – displacement on x axis;
- l_y – displacement on y axis;
- F – cumulative force;
- F_x – force on x axis;
- F_y – force on y axis;
- l – displacement of the particle;
- Each particle is moved until the displacement no longer lessens the force that is affecting the particle, or energy level of the entire system no longer decreases. Then the positioning of the charged particle is optimized.

The proposed method also makes it possible to obtain experiment plans containing concentration or distribution in specific areas of the calculation area. Using this special approach, the process can be improved if the optimal particle distribution area for obtaining experiment plan is known. This can be easily achieved by assigning charged particle coordinates in calculation as a function.

$$F = \frac{q_1(x,y) * q_2(x,y)}{r^2} \quad (7)$$

By assigning the value of the charge as a function q=q(x, y) of coordinates x and y, it is possible to obtain experiment plan with a concentration in areas where the value of q(x, y) is low or with a distribution in areas where the value of q(x, y) is higher.

V. ITERATIVE PROCESS OF CHARGED PARTICLE DISPLACEMENT

To acquire experiment plan or normal distribution of charged particles in multidimensional hypercube calculations are made that are analogous to a theoretical experiment. At first, all charged particles are freely distributed. Coordinates of these particles can be generated using random number generator or using different types of functions as input parameters. Phantom areas that imitate the surrounding infinite space are placed around the perimeter of the calculation area. Whenever a particle in the calculation area is moved, the corresponding particle in the phantom areas is also moved. When calculating the displacement of a particle all phantoms of that particle are taken into account.

The following process executed for all charged particles:

1. Position of all particles is recorded;
2. Particle whose displacement will be calculated is determined;
3. New coordinates, where cumulative force affecting this particle is zero or as low as possible, are calculated for the chosen particle taking into account other particle effect and all phantom particle effect in all phantom areas on the chosen particle;
4. Phantom particles of the chosen particle are adjusted based on new coordinates;
5. It is determined whether the placement of the particle at its equilibrium state improves the quality of the entire system - will this reduce the absolute amount of unbalanced forces in the system, equalizing the distance between particles;
6. Return to step 1.

This process is used to iteratively optimize positioning of all particles and the state of the entire system. Executing a final number of iterations a particle positioning is obtained that is close to normal distribution. Quality indicators of the particle normal distribution are:

- Cumulative force that affects the particle and that cannot be minimized;
- Distance from the chosen particle to the nearest charged particle;
- Vectorial sum of the interaction forces in the system;

- Sum of the interaction forces on each of the axis;

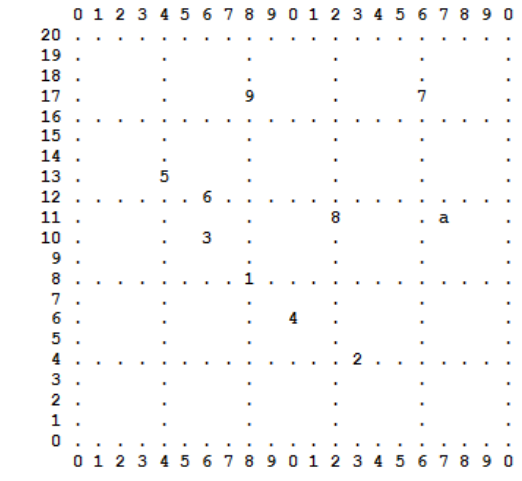
Practical implementation of methodology provides both optimization of charged particle coordinates in a single iteration and iterations for single particle state optimization. The latter gives an opportunity to, for example, select particles that have a distance to the nearest particle that is larger than the average distance and optimize coordinates for these particles several times, thus increasing convergence of the solution.

Numerical calculations show that in separate cases the system reaches a state where optimization process stops. In these cases the convergence of the process can be restored by freely changing the coordinates of some particles (creating a mutation as in genetic algorithm).

Proposed methodology is practically realized by creating software, many experimental calculations are made and practical results are obtained.

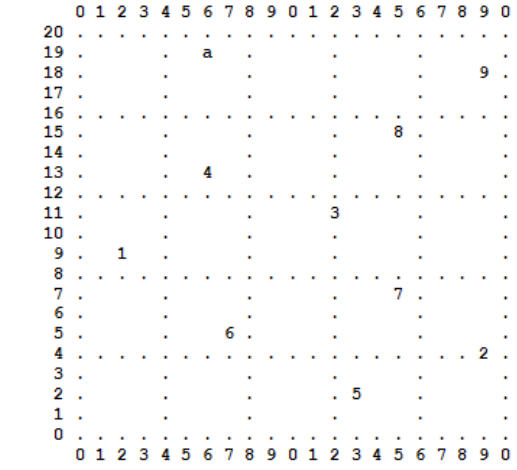
VI. PRACTICAL RESULTS AND CONCLUSION

Described methodology was practically implemented and software was created. Calculations were made to obtain experiment plan in two-dimensional space (see results in Figure 5 and Figure 6).



i	f	fx	fy	Rmin
1	3.00E+0001	-6.06E+0000	-2.94E+0001	0.14
2	2.87E+0001	2.46E+0001	-1.48E+0001	0.22
3	8.99E+0001	-4.37E+0001	-7.86E+0001	0.10
4	5.64E+0001	2.42E+0001	-5.09E+0001	0.14
5	7.56E+0001	-5.24E+0001	5.44E+0001	0.14
6	8.18E+0001	1.23E+0001	8.08E+0001	0.10
7	1.04E+0001	8.90E+0000	5.30E+0000	0.32
8	3.16E+0001	2.67E+0001	1.69E+0001	0.25
9	1.96E+0001	1.28E+0000	1.95E+0001	0.28
10	2.56E+0001	-3.24E+0001	2.43E+0001	0.15
Sum	5.28E+0000	4.21E+0000	-3.19E+0000	0.30

Fig. 5. Starting position of 10 points in calculation area.



i	f	fx	fy	Rmin
1	6.41E+0000	-3.49E+0000	5.38E+0000	0.28
2	1.01E+0001	8.54E+0000	-5.43E+0000	0.26
3	2.23E+0000	-1.54E+0000	-1.62E+0000	0.24
4	1.43E+0000	-1.43E+0000	-6.43E-0002	0.28
5	3.93E+0000	-3.07E+0000	2.46E+0000	0.25
6	2.34E+0000	-1.10E+0000	2.07E+0000	0.31
7	9.66E-0001	-6.25E-0001	7.36E-0001	0.24
8	1.92E+0000	-1.90E+0000	2.88E-0001	0.24
9	1.03E+0001	8.60E+0000	-5.64E+0000	0.30
10	4.39E+0000	-3.99E+0000	1.82E+0000	0.30
Sum	4.40E+0001	3.64E-0011	1.36E-0010	2.72

Fig. 6. Position of 10 points after 25 iterations in calculation area.

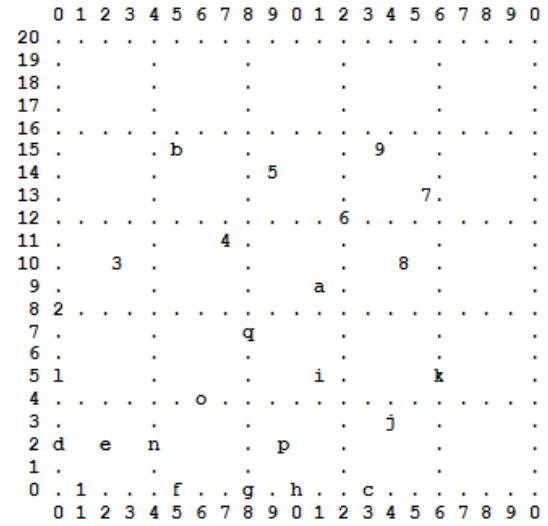


Fig. 7. Example of an experiment plan with a particle concentration around the coordinates (0, 0).

It must be noted that the quality and sped of the replacement method „Wallpapers" is dependent on charged particle (experiment) amount – the amount of charged particles in the calculation area might be detrimental. It was empirically detected that, if result cannot be found due to poor convergence of the method, it is necessary to increase the amount of phantom rings around the calculation area to obtain a qualitative experiment plan. I was also empirically detected that by changing the parameters, the location of the particle in the calculation area can be adjusted as needed. Even though several qualitative results are

obtained using calculation schema, methodology still needs to be optimized.

Following conclusions can be made:

- Experiment plan obtaining method based on charged displacement modeling was practically implemented;
- The developed method is implemented in the Java programming language and it can be used just like other methods [1];
- Developed method was tested for experiments in two-dimensional space. It can be easily used for a larger number of dimensions;
- Method can also be used to obtain an experiment plan for unevenly distributed particles. In this case the charge of the particle must be defined as function of coordinates;
- The results acquired are interesting and the work on the methodology should be continue.

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Auto-scaling and Adjustment Platform for Cloud-based Systems

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Abstract. For customers of cloud-computing platforms it is important to minimize the infrastructure footprint and associated costs while providing required levels of Quality of Service (QoS) and Quality of Experience (QoE) dictated by the Service Level Agreement (SLA). To assist with that cloud service providers are offering: (1) horizontal resource scaling through provisioning and destruction of virtual machines and containers, (2) vertical scaling through changing the capacity of individual cloud nodes. Existing scaling solutions mostly concentrate on low-level metrics like CPU load and memory consumption which doesn't always correlate with the level of SLA conformity. Such technical measures should be preprocessed and viewed from a higher level of abstraction. Application level metrics should also be considered when deciding upon scaling the cloud-based solution. Existing scaling platforms are mostly proprietary technologies owned by cloud service providers themselves or by third parties and offered as Software as a Service. Enterprise applications could span infrastructures of multiple public and private clouds, dictating that the auto-scaling solution should not be isolated inside a single cloud infrastructure.

The goal of this paper is to address the challenges above by presenting the architecture of Auto-scaling and Adjustment Platform for Cloud-based Systems (ASAPCS). It is based on open-source technologies and supports integration of various low and high level performance metrics, providing higher levels of abstraction for design of scaling algorithms. ASAPCS can be used with any cloud service provider and guarantees that move from one cloud platform to another will not result in complete redesign of the scaling algorithm. ASAPCS itself is horizontally scalable and can process large amounts of real-time data which is particularly important for applications developed following the microservices architectural style. ASAPCS approaches the scaling problem in a nonstandard way by considering real-time adjustments of the application logic to be part of the scalability strategy if it can result in performance improvements.

Keywords: cloud computing, auto-scaling, microservices, big data.

I. INTRODUCTION

Cloud computing platforms provide a virtually unlimited pool of computing power and storage resources for hosting various enterprise applications. Customers of such platforms are charged by the amount of resources they have used on a pay-per-use basis. Therefore, it is important to minimize the infrastructure footprint and balance it with the required level of Quality of Service (QoS) and Quality of Experience (QoE). Usually this is achieved by scaling the application up during peak times and removing the surplus of resources later. To assist with that cloud service providers are offering Application Programmable Interfaces (APIs) that support:

1. horizontal resource scaling by changing the number of currently running virtual machines or containers (e.g. add two more web-server nodes),
2. vertical resource scaling by changing the capacity of individual cloud hosted nodes (e.g. increase the RAM by 2GB and add 2 CPU cores).

Existing scaling solutions mostly concentrate on low-level metrics like CPU load and memory consumption which doesn't always reflect the actual QoE. Such metrics should be preprocessed and joined with high level application metrics when deciding whether the cloud based solution should be scaled up or down. Most of currently available scaling platforms are proprietary technologies owned by cloud service providers or third parties. Even if the enterprise application is designed in a platform-independent way, changing the cloud service provider might result in redesign of the applied scaling algorithm. Complex enterprise systems could also be hosted in multiple clouds, both private and public, dictating that the auto-scaling solution should not be isolated inside a single cloud platform. It could span multiple public clouds and some parts of it could be deployed on premises. The chosen deployment model should not be dictated by the limitations of the auto-scaling platform; it should be the choice of the software architect. Although there are existing specialized scaling platforms that are cloud-independent, they are proprietary technologies that come with the risk of vendor lock-in. Their extendibility is limited due to the closed source.

Design of such platforms is challenging because of the scalability requirements and the amount of real-time data that needs to be integrated and

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processed for decision-making purposes. This can be even more complex for applications designed in microservices architectural style, since each service acts as a data source with one or more measurable properties.

The goal of this research is development of the Auto-scaling and Adjustment Platform for Cloud-based Systems (ASAPCS) that addresses the challenges described above.

The structure of this work is as follows. Section II gives a brief look at the related work in scalability, microservices and concepts of Capability Driven Development (CDD). Section III defines the requirements for the auto-scaling platform. Section IV describes the overall architecture of the platform in a technology independent manner while Section V looks at the technological stack that was used to build the first prototype of the platform. Section VI concludes with final remarks and future work directions. Section VII contains acknowledgments.

II. RELATED WORK

Most of the academic work in the area of scalability is concentrated on scaling algorithms and strategies aiming at maximizing the performance metrics and minimizing the related costs or on architectures that should be applied to ensure that the application would effectively scale. Auto-scaling strategies are categorized as [1]:

- reactive – a scaling operation is performed immediately as soon as performance values have fallen out of a previously defined interval during the last time window,
- conservative – a scaling operation is performed if during the last few time windows performance values have fallen out of a previously defined interval,
- predictive – performance values for the next time window are predicted and acted upon similarly as with the reactive strategy.

The step of the scaling operation can be fixed (e.g. one node at a time) or adaptive (based on the difference between current demand and resource capacity).

There has been little research done on executing scaling algorithms in production environment for large scale applications that require real-time analysis of big amounts of data. When scaling cloud-based systems, the auto-scaling platform must also be made of components that can scale horizontally, ensuring its resilience and scalability [2]. The auto-scaling platform must scale together with the applications or it will become the single point of failure and the bottleneck of the whole solution.

There have been developments in the area of platforms providing auto-scaling, however, most of them lead to vendor lock-in. Notable examples are platforms by the major cloud service providers - AWS Auto-scaling, Microsoft Azure auto scale and Rackspace Auto Scale. These auto-scaling solutions are tied to the underlying cloud computing platforms and services. Therefore, moving from one cloud service provider to another might result in redesign of the scaling solution. There are other options like RightScale and New Relic which are not limited by the use of a single cloud computing platform, however both are proprietary technologies being offered in Software as a Service (SaaS) model and their users have to consider threats arising from the vendor lock-in. Since these are closed-source programs they can't be easily extended. Kubernetes, an open-source platform for orchestrating containers, provides basic auto-scaling capabilities. Similarly, simple auto-scaling scenarios can be implemented on Mesos using Marathon, however this is not the main concern of the platform. In both cases the auto-scaling functionality can only be used for container-based solutions hosted on the specific platforms, which is not suitable for systems spanning multiple environments.

Developments in the area of auto-scaling platforms can be especially beneficial for applications designed following the increasingly popular microservices architectural style. Microservices have become a dominant architectural style choice for service oriented applications [3]. Traditionally cloud based systems are divided into service groups like database, web and application. Those groups consist of homogenous servers that can be scaled independently of other groups. This approach gives a certain level of control and allows to scale up just the web server if there is lack of capacity in this specific tier. In reality this might lead to inefficient use of resources and waste of money. For example - if extra resources are needed just for the video transcoding process, the only option to achieve this might be to scale up the whole application server cluster. In reality this might turn out to be a significant overhead since application servers might be running many other processes which were having no lack of capacity. Microservices, being a cloud-native architecture [4], address this challenge by dividing the system into small and lightweight services that are purposely built to perform a very cohesive business function, and it is considered to be an evolution of the traditional service oriented architecture (SOA) [5, 6, 7]. Scalability is often mentioned as one of the advantages of the microservice architecture and it is quite obvious since in terms of architecture it gives a fine-grained control over how application scales during varying load. Unfortunately, still very little research is done in the area of microservices [3, 8] and even less so on their scalability.

Kukade et al. [9] and Toffetti [2] are among few investigations done in the area of microservice auto-scaling. The work by Kukade et al. [9] is the only literature source covering auto-scaling aspects from ones reviewed in the systematic mapping study done

by Pahl [8]. Yet Kukade [9] only briefly covers the auto-scaling aspects and puts more emphasis on containerization as a suitable technology for implementing microservice architecture. The main parts of their solution are:

- Service Container Monitor – providing container health checks and detecting faulty containers,
- Request Monitor – counting the number of requests each container receives,
- Memory Load Monitor – measuring container's memory consumption,
- Scale – adding extra containers when existing ones have reached the top threshold of used memory and received requests, removing containers when the bottom margin is reached.

Little information is provided about the implementation of auto-scaling solution. Also the number of requests and memory consumption will not always provide a good correlation with SLA and might result in inefficient use of resources, therefore it can be concluded that proposed solution will be useful only in very specific scenarios.

Toffetti et. al [2] propose an architecture for auto-scaling microservices. To specify the relation between various service groups and instances a service type graph and instance graph is used (see Fig. 1).

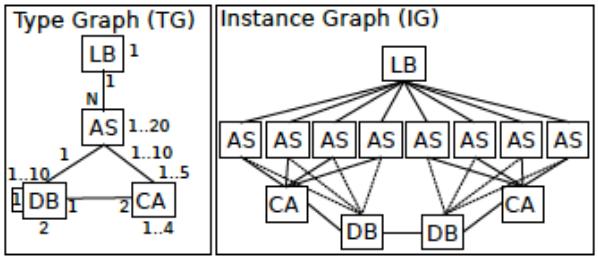

Fig. 1. Type and instance graphs [6]

The type graph defines service groups and their corresponding scaling limits (e.g. each database server, DB, is linked to exactly two caching instances, CA, there are 1 to 5 database server instances, DB) while instance graph keeps track of active instances (e.g. currently 4 database server instances are online). The graph data is stored in etcd, a distributed, consistent key value store. All cloud based components are aware of their type and can discover other nodes by using the etcd directory where they are registered upon deployment. The architecture makes sure that the required number of cloud nodes are online through provisioning of new ones and monitoring their health. Although the proposed solution might work well in some scenarios, it would be hard to implement complicated scaling algorithms and debug them.

The goal of the majority of auto-scaling solutions is achieving the desired QoS levels. Hoßfeld et. al [10] have concluded that QoE as perceived by users has the potential to become the guiding paradigm for managing quality in the cloud. We strongly support this opinion and propose to use some of the concepts of CDD (Capability Driven Development) [11] in scaling microservices, since they are organized around capabilities [5]. CDD aims at capturing the relation between context and capabilities enabled by information systems (IS) and adjusting the IS according to the contextual situation. Capability can be defined as the ability and capacity that enable an enterprise to achieve a business goal in a certain context. The fluctuations in application load could be considered as examples of varying context of the application while scaling of an application is an example of real-time adjustment. CDD provides ways for altering the business logic of the IS based on the contextual situation during run-time. This approach could also be applied in the auto-scaling problem area. Since QoE could be even more important than QoS, run-time adjustments in the business logic of application itself could become part of the auto-scaling strategy allowing to achieve results that wouldn't be possible by using infrastructure level adjustments all alone. Changing internal logic of the application in response to increased load (e.g. data consistency level in the database tier or limiting the free service when requests from paid customers are not served properly) could result in higher number of served requests while ensuring smaller infrastructure footprint.

III. REQUIREMENTS FOR THE AUTO-SCALING PLATFORM

This section lists the requirements for the auto-scaling platform that are largely derived from the previous section and review of related work in the area of scalability, microservices and CDD:

- QoE above QoS – the platform should facilitate constant monitoring of the QoE and QoS,
- Real-time data integration and processing – the platform should be capable of processing and analyzing large amounts of real-time data originating from application and infrastructure nodes,
- Windowing support – the platform should be able to provide basic windowing functionality (e.g. sliding window),
- Scalability and resilience – the platform should be resilient and scale together with the system that is scaled by it,
- Machine learning capabilities – in order to allow predictive scaling of applications platform should provide machine learning functionality,
- Graph processing capabilities – since distributed application is often described by type and instance graphs the platform should be capable of processing them,

- Abstraction – in order to develop the algorithms independently of cloud computing platforms and data sources a level of abstraction should be established,
- Run-time improvements of algorithms – users should be able to alter the behavior of scaling algorithms during run-time,

Open-source – platform should be based on open source technologies thus avoiding risks of vendor lock-in and facilitating extendibility of the platform.

IV. ARCHITECTURE

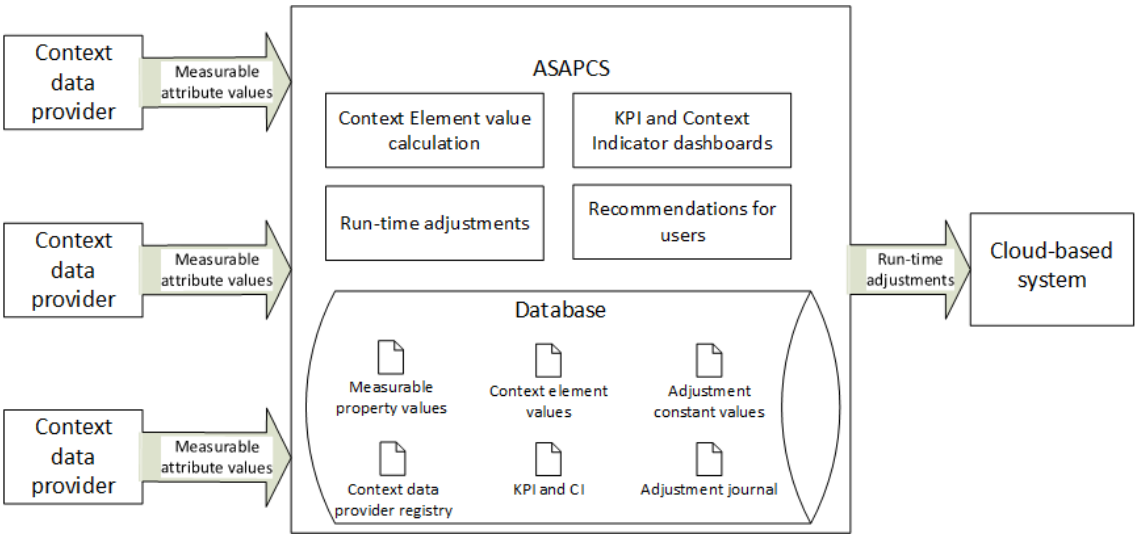

Fig. 2. Overview of the ASAPCS components

The architecture of the ASAPCS is largely inspired by the CDD approach [11] therefore it uses term "context" to address all information that can be used for scaling the application while actual scaling operations are referred to as run-time adjustments. Main components of the ASAPCS are illustrated in Fig. 2 and related concepts are discussed below.

Context data providers (CDP) are entities providing availability of the context data. Examples of CDP are monitoring tools like Zabbix and customized agents providing information about various aspects of the application performance and infrastructure. CDP is responsible for providing information about the current contextual situation. There is no need for the CDP to store historical data since ASAPCS takes care of that, which means that a relatively small effort is needed to create a CDP.

The contextual data provided by CDP is further divided into measurable properties (MP). An example of MP is the current queue length or memory consumption. Generally, MPs are data of low granularity that needs to be preprocessed and aggregated to be used in scaling algorithms.

While changing the granularity of MP it is transformed into a Context element (CE) – entities positioned at higher levels of abstraction that are not directly linked to a single CDP anymore. A typical example of CE could be an average number of visits during last minute with a sliding interval of 5 seconds (CE value is recalculated once in every 5 seconds). CEs could also be created as compound structures consisting of multiple MPs – for example a server load CE measured as high, medium and low could be expressed as a function from memory consumption and CPU usage. In a similar way as MPs, historical values of a CEs are stored in a temporal database of ASAPCS. New CEs can be defined even after the data collection has started. Values of the newly created CEs can be recalculated from the historical values of MPs available in the temporal database.

Another concept that has been derived from the CDD is Adjustment Constant (AC). The value of the AC can be changed during run-time by the user and it can be used to alter the scaling algorithm (for example change the interpretation of what is considered high, medium and low server load).

Run-time adjustments (RTA) are used for ASAPCS initiated scaling operations. Technically it is an in-code defined scaling algorithm that uses values of the AC and CE as input parameters. RTAs are used for transforming manually scalable solutions into ones that scale automatically based on the contextual situation. Thanks to the CE abstraction RTAs are not coupled to the CDPs therefore moving the system from one cloud to another would not result in the complete rewrite of the scaling algorithm. Only actual calls to the cloud platform scaling API might need to be rewritten. In theory these can also be abstracted using interfaces and their platform-specific realizations. Each scaling operation performed by the

run-time adjustment algorithm is logged to the adjustment journal for later reviewing. RTA are triggered by a combination of CE values falling below or exceeding a previously defined threshold. These margins can also be defined using AC allowing to easily change them during run-time.

If a certain contextual situation can't be handled with RTA, a notification can be shown in the user interface of the ASAPCS providing recommendations for further actions. These notifications are also triggered by certain values of CEs.

Key Performance Indicators (KPI) are indicators that have direct effect on the cloud-based system. KPI show how the strategic goals are met and in case of scaling applications it could be linked to the SLA, QoS and QoE. The current value of a KPI is calculated by using one or multiple CE values. The target value is specified using historical CE values or manually entered number. KPIs are visualized as dashboards thus giving an instant view at the value interpretation. Generally, KPIs show how well the scaling algorithms allow to provide the needed level of service and based on them the user can decide whether the values of AC should be altered or another implementation of the RTA should be deployed to ASAPCS.

If the real-time value of the CE is important for the user of the ASAPCS it can be transformed into a Context Indicator (CI). For example, although the current number of web-serer nodes is not a KPI it can still be valuable information for the ASAPCS user. The main difference between CI and KPIs are that the platform is not concerned with interpreting the value of CI and this is left to the end-user. If there would be a target value of the web-server nodes it would be a KPI rather than a CI.

V. ASAPCS TECHNICAL SOLUTION

The technical stack that was chosen for implementing the ASAPCS is shown in Fig. 3.

MP data originating from the CDP is sent to a DNS balanced Haproxy (a reliable, high performance TCP/HTTP load balancer) cluster. The Haproxy node receiving the data forwards it to one of the Kafka proxy nodes residing at the Kafka proxy cluster.

A proxy cluster is used for ensuring extra level of security and flexibility in defining ASAPCS MP API. Kafka proxies are implemented using Node.js and they forward the MP data further to one of the Kafka cluster nodes.

Kafka is chosen since it is horizontally scalable, fault-tolerant, ensures the right order of the messages and exactly-once processing. It is also known to perform well with streaming apps and other real-time data.

MP values from Kafka are processed by Spark Streaming consumer and transformed into CE. Data is persisted into Cassandra database which is known to perform well with temporal data and has good integration with Apache Spark platform.

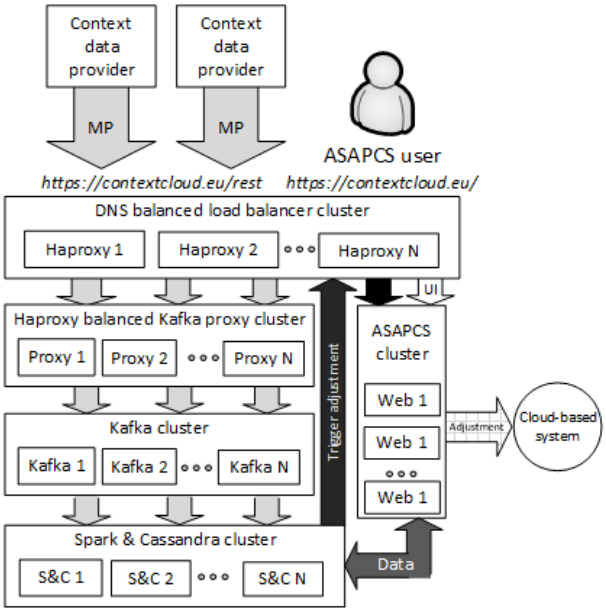

Fig. 3. ASAPCS prototype

Apache Spark was chosen because besides streaming component it also provides machine learning (MLlib) and graph processing (GraphX) libraries, which are important for meeting the previously defined requirements.

If it is determined that the current contextual situation identified by values of one or more CE requires execution of a RTA, Spark Streaming application makes a request to the DNS balanced Haproxy cluster which in turn calls the RTA. RTA is made available as a REST web service and is implemented together with the ASAPCS user interface as a NodeJS application. While calling the RTA Spark Streaming also passes the input parameters such as AC and CE values.

Based on the input data RTA scales the corresponding cloud application. ASAPCS ships together with a set of RTAs that are used for ensuring availability of ASAPCS itself. Currently we are investigating whether Docker containers would be a good fit for containerizing adjustments to provide wide support of programming languages and various libraries that could be used for RTA implementation.

Users of the ASAPCS platform access it through the DNS load balanced Haproxy cluster that forwards the requests to web-based ASAPCS UI, which is also implemented as a cluster of Node.js servers.

The prototype of the ASAPCS is in its early stages and is hosted on the CloudStack based RTU's open-source cloud computing platform. Currently ASAPCS is being validated with a use-case of video transcoding application requiring auto-scaling and altering data replication logic during run-time. This is done in collaboration with Komerccentrs DATI Grupa, a Latvia based IT company.

VI. CONCLUSION

Developments in the area of auto-scaling platforms are specifically important for microservice applications however traditional cloud-based systems would also benefit from existence of open-source auto-scaling platforms.

This paper presents architecture of ASAPCS and gives a brief overview of the current technological stack. Main advantages of ASAPCS are:

- ability to scale horizontally together with cloud applications,
- capability to process vast amounts of real-time data,
- definition of auto-scaling algorithms in a platform independent way thanks to extra level of abstraction,
- unlimited extendibility that comes from ASAPCS being truly open-source based,
- real-time monitoring of CIs and KPIs,
- run-time alteration of auto-scaling algorithms via graphical interface by changing values of ACs,
- machine learning and graph processing capabilities inherited from the Apache Spark platform,
- journaling of performed auto-scaling actions.

ASAPCS is still in active development and it must be extensively tested before the technological stack can be finalized. We are also looking into making ASAPCS more platform independent through providing support for other stream and batch processing platforms like Apache Flink. Upon reaching a sufficient level of maturity the source code of ASAPCS will be publicly released.

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LOGICAL AND PROBABILISTIC METHOD FOR RISK MANAGEMENT IN SOCIO-ECONOMIC SYSTEMS

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Abstract. In this paper we research the application of logical and probabilistic method to manage risk in socio-economic systems. Logical and probabilistic method is widely used for estimation of reliability and safety in structural complex technical systems. Authors have applied this method to estimate and analyze risk in some practical applications in economics and business. Based on risk scenario as tree of events, logics and probabilistic functions, this approach provides exact quantitative estimation of risk, risk analysis and decision-making procedures. Some promising results were obtained in banking industry and security portfolio management but application of the method has some features.

Keywords: logics, probability, management, risk, database, knowledge base, system, identification.

I. INTRODUCTION

Logical and probabilistic (LP) method has long history. As early as 1847 G. Boole published paper entitled *"The Mathematical Analysis of Logic"*, the first work about symbolic logic. This work began mathematical logic. Later, in 1886 P.S. Poretsky invented logical and probabilistic analysis [1]. In 1917 S.N. Bernstein applied Boole's axiomatic for casual events [10]. A.N. Kolmogorov suggested axiomatic for probability theory in 1929 [11]. In 1939 V.I. Glivenko generalized axiomatic of logic, event and probability [12]. Glivenko proved, for reliability concept we can apply axiomatic of set and measure. Based on above works, in 1959 I.A. Ryabinin developed LP method for estimation and analysis of reliability in complex technical systems [5].

Construction of LP risk models is performed in three stages:

1. *Structural risk model* or *risk scenario* (tree of events) is assembled, i.e. casual events and links between them are determined. There are initiating events (lowest level) and derivative events;
2. *Logical risk model* is constructed under structural risk model. Arguments of logical function correspond to events (1 – event appeared, 0 – event not appeared);
3. Transition from logical risk model to *probabilistic risk model* is performed. Using probabilistic model we can calculate probabilities of derivative events if we know probabilities of initiating events.

In technical systems LP-models are very different [5]. They can correspond to real structure of elements (electric circuit) or they can be a scenario of danger evolution (accident at nuclear power station). Also, there are monotonous LP models (series-parallel connection of elements) or not-monotonous (bridge circuit, tree of events with repeated events) [5, 6]. Models have various complexity and logical connections OR, AND, NOT.

But often it's difficult to determine probabilities of initiating events because large accidents are rare and statistical data volume is small.

In the contrary, in economics and business, risk is usual and widespread phenomenon. Many financial institutions and banks are working under risk conditions. There is good statistics with homogeneous outcomes and we can obtain probabilities of initiating events.

Statistical data is accumulated in tabular databases (DB) which are used for drawing of graphs and figures, making classification and clustering of objects, or, respectively, states of system, derivation of regressions and forecast with use of machine learning tools, which is important part of *artificial intelligence* and a way to develop *self-learning algorithms* [7].

In work we are studying the application logical and probabilistic method for estimation, analysis and management of risk and efficiency in socio-economic

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systems. To decide the problem, DB is transformed into knowledge base (KB) as a system of LP risk models for analysis and management of risk.

Typical databases have the feature: in some DBs (credit risk in bank, turnover of the restaurant) the efficiency of states (credits, profit of company) is known (success/default); in other DBs (security portfolio) the efficiency of states (yield of portfolio) is calculated. Respectively, aims of management are formulated differently.

II. LP RISK MODEL CONSTRUCTION

Usually, tabular DB contains statistical data about similar objects or states of the system. In table, a number of columns can be within 2 – 100 and a number of strings can be within 100 - 1000. Values (parameters) in each cell can be qualitative or quantitative, discrete or continuous [6].

To avoid complexity due to infinite number of values, let change presentation DB with substitution of parameters by their grades (numbers of intervals). Efficiency parameter E adopts the value from set $\{E_1, \ldots, E_r, \ldots, E_m\}$. Parameter E depends on $A_1, \ldots, A_j, \ldots, A_n$. Variable A_j adopts values (grades) from set $\{A_{j1}, \ldots, A_{jr}, \ldots, A_{jNj}\}$.

Statistical data are presented by table, where every string i looks like

$$A^i_{1,r1}, A^i_{2,r2}, \ldots, A^i_{j,rj}, \ldots, A^i_{n,rn}, E^i_r,$$

where:

$$i \in \{1,2,\ldots,N\}; r \in \{1,2,\ldots,N_E\}; r_1 \in \{1,2,\ldots,N_1\};$$

$$r_2 \in \{1,2,\ldots,N_2\} \ldots; r_j \in \{1,2,\ldots,N_j\}; \ldots; r_n \in \{1,2,\ldots,N_n\}$$

Let enter casual events (table 1) and designate them as logical variables. Event Z_{jr} is: the variable A_j for any string i adopts value $A_{jr} \equiv Z_{jr}$; $A_j=A_{jr}$, probability of this event is $P(Z_{jr}) = P(A_j=A_{jr})$. Event Y_r is: variable E adopts for any string i value E_r: $Y_r=E_r$, probability of events is $P(Y_r)=P(E=E_r)$. We are designating logical variables to events Z_{jr}, $j=1, \ldots, n$; $r=1,\ldots, N_j$ and Y_r, $r=1, \ldots, N_y$.

Events $Z_1, \ldots, Z_j, \ldots, Z_n$ and Y include groups of incompatible events:

$$Z_j = Z_{j1}, \ldots Z_{jr}, \ldots Z_{jNj}, \; j=1,2,\ldots n; \; Y = Y_1, \ldots Y_r, \ldots Y_{Ny}.$$

So, every event-parameter can take a value from finite set of events-grades which form group of incompatible events (GIE). (table 1).

Table 1.
States, events and logical variables

State	Event, Z_1	…	Event, Z_j	…	Event, Z_n	Event, Y_r
1	Z^1_{1r1}		Z^1_{jrj}		Z^1_{nrn}	Y^1_{ry}
…	…		…		…	…
i	Z^i_{1r1}		Z^i_{jrj}		Z^i_{nrn}	Y^i_{ry}
…	…		…			
N	Z^N_{1r1}		Z^N_{jrj}		Z^N_{nrn}	Y^N_{ry}

In risk scenario events-parameters are connected by logical connections *OR*, *AND*.

Largest number of various states (various objects) is equal to:

$$N_{\max} = N_1 \cdot N_2 \cdot \ldots \cdot N_j \cdot \ldots \cdot N_n, \qquad (1)$$

where: $N_1, \ldots, N_j, \ldots, N_n$ are numbers of grades in indicators.

Logical risk function for failure of state Y is:

$$Y = Z_1 \vee Z_2 \vee \ldots \vee Z_j \vee \ldots Z_n, \qquad (2)$$

where Z_1, Z_2, …, Z_n are logical variables for parameters. Logical function Y means state failure and give the sense of influence parameters $Z_1, \ldots, Z_n$ on failure of event Y.

Logical risk function in orthogonal form is:

$$Y = Z_1 \vee Z_2 \overline{Z_1} \vee Z_3 \overline{Z_2}\,\overline{Z_1} \vee \ldots. \qquad (3)$$

Orthogonality means: multiplication any two logical items in (3) is equal to 0. This allows make transition from logics to arithmetic and write probabilistic function of failure:

$$P(Y=0) = P_1 + P_2(1-P_1) + P_3(1-P_2)(1-P_1) + \ldots, \qquad (4)$$

where $P_j = P\{Z_j\}$ is a probability of event Z_j leads to failure Y. For every state in formula (4) the probability of corresponding event-grade Z_{jr} from GIE is placed instead event Z_j probability. Probabilities of events-grades are determined by method of identification under statistical data from DB [6, 8].

According to (2), the system of logical equations (KB) based on DB (table 1) is written so:

$$\begin{cases} Z^1{}_{1r1} \vee \ldots \vee Z^1{}_{jri} \vee \ldots \vee Z^1_{nrn} = Y^1_{ry}; \\ \ldots\ \ldots\ \ldots\ \ldots \\ Z^i{}_{1r1} \vee \ldots \vee Z^i{}_{jri} \vee \ldots \vee Z^i_{nrn} = Y^i_{ry}; \\ \ldots\ \ldots\ \ldots\ \ldots \\ Z^N{}_{1r1} \vee \ldots \vee Z^N{}_{jri} \vee \ldots \vee Z^N_{nrn} = Y^N_{ry}. \end{cases} \qquad (5)$$

For (5), based on (4), the system of probabilistic equations is:

$$\begin{cases} P^1_{1r1} + P^1_{2r2}(1-P^1_{1r1}) + P^1_{3r3}(1-P^1_{1r1})(1-P^1_{2r2}) + \ldots = P(Y^1=0); \\ \ldots\ldots\ldots \\ P^i_{1r1} + P^i_{2r2}(1-P^i_{1r1}) + P^i_{3r3}(1-P^i_{1r1})(1-P^i_{2r2}) + \ldots = P(Y^i=0); \\ \ldots\ldots\ldots \\ P^N_{1r1} + P^N_{2r2}(1-P^N_{1r1}) + P^N_{3r3}(1-P^N_{1r1})(1-P^N_{2r2}) + \ldots = P(Y^N=0). \end{cases} \qquad (6)$$

III. CREDIT RISK MANAGEMENT

Credits of individuals are described by 20 parameters, every parameter has from 2 to 11 grades [9]. Credit default due to concrete parameter or grade is casual event-parameter or event-grade. Events-grades of every parameter form a GIE. Events lead to credit default with certain probability. Risk scenario of credit default is stated so: default occurs, if any one, or two, or three, …, or all events-parameters occur.

Logical risk model of credit's default:

$$Y = Z_1 \vee Z_2 \vee \ldots\ldots \vee Z_n. \qquad (7)$$

Logical risk model of credit's default in equivalent orthogonal form:

$$Y = Z_1 \vee Z_2\ \overline{Z_1}\ \vee Z_3\ \overline{Z_2}\ \overline{Z_1}\ \vee \ldots$$

Probabilistic risk model of credit's default:

$$P = P_1 + P_2\, Q_1 + P_3\, Q_1\, Q_2 + \ldots \qquad (8)$$

where $P_1, P_2, \ldots, P_n$ – are probabilities of credit's default as a result of occurrences of events-parameters; $Q_1 = 1 - P_1$, $Q_2 = 1 - P_2, \ldots$, $Q_n = 1 - P_n$, In formula (8) values of probabilities for events-grades are placed. Credits in database are classified by risk value (probability of default) (fig. 1).

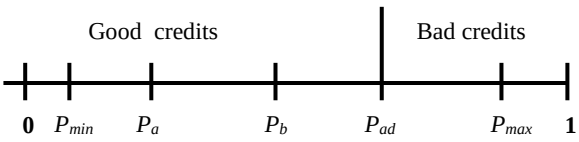

Figure 1. Credit classification scheme

The identification (learning) of the LP credit risk model is performed on the statistical data [8] and the goal of this procedure is to calculate probabilities of the events-grades P_{jr}, $r=1,\ldots,N_j$, $j=1,\ldots,n$, the admissible credit risk P_{ad} and risks P_i, $i=1,2,\ldots,N$ of credits. The condition $P_i > P_{ad}$ let us distinguish the following types of the credits: N_{gg} – are "good" both the LP-model and statistics; N_{gb} – are "good" by the LP-model but "bad" by statistics; N_{bg} – are "bad" by the LP-model but "good" by statistics; N_{bb} – are "bad" both the LP-model and statistics.

Transition from DB to KB and LP credit risk model allows to decide following problems [6, 9]:

1. Quantitative estimation of risk for every credit and average risk of a bank;
2. Quantitative estimation of contribution of credit's parameters and their grades in risk of every credit and average credit risk of a bank;
3. Determination of admissible risk proceed from condition of given asymmetry of recognition of "good" and "bad" credits.
4. Exception outdated and incorrect credits from bank's statistics, used for credit risk model learning,;
5. Re-learning of probabilistic risk model after the forming of signal part of finalized credits.

Use of LP model in credit risk estimation has following advantages:

- increasing of accuracy in risk estimation for "good" and "bad" credits in 1,5 - 2,5 times more, and, correspondingly, reduce of bank losses;
- increasing robustness (stability) of classification of credits on "good" and "bad" seven times more in comparison with models on basis of neural networks;
- effective management of crediting process in bank by changing of parameters both LP risk model and monitoring technology.

IV. OPERATIONAL RISK MANAGEMENT

In comparison with financial risks, operational risk is non-financial and realized in events: power system failure, personnel mistake, flood, earthquake or terrorism actions. Problem of estimation and identification of operational risk in bank is very complex. Operational risk is caused by different factors and difficult for formalization and modeling.

Basel Committee [10] divides bank's activity by 8 business lines. In advanced approach [10] every business line is considered separately. In every business line seven kinds of unfavorable operational risk events are considered: internal fraud Z_1; external fraud Z_2; personnel policy and labor safety Z_3; clients, products and business practice Z_4; physical damage of assets Z_5; faults in business and system failures Z_6; execution, delivery and process control Z_7. These are *derivative events*. Every event from $Z_1, \ldots, Z_7$ is caused by concrete elementary events, i.e. *initiating events*. Initiating events are considered as independent casual events. In overall, 98 events were entered. Final derivative event Y is possible losses at business line. The number of initiating events for every business line is equal to 70 and they are the same by description but their probabilities for every business line will be different. Logical variable corresponds to every initiating event. This variable takes values 1 or 0 (events will occur or not) with the certain probability. Initiating events have probabilities of occurrence. These probabilities can be obtained from statistical data accumulated during last period of bank's.

Structural, logical and probabilistic risk models are constructed for every business line [11].

As example, let consider first business line of bank (Corporate Finance). We construct the structural model and write the logical function of risk for seven kinds of unfavorable events $Z_1, Z_2, Z_3, \ldots Z_7$.

Risk scenario is formulated so: event Y_1 (losses at first business-line) will occur if event Z_1 or event Z_2,

or Z_3, …, or Z_7 will occur. By other words, Y_1 will occur if, at least, any one event from set $Z_1,\ldots, Z_7$, will take place, or any combination of events, or all of them will occur at the same time (probability of such variant is very small but not equal to 0). Let $Z_1,\ldots, Z_7$ are logical variables, every Z_j, j = 1, 2,…,7 is equal 1 (if events took place) or equal to 0 (in opposite case) with some probability.

Logical operational risk model for seven kinds of unfavorable events $Z_1, Z_2,\ldots, Z_7$ of operational risk for first business line is written in *disjunctive normal form* by following way:

$$Y_1 = Z_1 \vee Z_2 \vee Z_3 \vee Z_4 \vee Z_5 \vee Z_6 \vee Z_7. \qquad (9)$$

In order to obtain probabilistic model we have to write equation (9) in orthogonal disjunctive normal form:

$$Y_1 = Z_1 \vee Z_2 \overline{Z}_1 \vee Z_3 \overline{Z}_1 \overline{Z}_2 \vee Z_4 \overline{Z}_1 \overline{Z}_2 \overline{Z}_3 \vee Z_5 \overline{Z}_1 \overline{Z}_2 \overline{Z}_3 \overline{Z}_4 \vee Z_6 \overline{Z}_1 \overline{Z}_2 \overline{Z}_3 \overline{Z}_4 \overline{Z}_5 \vee \vee Z_7 \overline{Z}_1 \overline{Z}_2 \overline{Z}_3 \overline{Z}_4 \overline{Z}_5 \overline{Z}_6$$

and, in result, we obtain probabilistic operational risk model:

$$P\{Y_1=1\} = P(Z_1)+P(Z_2)(1-P(Z_1)) + P(Z_3)(1-P(Z_1))(1-P(Z_2)) + P(Z_4)(1-P(Z_1))(1-P(Z_2))(1-P(Z_3)) + P(Z_5)(1-P(Z_1))(1-P(Z_2))(1-P(Z_3))(1-P(Z_4))P(Z_6)(1-P(Z_1))(1-P(Z_2))(1-P(Z_3))(1-P(Z_4))(1-P(Z_5))P(Z_7)(1-P(Z_1))(1-P(Z_2))(1-P(Z_3))(1-P(Z_4))(1-P(Z_5))(1-P(Z_6)). \qquad (10)$$

Probabilistic risk model for one business line permits calculate the probability of losses at this business line if probabilities of initiating events are known.

Such models are constructed for eight business lines to calculate probabilities of events $Y_1, \ldots, Y_8$.

Let construct probabilistic model for calculation of bank's operational risk. Operational risk of bank is logical sum of probabilities of losses at eight business lines.

Logical model of bank's operational risk in disjunctive normal form is following:

$$Y = Y_1 \vee Y_2 \vee Y_3 \vee Y_4 \vee Y_5 \vee Y_6 \vee Y_7 \vee Y_8, \qquad (11)$$

where:

Y- bank's operational risk,

Y_i – event on i bank's business-line, $i = 1,\ldots,8$.

We obtain probabilistic model from logical model by orthogonalization:

$$P\{Y=1\}=P_1+P_2(1-P_1)+\ldots+P_8(1-P_1)(1-P_2)(1-P_3)(1-P_4)(1-P_5)(1-P_6)(1-P_7). \qquad (12)$$

Note, this model can be applied for estimation of bank operational risk by the standardized approach with use of values $P(Y_1), P(Y_2), \ldots, P(Y_8)$ instead of coefficients β in formula of capital reservation [10]. Such modified formula permits determine the volume of the capital for covering losses more precisely because it takes into account functioning features of the concrete bank in comparison with coefficients β, averaged on whole branch [10].

In practice, we don't need use classification of events, offered by Basel Committee. LP-models can be adopted for business lines and kinds of events in concrete bank. For example, in some Russian banks the additional ninth business line is used. Events, which were not classified on eight standard business lines, are referred to ninth business line. Basel Comittee recommends refer these events to line where the most profit is [10].

In general case, for calculation of economic capital we have to calculate probabilities $P_{i,j,k}$ and losses $L_{i,j,k}$ for every initiating event $Z_{i,j,k}$ by statistical data. Here:

i = 1,2,…,8 – number of business line;

j = 1, 2,…,7 – kind of events;

k =1,2,…,N_j – initiating events indexes in j-kind of events:

N_j = 2÷20 – number of initiating events of the kind j.

Initiating events probabilities are calculated by formula:

$$P_{i,j,k} = N_{i,j,k} / N, \qquad (13)$$

where: $N_{i,j,k}$ – the number of appearance of losses at business line i due to reason j and initiating event k; N – the number of operations at the business line of the bank in considered time interval.

Estimation of economic capital volume consists of two parts: expected and unexpected losses. Economic capital for expected losses EL is calculated by statistics and can be obtained by summarizing of all losses per a year (true economic capital):

$$EL = \sum_{i=1}^{8} \sum_{j=1}^{7} \sum_{k=1}^{N_j} L_{i,j,k}\ , \qquad (14)$$

where $L_{i,j,k}$ - summarized losses due to realization (or several realization) event k of kind j at business line i during report period (for example, one year).

Unexpected losses UL^{LP} is suggested to estimate by formula of predictable damage for technical systems:

$$UL^{LP} = P_Y L_{max}\,, \qquad (15)$$

where: P_Y - operational risk of bank is calculated by equation (12),

L_{max} – maximal possible loss at business line, concrete operation (transaction) or in bank as a whole, depending from modeling level.

Risk-manager should decide what losses will be chosen as L_{max}, proceed from the situation. Gross receipt at business line, maximal losses at business line or operation (transaction) can be chosen, or L_{max} can be given on basis of expert evaluation also.

Economic capital volume is calculated by formula:

$$R_{Sub}^{LP} = EL + UL^{LP}. \quad (16)$$

Value R_{sub}^{LP} is bottom limit of economic capital.

The basic indicator approach determines economic capital for operational risk of bank have to be 15% of average gross receipt of bank during three years [9]. For analysis we have to know top limit of possible losses from unfavorable economic situation and unforeseen rare events.

Top limit estimation of the reserved capital is performed proceed from the integrated risk of the bank as a whole:

$$R_{Sup}^{LP} = P_Y Q\,, \quad (17)$$

where: Q – gross receipt of the bank; P_Y – the probability calculated by probabilistic model (12).

Evaluations (14), (16) and (17) will be different. Choice of the formula depends on data and expenses of data obtaining. Formula (14) estimates real losses of last years. Formula (16) gives bottom limit of reserved capital under known losses. However, in practice it is difficult to estimate precisely the value of losses due to operational risk event, therefore, we need to know top limit of possible losses. In case of unstable economic and political situation we recommend use formula (17) for calculation of maximal economic capital, using the volume of bank's profit which can be lost in case of unfavorable events. Choice of formula depends on situation and this is duty of risk-manager.

V. SECURITY PORTFOLIO MANAGEMENT

The dissertation work by V. Alexeev is devoted to risk management of security portfolio [12].

Connection between parameters of risk and efficiency for security portfolio is presented at fig. 2. Discrete distribution of probabilities for efficiency parameter Y was constructed by database with N states. Minimal admissible value of efficiency parameter is Y_{ad}. Dark area determines *Risk* as probability of state with efficiency less than admissible one.

Database (table 1) contains statistics about yield of portfolio's assets in different time. The number of columns is equal to number of assets in portfolio, the number of strings (states) reaches a few hundreds. Modification DB is following: the interval of yield's change for every asset j is divided into N_j subintervals. Casual event-grade Z_{jr} corresponds to every state r of asset j. So, DB is transforming into KB.

To choice the optimal portfolio we need to determine shares of assets $x_1, \ldots, x_j, \ldots, x_n$ under optimization criteria:

1. Maximization of admissible portfolio yield Y_{ad} under given risk *Risk*: $Y_{ad} \rightarrow max$; $Risk = const.$
2. Minimization *Risk* under given admissible yield Y_{ad}: $Risk \rightarrow min$; $Y_{ad} = const.$

We suggest algorithms of optimization with casual search method and gradient method [8, 9]. Following selected value of admissible portfolio yield Y_{ad} are calculated (fig. 2):

- a number of states N_{ad} in «tail» $(Y < Y_{ad})$;
- portfolio risk $Risk = N_{ad} / N$, where N is a number of portfolio's states in DB;
- a number of appearances of events-grades for every asset $N_{j\,rj}$ in all states of portfolio, where $r_j = 1,2,\ldots,N_j$ are grades in asset j,
- probabilities of events-grades of assets, calculated by all states of portfolio $P_{j\,rj} = N_{j\,rj} / N$;

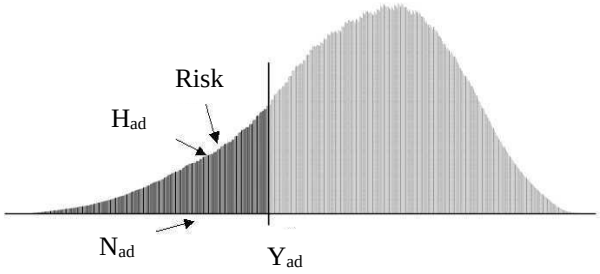

Figure 2. The histogram of yield distribution

Formula for calculation of state probability is [6]:

$$p_i = P(Y_i) = p_{1\,r1} \cdot \ldots \cdot p_{j\,rj} \cdot \ldots \cdot p_{n\,rn} \quad (18)$$

where $p_{1\,r1}, \ldots, p_{j\,rj}, \ldots, p_{n\,rn}$ are probabilities (frequencies) of corresponding events-grades of assets for portfolio's state i.

Let we know relative shares of capital $x_1,\ldots,x_j,\ldots,x_n$, invested in every asset $1,2,\ldots,n$. Calculation of contributions of grades are calculated by algorithmic way.

Contributions of events-grades in admissible portfolio yield Y_{ad} are equal

$$W_{jr} = \frac{N_{jr}}{N_{ad}}, \quad j = 1,2,\ldots,n \;\; ; \;\; r = 1,2,\ldots,N_j, \quad (19)$$

where N_{ad} and N_{jr} are numbers of all unfavourable states of portfolio in «tail» and number of states of portfolio containing grade r of asset j and satisfying to condition:

$$Y < Y_{ad} \quad (20)$$

Contributions of events -grades in *Risk*:

$$C_{jr} = \frac{P_{jr}}{Risk}, \quad j = 1,2,\ldots,n \;\; ; \;\; r = 1,2,\ldots,N_j, \quad (21)$$

where P_{jr} - is summarized probability of portfolio states with grade *r* of asset *j*.

Grades, which have largest contributions, indicate the possibility of security failure. These contributions are basis for management of portfolio with replacing one assets by others or change of capital shares x_1, x_2,…x_n , invested in portfolio.

By formula (18) we can calculate probabilities of all portfolio states and probabilities for not realized states, generating them by Monte-Carlo method. We can also calculate *Risk* of portfolio exactly, as sums of probabilities of portfolio's states in «tail».

Let set minimal admissible yield Y_{ad} and make transition from VaR model (fig. 2) to LP risk model:

$$Y = Z_1 \vee Z_2 \vee \ldots \vee Z_j \vee \ldots \vee Z_n , \qquad (22)$$

transform it in orthogonal form and write probabilistic risk model

$$P\{Y\} = P_1 + P_2(1-P_1) + \ldots + P_3(1-P_2)(1-P_1) + \ldots \qquad (23)$$

In (21) for every portfolio state we have to replace logical variables Z_1 , Z_2 , …Z_n by corresponding logical variables of their grades. In (22) for every portfolio state we have to place probabilities of events-grades correspondingly.

For determination of probabilities P_{jr}, $j = 1, 2,\ldots n$; $r = 1, 2, \ldots, N_j$, which are placed in (23), we perform identification [8].

Research in security portfolio management. The portfolio management is regular change of shares of assets in accordance with optimization results. We had considered portfolio with 9 assets of large companies (Aeroflot, AutoVAZ, Norilsk Nickel, Irkutskenergo, Gazprom, Rostelecom, RAO UES, Sberbank, Tatneft). Primarily, the capital was distributed among assets in same shares. Time period is January 1, 2005 – December 31, 2005. 100-days long prehistory was selected. The portfolio was being optimized daily under risk minimization criterion for given value of yield. Also, risk and efficiency for not changed portfolio, RTS index and Sharpe ratio [13] (which indicates efficiency of management and demonstrates how portfolio yield can be justified by given value of risk) were calculated.

Results of calculated research under various Y_{ad} are presented in table 2.

Table 2. Probabilistic weights of events-assets in portfolio risk

Asset	Share in portfolio, %	P_{jm} under Risk =0 %	P_{jm} under Risk =0,5 %	P_{jm} under Risk =1 %	P_{jm} under Risk =2 %
Rostelecom	24,1	0,1317	0,1105	0,0491	0,0198
RAO UES	36,3	0,2124	0,0933	0,0517	0,0229
Sberbank	21,6	0,1875	0,0727	0,0703	0.0349
Lukoil	18,0	0,1431	01063	0,0636	0,0168

Mainly, RAO UES assets are influencing on risk 0 %. The situation is another if we are increasing the risk. For example, risk more than 1% and 2 % is caused by Sberbank assets mainly.

In result of analysis by weights of events we are determining most danger assets and their grades. These weights are used for portfolio management, replacing of one asset by other or changing shares x_1, x_2, …, x_n of invested capital.

VI. RISK MANAGEMENT IN RESTAURANT

Management of risk and efficiency of restaurant (or profit of company) differs from security portfolio management because efficiency (yield) of portfolio is calculated for every state of portfolio (DB) but efficiency (profit) of the restaurant (company) is known by statistical data of DB.

Efficiency parameter (turnover per a day) *Y* is considered as casual value that depends on parameters *Z*. Parameters *Z* are presented by discrete values that are nominated as events-grades and designated by logical variables [6].

Daily statistics per calendar year was considered (*N* = 365 days). State of restaurant is determined by following parameters and their grades:

Z_1 – a month, grades are 1, 2, ... ,12;

Z_2 – a day, grades are 1, 2,…,7;

Z_3 – type of advertisement: 1 – for months 3, …, 8; 2 – for months 9, …, 1, 2;

Z_4 – determines cooking team and depends on season and days of week: 1 – for months 9, …, 12; 1, 2 in days 1, 2, 3, 4; 2 – for months 9, 10, 11, 12, 1, 2 in days 5, 6, 7; 3 – for months 3, 4, 5, 6, 7, 8 in days 1, 2, 3, 4; 4 – for months 3, 4, 5, 6, 7, 8 in days 5, 6, 7;

Z_5 – quality of personnel: 1 – inexperienced (2006 – for months 11, 12), 2 – average skills (2007 – for months 1, 2, 3), 3 – experienced (2007 – for months 4,…,10);

Z_6 – type of menu: 1 – 2006, for months11, 12 (70 % usual menu plus 30 % gourmet); 2 –2007, for months 1, 2 (65 + 35 %); 3 – 2007, for months 3, 4, 5 (60 + 40 %); 4 – 2007, for months 6, 7, 8 (55 + 45 %); 5 – 2007, for months 9, 10 (50 + 50 %);

Z_7 – type of evening: 1 – usual; 2 – usual plus banquet; 3 – usual plus thematic; 4 – usual plus tasting.

For turnover of restaurant *Y*, the histogram of distribution of turnover with intervals on 25 000 rubles was constructed. We had obtained 23 intervals or events-grades for efficiency parameter and calculated the number of days when turnover was within interval (the frequency). Monitoring of states of restaurant was performed during calendar year (*N*=365 days) and, in average, $N / N_y = 365 / 23 = 16$ states of restaurant were within every interval.

Following parameters are calculated under selected value of minimal admissible turnover Y_{ad} :

- a number of states of the restaurant N_{ad}, which are in «tail» $(Y < Y_{ad})$;
- a risk of restaurant $Risk = N_{ad} / N$, where N – is general number of states of restaurant in DB;
- a number of appearance of events-grades of every parameter $N_{j\,rj}$ in all states of restaurant, where $r_j = 1,2,\ldots,N_j$ – are grades in parameter j;
- a number of appearance of events-grades of every parameter $N_{jrj}{}^{ad}$ for states of restaurant which are in "tail" $(Y < Y_{ad})$;
- probabilities of events-grades, which were calculated for all states of restaurant $P_{j\,rj} = N_{j\,rj} / N$;

Formula for calculation of probability of i-state is:

$$p_i = P(Y_i) = p_{1\,r1} \cdot \ldots \cdot p_{j\,rj} \cdot \ldots \cdot p_{n\,rn}, i=1, 2, \ldots, N. \quad (24)$$

where $p_{1\,r1} \cdot \ldots \cdot p_{j\,rj} \cdot \ldots \cdot p_{n\,rn}$ – are probabilities (frequencies) of corresponding events-grades of parameters for state i of restaurant.

By formula (24) we are calculating probabilities of all states of restaurant which are presented in DB, and risk of not realized states of restaurant, generating them by Monte-Carlo method. *Risk* is calculated by (24) as sum of probabilities of states in "tail".

Contributions of events-grades in risk and efficiency of the restaurant are calculated simply. Contributions of parameters are calculated by method, described for security portfolio management.

Construction of LP-model of risk and efficiency of the restaurant provides the possibility to manage risk and efficiency of the restaurant [6].

We are constructing LP risk model for restaurant and determining probabilities of events-grades of parameters by identification method under statistical data. Calculations led to conclusions:

- Risk is different depending on month. Earlier months of restaurant's functioning are most risky (11, 12, 1, 2, 3, 4).
- Risk is also different depending on day. Friday and Saturday are less risky (grades 5, 6).
- Risk in both types of advertisement are same (1, 2).
- Risk due to various team (1, 4) differs almost twice.
- Risk due to qualification of personnel (1, 2, 3) is same.
- Risk due to type of menu differs almost 25 times (3, 5). Five type menu is less risky.
- Risk due to type of evening changes almost 400 times (type 1 - usual – has largest risk, type 2 – with a banquet – has smallest risk).

Risk of efficiency parameter Y is proportional to probabilities of parameters Z. Therefore, average values of probabilities P_{jm} of grades of influencing parameters Z can be considered as significances of parameters for average risk of efficiency parameter.

We can manage risk and efficiency of the restaurant by changing the type and quality of advertisement, menu, evening, and increasing qualification of personnel. This technology can be applied for another objects, shops, warehouses and enterprises.

VII. NARCOTIZATION RISK ESTIMATION

The construction of indicative LP-model we are considering at example of socio-economic system for counteraction to narcotization. The aim of risk management is reduction large economical losses in State, caused by narcotism, and increasing of morality in society [6, 14].

The main difficulty of this problem is determination latency value of narcotism. It's supposed, about 10% population is inclined to narcotism; 80% population is in risk group and can be involved in narcotism; 10% population cannot become drug addict in any conditions. There is inverse relationship between narcotization latency and indicators.

LP-models of narcotization risk use DB from monitoring system. Narcotization indicators are constructed so that risk is growing with increasing of these indicators. Danger event is deviation of indicators from 0. Probability, the indicator q_i is larger 0, is:

$$P\{q_i \geq 0\} = R_i,$$

This probability is risk R_i. Since indicators are normalized within [0, 1] so risk is equal to $R_i = q_i$.

Fundamental parameters, which demonstrate the narcotization rate in region [14], are divided into blocks B_1, $B_2,\ldots,B_7$. They show efforts for counteraction to illegal drug trafficking (IDT) [14] and not determine risk of dangerous situation, which can be used to manage narcomania situation. Difficulty of model's construction is in latency of narcomania, namely, consumption soft drugs.

Latency estimation in IDT. In arrested parts of drugs, strong drugs are 10% and soft drugs are 90%. About 10% drug addicts are registered, who are taking strong drugs and were identified by health authorities and after crimes. Drug addicts, who take soft drugs, are not registered although they cause potential threat to society. Latency of narcomania means: general number of drug addicts is beyond of control and this fact leads to difficulties in planning of measures for their reduction.

The latency is estimated by comparison of data about crimes, morbidities of drug addicts, opinion polls. The technique of latency coefficient estimation is described in [7, 14].

Indicators of narcotization. Fundamental parameters, which can be associated with concept of danger event, are initiating indicators also, that say

about risk of narcotization. Identifiers of indicators are designated as *Y*.

Fundamental parameter «Narcoimmunity of territory» were been normalizing:

1. Human potential development index Y_{16} is normalized by the condition: if index is growing then risk of territory narcotization is reducing: $Y_{16} = 1 / (100 \bullet Y_{16})$.
2. Personal development index Y_{17} is normalized by the condition: if index is growing then risk of narcotization is reducing: $Y_{17} = 1 / (100 \bullet Y_{17})$.
3. Latency index Y_{18} is normalized by the condition: if coefficient K_{lat} is reducing then risk of narcotization is growing: $Y_{18} = 1 / K_{lat}$.

Fundamental parameters of blocks 6 and 7 are used for calculation of narcomania latency coefficient on territory K_{lat} and, further, corresponding latency indicator Y_{18}.

The measure of region narcotization danger is probability or risk. In LP-models all events have the sense of danger, that increase with each new event. In logical addition of events the risk (probability) is within interval [0, 1].

LP-model of narcotization danger considers following risks:

- *probabilities* of invalid events - indicators *Y*;
- *probabilities* of danger events, blocks of indicators *B*;
- *probability* of narkotization danger in region *Y* and blocks *B*;
- *probability* of narkotization with taking into account the narcomania latency Y_{18}.

Some fundamental parameters are const and not entered into model because their risk is equal to 0 and they cannot be used in management.

Derivative indicators and LP-model of narcotization risk. LP-model of narcotization danger in region is constructed under parameters in blocks $B_1, B_2,\ldots,B_6$. We imply these blocks as derivative indicators-events and logical variables.

Parameters $B_1, B_2,\ldots,B_5$, as derivative events are functions of corresponding identifiers *Y*. Probabilities of these events are within interval [0, 1]. The probability is growing, the risk of narcotization danger in region is increasing. Derivative indicators are determined as logical risk functions:

for block – medical and biological parameters:

$B_1 = Y_{23} = Y_1 \vee Y_2 \vee Y_3 \vee Y_4$;

for block – crime rate in illegal drug trafficking:

$B_2 = Y_{24} = Y_5 \vee Y_6 \vee Y_7 \vee Y_8 \vee Y_9$;

for block – economic cost and damage:

$B_3 = Y_{25} = Y_{10} \vee Y_{11} \vee Y_{12}$;

for block - population stability:

$B_4 = Y_{26} = Y_{13} \vee Y_{14} \vee Y_{15}$;

for block - narcoimmunity of the territory:

$B_5 = Y_{27} = Y_{16} \vee Y_{17}$;

LP-model of risk of danger drug situation in region by parameters:

$B = Y_{29} = B_1 \vee B_2 \vee B_3 \vee B_4 \vee B_5$;

LP-model of risk of danger drug situation in region by derivative indicators with taking into account the narcomania latency: $Y_{30} = Y_{28} \vee Y_{29}$.

Calculation research. The research was performed by data of monitoring of drug situation in Saint-Petersburg in 2012. The results of automated research on LP-model of risk of danger drug situation by indicators are presented. Indicators are given by numbers of their indexes.

Logical function of risk of danger drug situation is:

$$Y_{30} = Y_{17} \vee Y_{16} \vee Y_{15} \vee Y_{14} \vee Y_{13} \vee Y_{12} \vee Y_{11} \vee Y_{10} \vee Y_9 \vee Y_8 \vee Y_7 \vee \vee Y_6 \vee Y_5 \vee Y_4 \vee Y_3 \vee Y_2 \vee Y_1 \vee Y_{22} \vee Y_{21} \vee Y_{20} \vee Y_{19} \vee Y_{18.} \quad (25)$$

Probabilistic function of risk of danger drug situation was obtained after the orthogonalization of logical function. Probabilities of indicators *P* and *Q=1-P* have same indexes as logical variables. Probabilistic function of risk of danger drug situation in region is:

$P\{Y_{30}\} = P_{17} + P_{16}.Q_{17} + P_{15}.Q_{16}.Q_{17} + P_{14}.Q_{15}.Q_{16}.Q_{17} + \ldots + Q_1.Q_2.Q_3.Q_4.Q_5.Q_6.Q_7.Q_8.Q_9.Q_{10}.Q_{11}.Q_{12}.Q_{13}.Q_{14}.Q_{15}.Q_{16}.Q_{17}.P_{18}.Q_{19}.Q_{20}.Q_{21}.Q_{22}$,

where «.», «+» are operations of arithmetical multiplication and addition.

Probabilities of initiating events Y_1 - Y_{22} are given by monitoring results. Risk of drug situation danger in region by indicators with consideration of latency is equal $P\{Y_{30}\}$= 0,191852. Risk of danger caused by narcomania latency only is equal $P\{Y_{28}\}$=0,118389. Risks of danger of blocks of indicators are following:

$P\{B_1\}=P\{Y_{23}\}$=0,028; $P\{B_2\}=P\{Y_{24}\}$=0,00849; $P\{B_3\}=P\{Y_{25}\}$=0,01493; $P\{B_4\}= P\{Y_{26}\}$=0,007449; $P\{B_5\}= P\{Y_{27}\}$=0,0264; $P\{B\}= P\{Y_{29}\}$=0,0833.

VIII. CONCLUSION

As you see above, we have applied LP method to estimate and manage risk in various spheres of socio-economic systems. Research was performed during 15 years and demonstrates the possibility to apply LP method but, in comparison with engineering, LP models are simple and, as a rule, have disjunctive normal form, corresponding to initial statistical data structure. Equation (7), (11), (22), (25) are same and equal to (2). But LP-models in economics can be more complex and based on risk scenario, e.g. the model of internal fraud in bank [15] or models bribery and corruption [6].

Of course, large volume of statistical data makes LP-model's application easier but the algorithm of identification is required. This is complex optimization task for multidimensional integer function having real arguments and many extremes [8].

LP-models allow calculate risk (probability of unfavourable event) and contributions of initiating

events in risk. So, we can identify “weak” elements in system and try to reduce risk. Risk management is made by decision-making procedures proceed from contributions.

If there is no any statistics, we can use the method of summarized randomized indexes [16] and obtain estimations of probabilities by non-numeric, not-exact and incomplete expert information.

Integration of LP-models, identification algorithm and method of summarized randomized indexes is powerful analytical tool for risk management and decision-making in complex socio-economic systems.

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Various Aspects of Intelligent Collaborative Educational Systems

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Abstract. In connection with the transition to a knowledge-based economy, at a time when a key factor in the development of society is the accumulated human knowledge and skills, as well as the availability of a wide range of users, intelligent systems are becoming very popular. Accordingly, the demand of the ergonomic and effective means of designing this class system is growing as well. The most time-consuming and most important stage of intelligent system development is the formation of the system knowledge base which ultimately determines the efficiency and quality of the entire intelligent system. Knowledge representation and processing models and methods as well as the intelligent system development techniques operating on the basis of these methods and models have a crucial role in relation to this.

The article explores the different aspects of intelligent collaborative educational systems, describes the overall structure of an intelligent collaborative educational system and reflects the different steps of development the system.

Keywords: self-directed learning; intelligent collaborative educational system; knowledge base; inference engine; extended semantic network.

I. INTRODUCTION

One of the characteristics of the emerging global information society is the creation of a new educational paradigm – "education as a tool of social welfare". On the one hand, rapid and constant technological change creates massive demand for life-long further education. On the other hand, regarding human rights this means that any member of the public, regardless of their age, social status and location, is meant to be provided with educational services at any time and in any field.

"ES 2020" strategy was defined on the 3rd of March, 2010, in the European Commission communication "Europe 2020: a strategy for smart, sustainable and inclusive growth" and was approved on 17th of June, 2010 by the European Council. The strategy "Europe 2020" is the European Union's growth and employment program of this decade. The emphasis is on smart, sustainable and inclusive growth, in order to overcome the structural weaknesses of the economy, to improve its competitiveness and productivity and underpin a sustainable social market economy. One of the "ES 2020" priorities is "Smart growth - an economy based on knowledge and innovation" which include "Education, training and lifelong learning" and "Digital Society" [1].

On the other hand, contemporary societies face new challenges such as how to organize educational processes in such a way that graduates become the so-called knowledge workers in the full sense of this term [2].

II. SELF-DIRECTED LEARNING AND COLLABORATIVE EDUCATION

Self-directed learning has been studied for a while now. The term "Self-directed learning" is defined as a process in which individuals take the initiative (with or without other people's help) in determining their learning needs, defining learning aims, determining the people and learning resources, selection and implementation of the most appropriate learning strategy as well as in assessing the results [3]. It was established that this was mostly characteristic of adults.

Knowledge workers carry a major role in today's society. Knowledge workers are knowledge executives who know how to allocate knowledge to productive use [4]. A knowledge worker must constantly learn innovative knowledge to be competitive. This makes employee training functionality one of the priorities of staff management functions within modern organizations. A large problem with global virtual organizations, though, employees are scattered around the world, making this functionality difficult to implement [5]. Thus, knowledge worker training is possible mostly by following a self-directed learning path.

Self-directed learning is a complex concept: competence relating to the learner's ability to take responsibility for their own study process, defining

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aims, tasks and needs when developing ideas and alternative perspectives, planning one's time in finding the right material; self-evaluation; the ability to find one's adviser; the ability to think critically, and to find internal resources for self-motivation. When there is no motivation, self-learning does not exist.

The collaborative educational systems tend to implement exactly this idea – the metaphor of "self-service", that is, the user can freely choose how the training process should be organized on his or her terms. Undoubtedly, such a training model is used and is useful only if the students are able to manage their own study process.

Collaborative education is an approach to training which seeks to create groups of students for finding common solutions to any problems. Collaborative education is based on the idea of learning being a natural social act in which the participants talk to each other and the lesson takes place in the process of communication [6]. This type of education does not involve a set of techniques and methods in relation to training; it is a philosophy and a way of life in which every person is responsible for their own actions, including training and respect towards their colleagues' abilities and contributions [7].

The authors mentioned in this article [8] note that the students with a high level of self-motivation are able to clearly formulate their own solutions and ways of understanding things which leads to a better understanding and application of the material by the members of the group.

In all real-life situations where people have to work in a team there is communication and interaction between these people; this reveals their personal abilities, characteristics, each person's investment in the work etc. The main idea of collaborative education is based on the collaboration of the group members rather than competition when every individual would be opposed to the other members of the group. The developers of this approach combined three main ideas into a single process:

- collective learning,
- mutual evaluation,
- learning in small groups.

Herewith appears a problem - how to divide users into collaborative learning groups, which criteria it is advisable to take into account in doing so. One of the ways – to divide knowledge workers into groups for collaborative learning based on the level of knowledge and current competence of each participant, taking into account also his/her cognitive and social abilities.

Knowledge workers are characterized by a set of competences describing key qualities, behaviors, knowledge, abilities, and other characteristics that are necessary to achieve the standards of quality and efficiency of work. In this case one of the methodological problems is the choice of a rating scale. In addition, it is necessary to identify the most important competences by limiting the total number of them. On the other hand, a list of competencies should be relevant and, therefore, a need exists to determine how often this list will be updated [9,10].

Why is it valuable to use the collaborative educational system for studying? The authors of the article [11] note that collaborative education provides greater human cognitive development because the students:

- are actively working with partners in promoting the synthesis of information rather than memorizing it mechanically;
- acquire a lot more knowledge in a situation where they are given the opportunity to work with several different people's points of view;
- talk to each other and during this intellectual exercise they find their own judgment justification and reasoning;
- formulate and defend their views whilst creating their own unique conceptual structure during this process rather than rely solely on expert opinion or textbooks.

III. COLLABORATIVE EDUCATIONAL SYSTEM

The educational system is interrelated education and innovation process as well as the set of process management which works with the aim of providing people with educational services. This innovative activity includes the educational content update, pedagogical technique and method activating, the need to support new educational standards as well as keeping up with scientific developments. The organization of the educational process, namely, the options of choosing the training content, profile and outline, aims at reaching the training and development plan and providing the system effectiveness.

The educational system is rather complex – each of the components can be regarded as a subsystem or as an indivisible whole which derives from a common system [12].

This depiction makes it possible to determine the structural elements of the educational system:

- aim of the educational system;
- management of the educational system;
- members that interact with one another to implement training services;
- educational programs;
- educational content;
- educational-pedagogical activity;
- labour intensity of the educational system;
- information.

The functional elements of the educational system are the mutual relations of structural elements arising from the work process of the system participants.

The collaborative system is a system in which many users or agents are involved in a joint operation, often in different locations. The collaborative systems of the great family of shared usage are distinguished by the fact that the participants of these systems work together to achieve a common aim and they feel the need to interact with one another, that is, to share information, exchange requests etc. [13].

The collaborative systems let you change the organization of science, research and studying by merging the people together as well as the power of computers whilst using new ways of distributing information. Such systems are used in all areas: in administration, business, education, culture and the like. The collaborative systems in the field of education are collaborative educational systems.

A collaborative system has the following characteristics [14]:

- the system elements – both users and agents – interact with each other and affect the behavior of the system;
- the system components use shared resources to achieve both their separate and also common goals;
- the system has permanently open channels of communication between the users and the agents;
- the agents do not possess antagonistic interests.

The key tasks of the collaborative educational system are considered:

- the creation of a group of students at the basis of a deep diagnosis of each participant;
- the creation of the academic program taking into account the characteristics, training goals and objectives as well as the necessary set of competencies of the group of students;
- the creation of the group of teachers and the support staff based on employee characteristics and the academic program;
- developing a set of methodology for the particular academic program;
- the evaluation of the academic results comparing the acquired competences and the existing standards of the students;
- the determination of the labour utility and labour intensity.

The overall scheme of the educational process contains the following activities:

- building the knowledge, skills and competence model;
- student model building and updating;
- curriculum model creation according to the student and competence models;
- the maintenance support of the training process.

An inspection takes place during this process in order to establish whether the created study program corresponds to the student model (specialty, learning objectives, and levels of knowledge, skills and competence) as well as the competence model. If there is a match, the study program is considered to be set up, otherwise the process is repeated (see Figure 1).

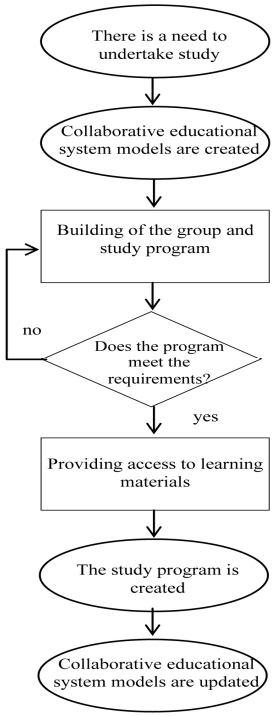

Fig.1. Academic program development process

IV. INTELLIGENT COLLABORATIVE EDUCATIONAL SYSTEM AND STRUCTURE OF IT

Artificial intelligence methods are used within an intelligent collaborative educational system in order to provide better user support for the educational system and it is based on four elements: interaction which is the resource sharing technology in education; tools required for storing data; intelligence for enhancing the decision-making of the educational process; joint action. There are these following main reasons for support of the investment of intelligent collaborative educational systems [15]:

- flexibility – the learning process can happen at any time, any place, there is access to all the different learning materials;
- collaboration – the intelligent educational system allows receiving instant feedback and necessary advice;
- motivation – multimedia resources that are used in intelligent educational systems can make studying fun;
- tools – the intelligent educational systems are able to collect and summarize detailed information, such as, for example, notes, projects, essays etc., and to give relevant information about the student activities;

– the reduction of the required resources – new technology extends the time and reduces the space.

The intelligent collaborative educational system is a modern tool for new knowledge and skill acquisition (see Figure 2).

Within the intelligent collaborative educational system the common structural fragment consisting of the major subsystems and data flows between those are represented in Figure 3.

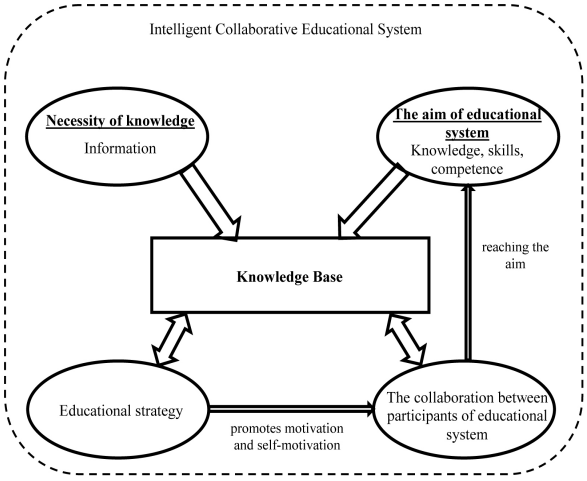

Fig.2. The acquisition of new knowledge in intelligent collaborative educational system

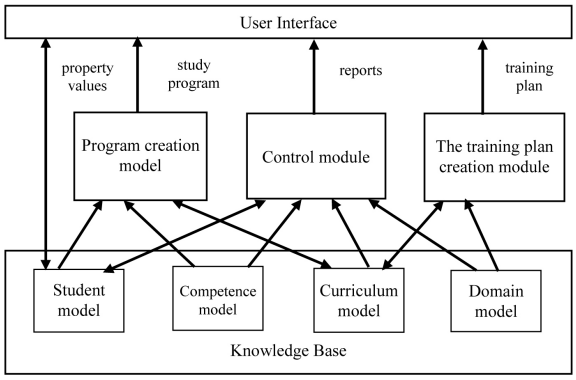

Fig.3. Fragment of intelligent collaborative educational system structure

Strategies for curriculum development and learning content management are included into the educational content model. The student model contains information about students, their set of characteristics (personal data, the level of knowledge etc.). Competence model is the set of necessary competencies (study objectives) established by assessing the requirements of the certain industry, and which is compared to the students' competence. The environmental subject model involves study object (courses, assignments, tests, control issues etc.)

In the basis of the main module operations are appropriate models. The rest of the modules provide auxiliary functions.

Since intelligent collaborative educational system by its very nature is a distributed system, the role of modules is provided by according agents which interact with each other dynamically. The required set of functions is provided by collaboration of the agents. In order to perform the tasks successfully an agent should be able to implement both intelligent behavior (choice of plan, problem decomposition, and task distribution) and reactive behavior (timely response to new information, changes to the data, etc.). Intelligent behavior is ensured by a combination of decision-making requirements for the selection of a plan as well as decomposition and task distribution implementation with the rules of collaboration. Reactive behavior is provided with a level of control that responds to changes in the working memory (for example, determining new aim, reports on changes in the existing data, tasks or responsibilities) [16].

V. KNOWLEDGE BASED DEVELOPMENT

When developing an intelligent system it is necessary to fulfil the following tasks [17]:

– identifying a subject oriented environment tasks;
– the creation of a subject oriented environment description for each task;
– the placing of any intelligent task;
– intelligent task solution methods and their corresponding algorithm selection or development.

After completing this work it is possible to start the system conceptual design and a knowledge based moulding.

Intelligent systems are based on the knowledge base that contains all the information that the system uses in a systematized manner. Thus, within the intelligent systems all the information that is used and processed is provided in a semantically structured, unified knowledge base which on a semantic level reflects a complete view of the world where this system "lives". The processing machine of the knowledge is a set of independent agents that interact with each other only through the knowledge base.

Knowledge base must include all the information that is necessary for agents that work with semantic memory, organizing joint activities for the purpose of conveying intelligent system tasks [18].

In order to develop a knowledge base it is needed to clarify the environmental structure of the subject, namely, the research object and subject of the research.

Accordingly, the basic components of the knowledge base of intelligent collaborative educational system, namely, academic and science objects corresponding to the subject oriented environment units may be the following:

– the academic program elements that describe a specialty, specialization, aims, objectives, total amount and deadlines;

- the structure elements of the study program related to the curriculum, basic courses, specializing courses, description of the practice areas;
- the students are described by the elements, namely, the group size and level of preparation;
- a set of methodological material items;
- the methodological techniques and training elements are described by elements;
- competences describe the elements;
- the test group elements – tests, control tasks, etc.;
- the elements of the teachers and school support staff descriptions;
- the final report items;
- labour intensity calculation elements;
- a set of regulatory documents describes items.

A comprehensive model for the representation of knowledge recommendations does not exist, but some criteria have been developed. For example, in one of the works [19] it is determined that if the subject oriented environmental concepts are difficult, there are many relationships with the notions of judgment and type of hypotheses, then it is appropriate to use the network models. In this case the hypotheses are related to the recommendations, diagnosis, predictions and other decisions that are determined by the specifics of subject oriented environment.

The concept of semantic networks of knowledge representation is based on the idea that all knowledge can be represented as a set of objects, or concepts, and links, or relations, between them.

According to the semantic network example, it is possible to determine the database (working memory) and knowledge-based difference. Subject oriented environment is its own possible entity of a set of states. This set which is reflected through common terminology, concepts, relations and laws creates a knowledge base in an intentional semantic network form. However in every particular situation these subject oriented environment entities possess specific characteristics. These specific data are reported in the extensional semantic network (data base or working memory). Working memory is used to store temporary data. It contains information on the objectives, current tasks, completed tasks, incoming and outgoing messages and short-term liabilities.

The advantages of semantic models of information processing [20]:

- the representation of knowledge with semantic networks to significantly simplify the knowledge integration process which is implemented as the identification and bonding of integrated semantic network synonymic elements;
- correctly established intelligent system knowledge base in the form of the semantic network completely eliminates the duplication of information within the knowledge base;
- the knowledge reflection in the form of semantic networks for simple associative access to different types of knowledge-based fragments;
- the semantic models of knowledge processing are well suited for asynchronous parallel information processing.

The semantic knowledge processing model is an abstract multi-agent system composed of semantic memory which stores the semantic networks as well as the semantic network processing-oriented agent sets [20].

As the formal basis of the intelligent system a special kind of representation and processing models of semantic knowledge are considered and they are based on semantic networks.

The article [5] has offered to use the extended semantic networks [21, 22] which can be considered as the semantic network model for the improvement of logical and computing aspects. In extended semantic networks, nodes can correspond not only to objects or concepts, but also to relations, logical components of information, complex objects, etc. To everything that can be regarded as an independent unit, its own node must correspond. Thus, nodes of a different type are entered – nodes corresponding to names of relations, as well as a special composite element called connection node. They are connected by marked edges with nodes taken from the array of the above-mentioned nodes. As a result, a fragment appears that corresponds to elementary situations, i.e. objects that are bound by relation. Such a fragment is called an elementary one. The basis of extended semantic networks is a set of nodes D from which elementary fragments

$$D_0 (D_1, D_2, \dots , D_k / D_{k+1})$$

are compiled, where D_0 stands for relation name; D_1, D_2, ... , D_k – for the objects participating in relation; D_{k+1} is for the connection node denoting the whole array of objects participating in the relation. This node is also called the s-node of elementary fragment; $D_0, D_1, D_2, \dots , D_{k+1} \in D$, $\kappa>0$.

VI. INFERENCE ENGINE

The solver is implementing a certain type of judgment in the intelligent systems as well as the search algorithm in the knowledge base, conflict resolution strategies and confusion and error handling mechanism. The fact of working memory interpretation process within the requirements is defined by the logic output.

Within the semantic network models direct judgment chain algorithm is often used and it is based on three basic methods [23]:

- the coating method is based on the comparison of individual fragments of the semantic

network; a successful coating is when the semantic network fragments are identical;
- the intersection search method determines the location of nodes which is the junction of particular ways;
- the specialized methods are based on the tracking of the relationship characteristics of network nodes.

Unfortunately, in the basis of the direct judgment chain process is a re-reading algorithm that reduces the logical output implementation efficiency. To overcome these drawbacks, for various semantic network models the use of other approaches to the logical output organization was offered [24, 25, 26], but still the problem remained, therefore, it is appropriate to design such a logical output method that complies with the following essential requirements [24]:

- the output method should be based not on re-reading algorithms, but should be based on the algorithms based on the output of the search process of the current situation analysis;
- the output method must be based on the effective output procedures;
- the output method has to be unified, that is, there should be a unanimous output method used to develop the knowledge representation model;
- the output algorithm must be universal, that is, it should allow handling both clear and fuzzy procedural-declarative knowledge.

VII. CONCLUSION

The article describes principles for development of intelligent collaborative educational system which are based on the knowledge representation of semantic network model; the main tasks of the system are formulated; certain problems that need to be addressed.

The proposed development version of an intelligent collaborative educational system which is based on multi-agent technology has a number of advantages compared to the traditional system of this type because the intelligent agents provide the academic process with flexibility and dynamism.

The described methods and models creation is continuation of this article authors' work which is devoted to development the intelligent collaborative educational system for knowledge workers, and it might be useful for these kinds of intelligent system developers.

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Evaluating the Quality of E-learning Material

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Abstract. An increasing number of educational institutions in the study process uses one of the e-learning systems. Consequently, more and more students are offered learning materials in electronic format. E-materials in distance learning and e-learning is one of the most important elements, therefore much attention and enough time should be paid for their development. There are a number of studies on e-learning quality, where criteria of quality are discussed in the context of chosen e-learning environment and the process of implementation. This article examines only the quality of e-material. The aim was to find a way to reduce the effort and time of electronic learning material quality evaluation. The study used content analysis by summarizing the most important factors influencing the quality for teaching materials. Based on the quality criteria mentioned in the literature and personal experience, a criterion, which affects quality of e-learning material, were summarized and grouped. The criteria were grouped into four groups resulting from didactic, media, usability and formal quality. Quality evaluation is performed by using one of the methods used in software engineering - checklist. Based on the identified quality criteria a checklist was established. In order to facilitate the evaluation process a web-based tool is offered. The tool includes a defined checklist with assessment rating scale and three levels of impact. Evaluation of material quality is shown in the terms of percentage. After testing the tool, it could be used for course developers, program managers or other persons involved in evaluation process of e-learning resources.

Keywords: checklist, evaluation, quality indicators, self-assessment tool.

I. INTRODUCTION

Any company's goal is to provide quality service or sell a quality product. According to the general definitions, quality is a set of features and characteristics of a product or service that relates to its ability to satisfy certain or planned needs [1]. In the distance learning quality is defined as the characteristic or set of properties that characterizes object, event or process compliance with certain previously appointed requirements [2]. However, requirements are determined by two main factors: customers and legislation. Often, when it comes to e-learning quality, then the interpretation is quite differing. Its definition depends on the stakeholders' point of view. In the distance learning quality is defined as the characteristic or set of characteristics of the object, phenomenon and process compliance with certain prior requirements [3]. There are a number of project activities and organizations studies that relate to quality of e-learning and distance learning. Quality is mainly focused on the use of resources to achieve specific goals. There are a number of recommendations on e-environment choice, process organization, accessibility of education, adaptation of learning environment for personal characteristics and needs. In order to support a common understanding of quality and organizations, providing e-learning services, could be able to provide the appropriate quality, the studies have been conducted. Studies have analysed approaches and the aim of studies is to establish unified quality criteria for e-learning [4].

There are now a number of organizations and educational institutions, who have created their products for quality assessment [5]. Depending on the target object (lecture, course, institution), these criteria are focused either on design or usability, on didactics, or to learning process. As shown by study of E.Bratengeyer and G.Schwede, the most commonly occurring criteria is pedagogy, didactics and media design, the quality of the content [5]. Emphasizing the significance of learning material content quality, exactly these quality indicators were analysed in this study. For the company or institution providing distance learning services, it is essential not only to provide service and organization, but also quality of e-learning materials used in the process. Its basic requirements are resulting from learning content, which in turn is determined by the corresponding educational standard. Quality assessment has an internal dimension – self-assessment and external dimension carried out by external experts. Project implementer or creator of e-learning material can implement self-assessment by using a checklist.

Checklists are being used in the case of evaluation several aspects of product quality or separate stages of process. Them used in quality assurance of software engineering, to check process compliance, code standardization and error prevention, and others.

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Checklist is a list of items required, things to be done, or points to be considered, used as a reminder [6]. With the help of a checklist it is possible to determine conformity of content to quality indicators. Checklist is a character or a list of activities in which the observer makes notes [7]. Checklists have been used in numerous evaluations and have been considered as a helpful tool for quality assessment. In many cases, only if there is compliance with certain criteria, there is a further evaluation using other methods. Checklists help evaluators monitor criteria during an evaluation process. Wingate [8] noted that the most basic type of checklist can be useful in conducting an evaluation in many aspects. Checklist can be short and simple list of some of the elements, but can also be a complex surveillance system with precise definitions of expected behaviour. In any case, the development of checklist should be taken into account for assessment of work analysis, analysis of objectives and tasks.

The aim of the research was to find way to minimize the effort and time required for evaluation of the electronic learning materials. This article describes the checklist as a quality assessment tool, its creation and application to e-learning.

II. MATERIALS AND METHODS

Monographic method has been used for this article. Information was searched in electronic databases and printed publications, published in Europe. Broad spectrum is discussed and analysed the scientific literature on quality evaluation of e-learning material, factors influencing quality and most important characteristics of the period from 2004 to 2016.

The study used content analysis by summarizing the most important factors influencing the quality of the e-learning materials. A checklist was created based on the collected quality criteria which are mentioned in the reviewed literature (15 sources) and based on the author's experience, obtained while working as a teacher from 1997 to 2014 at the Latvia University of Agriculture and from 2014 at the Professional Distance Learning Centre of Latvia. To evaluate teaching materials checklist questions (total 86 questions) were evaluated and adjusted in conversations and discussions in the work and educational environment. In September and October of 2016 unstructured interviews were conducted with both teachers and distance learning students in an informal atmosphere.

III. RESULTS AND DISCUSSION

In sources of information on e-learning the most emphasis is on following criteria: content, navigation, design of text and graphics, learning tasks and feedback [9], [10]. Of course the most important element is the Content [11]-[17]. Any electronic learning material fall into three types: technical parts, learning units and learning entities [14]. In this study attention has been brought to the quality criteria relating to content of learning units. Quality criteria are grouped into four sections according to their nature - criteria relating to didactics, technical requirements of media, usability. Individually isolated is formal criteria, which have the greatest impact on the overall quality of the material. Table 1 shows the list of the quality indicators used in the various E-Learning systems.

Table I
List of quality criteria

Quality Criteria	Quality Subcriteria	Reference
Formal	Segmenting, text structuring	[16], [18], [19], [20], [21], [23]
	Grammatical and spelling errors	[16], [19]
	language	[16], [18], [19]
	topicality	[19]
	Literature sources	[16], [19]
	Copyright compliance	[19], [23]
	Review of Version	[19]
Didactic	Course Objectives	[4], [15], [16], [19] - [21]
	Course Assessments	[4], [15], [16], [19], [20]
	Target group	[19] – [21], [23]
	media choice	[4], [16], [20]
	Course metadata	[4], [16], [18], [19]
	compliance with the curriculum	[20], [22], [23]
Media	Corporate Design	[19]
	Content Layout	[4], [15], [16], [19], [22]
	Graphics and Fonts	[16], [19], [21]
	Multimedia	[4], [15], [16], [19], [22]
	Design of text and graphics	[16], [18], [19], [21]
	External content resources	[4], [15], [18], [21], [23]
	Search	[19]
	Material load time	[16], [18]
Usability	Navigation	[16], [18], [19], [21], [23]
	Functionality	[18] - [20]
	Perception	[19], [20]
	Accessibility	[16], [19], [21]
	Alternative provision	[19], [20]
	Learning tasks and feedback	[18], [21], [23]

From an analytical point of view, the existing works helps to obtain a complete overview of the various aspects, which have be considered in order to provide quality of the e-learning material. With critical assessment it can be concluded that the major attention is on the didactic aspect and the appropriate use of media. Less often mentioned is criteria, which relates to the material adaptation for people with special needs.

During the research a web-based self-assessment tool was developed for e-learning material content quality evaluation. This tool can be used by course developers, program managers or other persons involved in the evaluation process of e-learning

resources. It is based on a checklist, which is grouped into four sections:

- Formal quality;
- Didactic;
- Media;
- Usability.

Checklist is prepared according to the identified quality sub-criteria. The evaluation uses a rating scale from 1 (doesn't comply) to 5 (fully meets) and three impact levels: low, medium, high (Fig. 1). After evaluation of the material also quantitative assessment is given. It is shown in both -by all the four sections and the overall average rating.

Fig. 1. The view of e-learning material content quality evaluation tool - formal quality evaluation part.

After evaluation of the material also quantitative assessment is given. It is shown in both - by all the four sections and the overall average rating (Fig. 2).

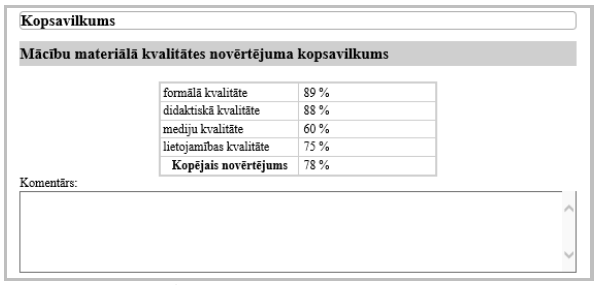

Fig. 2. The view of e-learning material content quality evaluation tool – summary of quality.

The developed web-based self-assessment tool is still in the testing stage and its activities remain to be tested in real work environment.

IV. CONCLUSIONS

The main quality criteria have been identified and grouped according to their effect. Mainly they are based on the technical requirements, but also cover didactical aspects. Based on these criteria has been created a checklist. E-learning material assessment checklist has two main roles:

- a tool to guide a discussion between evaluators and material developers regarding the preferred contents of e-learning materials;
- a tool that can use the course developers to evaluate the material already in the development phase.

Checklist provides guidelines for course content for developer about whether it is necessary to improve the e-learning materials, allow identify weaknesses in the material that need improvement. Course developers themselves can use the checklist as a monitoring and reflection tool. Checklist allows identifying a number of conditions and requirements that needs be taken into account in the development of e-learning materials. To improve assessment process of materials, a web-based self-assessment tool was created. Electronic checklist tool is intended to help assessors to evaluate the final product - the electronic learning materials, that is, whether it meets the expected quality. The research should continue to evaluate the usefulness of the developed checklist tool.

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Geometric Feature Selection of Building Shape for Urban Classification

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Abstract. The proposed research is related with building detection in airborne laser scanning data. The result of geospatial surface segmentation provides a vector layer of unclassified shapes. Geometric features of shapes can be applied to classify urban objects and to detect buildings among them. The goal of this research is to select the appropriate geometric features considering their importance for building recognition. The feature selection is completed using random forest algorithm. The obtained list of features and their influence weights can be used to improve building recognition methods and to filter noise objects.

Keywords: feature selection, LiDAR, remote sensing, urban classification.

I. INTRODUCTION

Airborne laser scanning is the modern technology of remote sensing to acquire 3D model of Earth surface using aircraft and laser altimeter. The recorded 3D model is a point cloud, which points are detected locations of scanned object surface, where a laser beam is reflected. However, the acquired data are not applicable for geospatial analysis until a semantic meaning is assigned to them that is doable by classification methods developed for LiDAR data.

The methods of urban classification can be divided into two groups:

- 3D methods, which group near points into 3D clusters, classify them (e.g. the voxel-based method [1]) and return classified point cloud;
- and 2D methods, which use the projection of point cloud converted into 2D grid, that is segmented and classified (e.g. saliency-based method [2]) providing a classified raster or vector layers of classes.

This research is related with 2D methods. Different LiDAR features have been analysed and compared in the scientific publication [3], but these features are useful to convert the point cloud into 2D projection. When the segmentation of 2D projection and the classification of the obtained segments are completed, the vector layer of search objects is prepared. Depending on the used methods, the different amount of noise objects can be obtained together with search objects, but the vector layer provides the secondary data for the noise removing tasks. Therefore, it is possible to construct the classification workflow (see Fig.1), where clear data are obtained through the sequence of different feature analysis removing specific noise objects step by step.

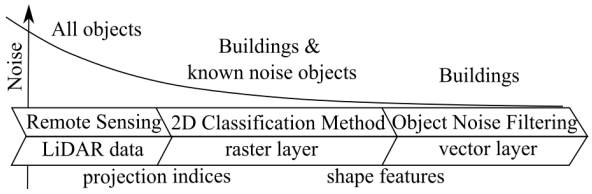

Fig. 1. Workflow of urban classification with three steps

There are three types of object features, which are applicable for secondary data classification using vector layer with shapes:

- geometric features;
- statistical features;
- spatial relations.

The goal of research is to analyse the geometric features of shape and to select the most appropriate of them for building detection and recognition tasks.

II. MATERIAL AND METHODS

A. Dataset

The LiDAR data of 25 km^2 territory have been used to complete research.

The minimal point density of samples is 1 p/m^2.

The coordinate system is LKS92 TM (EPSG:3059).

B. Dataset pre-processing

The dataset is processed in two stages:

1st stage: LiDAR data are segmented and classified by EMA-based method [2]. The output is the vector layer with buildings and noise objects. The known noise objects are bridges, huge engines, robust trees and shrubs, hedges, walls and cliffs.

2nd stage: All shapes are manually classified by two classes “building” or “noise object”.

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C. 2D classification method of 1st stage

The classification of LiDAR data is based on "Energy Minimization Approach" methodology [2].

The method applies the next algorithms:

- LiDAR data projection:

max-min method, which set pixel value equal to the height of single or last return point with the maximal height. Size of used grid for projection is 1 m^2.

- segmentation seeds:

the height difference points with the bias equal to 1.8 m, which is the most important feature according to the research [3].

- segmentation and classification:

4-path min-cut/max-flow Dinic's algorithm, where objects are buildings and noise objects, background – ground.

- vectorization: 4-path Theo Pavlidis' algorithm.

D. Data collections

The detected objects are manually verified and classified with label "building" or "noise" using the geographical information system called *Quantum GIS*. The total number of detected objects after the classification method is 844 284, where 99.68% are noise-objects (2658 objects are buildings only). The number of unique objects is 34 793 (only 4% from total number of objects), where 2484 are unique building shapes (7% from total number of unique samples). The most number of noise-objects are robust trees and shrubs (see Fig. 2).

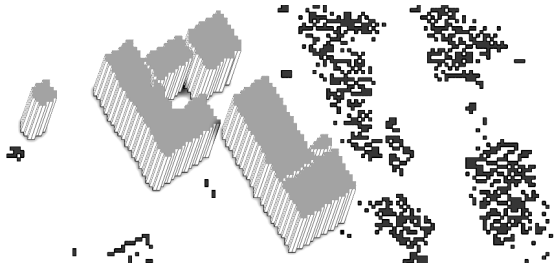

Fig. 2. Sample of building vector layer noised by robust vegetation elements

E. Analysed geometric features

Eleven geometric features are analysed under the scope of study, the list of them and their equations are provided in Table I. The geometric features are calculated using *Quantum GIS* and *OpenJump GIS* software, then the collected data are saved in *CSV* format to process them by data mining tools.

F. Feature importance analysis

The analysis are completed using *"R project"* tool. The correlation among features are analysed using Spearman monotonic correlation coefficient. The importance of features for object recognition is measured using random forest algorithm.

III. DISTRIBUTION ANALYSIS OF FEATURES

The distribution analysis of noise data show that data have two hills (*R*, *E*, *F*, C_2 and *S* cases). It means that two classes of data are grouped in one dataset. The feature eccentricity (*E3*) has the most strongly expressed distance between these subsets (see Fig.3).

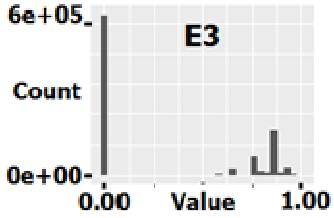

Fig. 3. Eccentricity distribution of noise samples, which shows existence of two subsets of noise classes

The anomaly subset has been selected by the logical expression: ($R > 0.875$) & ($E1 < 0.125$) & ($E2 > 1.05$) & ($E3 < 0.125$) & ($F > 0.875$) & ($C2 > 3.5$) & ($S > 0.95$). The obtained set contained 456 144 objects (54% of noise objects) and only one unique sample with area 1 m^2 (one pixel object).

IV. CORRELATION ANALYSIS OF FEATURES

Correlation among features are very important parameter in machine learning, because strongly correlated features don't have additional information for classification and can be replaced by related other parameter with a goal to use the better minimal feature set for classification tasks, that sufficiently can minimize the processing time.

If the random forest is used for analysis of feature importance, the existence of correlation is very important factor, because the magnitude of feature importance is steadily decreasing, when the strongly correlated features are added to dataset [7].

Spearman correlation coefficients are calculated for unique object shapes. The buildings and noise objects are analysed independently (see Fig.3 and Fig.4).

The correlation analysis has showed, that building shapes have strong correlation among next features (see Fig.3): {*A*, *P*, C_2}, {C_1, *K*}, {E_1, E_2, E_3, *F*} and {*R*, *S*}.

The noise objects have strong correlation among (see Fig.4): {*A*, *P*, *C1*, *K*}, {E_1, E_2, E_3, *F*} and {*R*, *S*}.

The calculation complexity and intersection of value distribution are considered selecting the better feature of correlated sets (see Table I and II):

- {E_1, E_2, E_3, *F*} → *F* (form factor);
- {*R*, *S*} → *R* (rectangularity);
- {*A*, *P*, C_2}, {C_1, *K*}, {*A*, *P*, *C1*, *K*} → {*A* (area), *C1* and *C2* (compactness)}.

So, the suitable feature set is {*A*, *R*, *F*, C_1, C_2}.

V. RANDOM FOREST ALGORITHM

The classification task is to correctly assign class y to object x, where X is the set of objects and Y – the set of classes. So, the classification problem is to find the function, which most closely approximates function $f : X \to Y$.

Decision trees and random forest algorithms belong to supervised learning algorithms, when m samples are used to teach a classification system.

Decision trees are based on the graph theory. The goal of algorithms is to find the best rules of data classification. The result is the acyclic directed graph, where each node divides the input dataset by some rules and provides new subdatasets. The terminal nodes called leafs contain the classified samples.

Table I
Geometric Features of Vector Shapes

Geometric Feature	Equation	Description
Geospatial area	$A = \sum p$	Each pixel p of LiDAR data projection is proportional to real geospatial area of Earth, therefore feature "area" is applicable for geospatial images.
Geospatial perimeter	$P = \sum b_p$	b_p is the external side length of border pixel. Many authors are against perimeter and perimeter-based features, because of coastline paradox. The modern most used resolution of DSM (digital surface model) is 1 m^2. If the constant resolution is accepted, this parameter is important for analysis.
Rectangularity [4], [6]	$R = \frac{A}{a \cdot b}$	a – major axis (length of minimal bounding rectangle) and b – minor axis (width of minimal bounding rectangle). The parameter describes the object shape similarity with rectangle shape.
Elongation [4]	$E_1 = 1 - \frac{b}{a}$	The character expresses how strong the shape is elongated.
Elongation [5]	$E_2 = \frac{2\sqrt{A}}{a \cdot \sqrt{\pi}}$	This feature is used to evaluate the elongation of basin shape, but it evaluates not only ratio of minor axis with major axis, it measure the circle/ellipse solidity.
Eccentricity [4]	$E_3 = \frac{\sqrt{a^2 - b^2}}{a}$	The ratio of distance between the ellipse focal and major axis.
Form factor [5]	$F = A / a^2$	Form factor is used in hydrology to analyse basin, it expresses the elongation of shape too.
Compactness [4-6]	$C_1 = \frac{P}{2\sqrt{\pi A}}$	The ratio between object area and circle area. Sometimes compactness is interchanged by the parameter circularity, which is equal to $1/C_1$.
Compactness	$C_2 = P / A$	The ratio between perimeter and object area.
Convexity [4], [6]	$K = P_c / P$	P_c – perimeter of convex hull, where convex hull is the smallest ambient shape.
Solidity [4], [6]	$S = A / A_c$	A_c – area of convex hull. The solidity expresses the density of object - how many wholes the object contains.

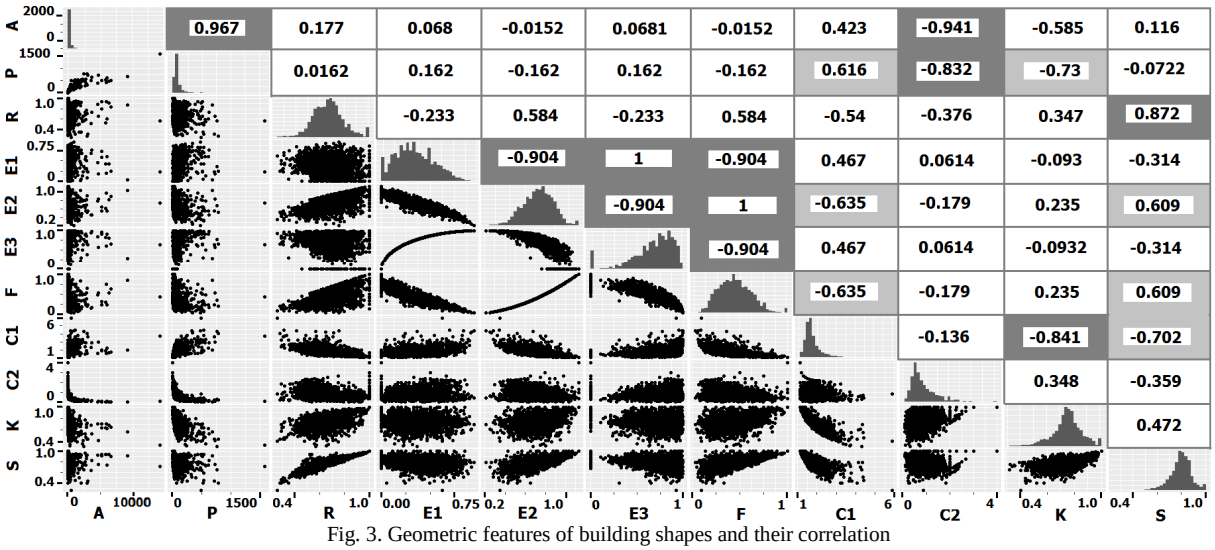

Fig. 3. Geometric features of building shapes and their correlation

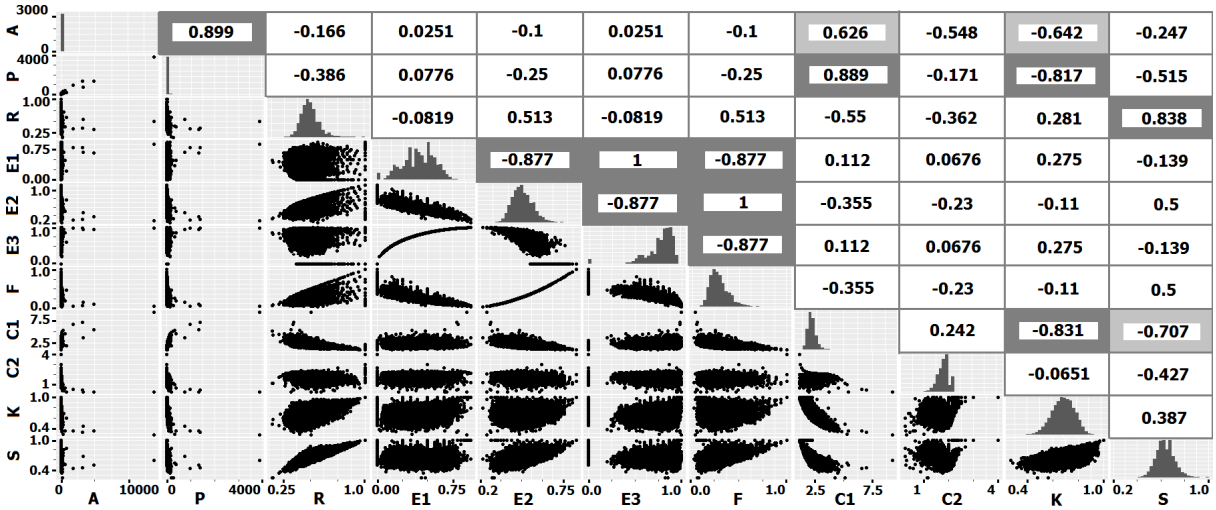

Fig. 4. Geometric features of noise shapes and their correlation

The common decision tree algorithms are *CART* (Classification and Regression Tree), *ID.3* (Interactive Dichotomizer 3) and *C4.5* [8].

Random forest is the ensemble method, which constructs many decision trees using bootstrap datasets with random feature set. The final prediction is defined by the majority of votes [7-8].

Random forests can be applied to measure the feature importance for object recognition. The most widely used score of importance of a given feature is the increasing in mean of the error of a tree (MSE for regression and misclassification rate for classification) in the forest, when observed values of this variable are randomly permuted in out-of-bag samples [7].

Table II
Geometric Features of Vector Shapes

	Building Shapes			**Noise Shapes**		
	1st quarter	**Median**	**3rd quarter**	**1st quarter**	**Median**	**3rd quarter**
A						
	26	70	139	13	16	21
P						
	28	48	72	24	28	36
R						
	0.59	0.67	0.75	0.43	0.48	0.54
E1						
	0.13	0.27	0.50	0.30	0.43	0.53
E2						
	0.64	0.75	0.85	0.53	0.59	0.66
E3						
	0.59	0.75	0.87	0.71	0.82	0.88
F						
	0.32	0.44	0.56	0.22	0.27	0.35
C1						

	1.48	1.63	1.85	1.87	2.04	2.28
C2						
	0.51	0.72	1.13	1.67	1.85	2.00
K						
	0.70	0.76	0.82	0.64	0.70	0.76
S						
	0.75	0.80	0.85	0.59	0.63	0.69

* If feature is marked by gray color, then buildings and noise objects don't have intersections of 1st and 3rd quarters or they are very small.

VI. GEOMETRIC FEATURE IMPORTANCE ANALYSIS

Feature importance is measured using the full dataset of unique shapes (buildings and noise objects). The selected number of trees is 500.

Completing the analysis of perimeter-based indices, the authors of scientific article [5] mention that some other authors suggest completely abandon shape indices because of fractal behave of boundary called coastline paradox. The most important feature is C_2 (see Fig.5), which is perimeter-based index and resolution dependant parameter (1 m^2 in this study). Therefore, it is a good argument, that resolution dependant indices must not be ignored, only they must be used and analysed considering the resolution of processing data.

Other features are important too, but they are not so strongly important as C_2 (see Fig.5), but diagram shows that the features {*R*, *F*} strongly changed their place after the correlated features had been removed, that coincides with the results of experiment mentioned in article [7].

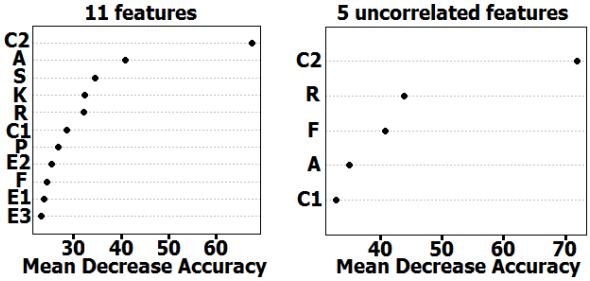

Fig. 5. Geometric feature importance: left diagram – 11 features, right diagram – selected 5 uncorrelated features

VII. VALIDATION OF RESULTS

Constructing the random forest for importance analysis 500 trees have been created, but 25 trees are sufficient number to classify object shapes (see Fig.6). Therefore 25 trees are used to complete the analysis of classification accuracy.

All dataset of unique shapes is randomly split into training set (80%) and validation set (20%). Four confusion matrices of classification are calculated (see Table III): two matrices for validation dataset (6997 shapes) using 11 features and only 5 uncorrelated features, dataset of unique shapes (34 992 shapes, where buildings and noise objects have 199 equal samples) and for raw dataset with all shapes (844 284 shapes).

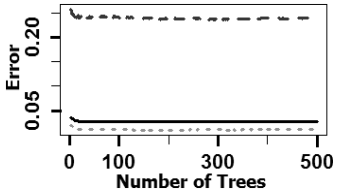

Fig.6. Dependence between error and number of trees in random forest

Table III
Confusion Matrices

	Validation dataset 11 features		Validation dataset 5 uncorrelated features	
	B	*N*	*B*	*N*
B	0.053	0.011	0.054	0.009
N	0.017	0.919	0.017	0.920
	A = 0.972	*K* = 0.776	*A* = 0.975	*K* = 0.800
	Unique Shapes		All Shapes	
B	0.062	0.004	0.003	0.784
N	0.009	0.925	0.000	0.213
	A = 0.987	*K* = 0.904	*A* = 0.216	*K* = 0.001

B – buildings, *N* – noise objects, *A* – total accuracy, *K* – Kappa coefficient

The confusion matrices show, that two models (11 features and 5 uncorrelated features classification models) do not have significant difference in accuracy.

The confusion matrix of unique shapes shows the strongly better accuracy, that can be explained, that the classification system remembered the shapes from training set, but it is more appropriate index in this case, because the shapes of buildings in most cases are similar.

The most interesting fact is real dataset recognition with very low accuracy and Kappa coefficient, which can be explained by "one pixel noise" mentioned in chapter III. "One pixel noise" is classified as building, because of square form of shape, which is very similar to building. Noise objects with small rectangle shapes provide the similar problem.

"One pixel noise" was selected by complex expression in chapter III, but noise filtering by area is more simple approach. The accuracy and Kappa

coefficient increase after noise filtering by area, that is depicted in Fig.7.

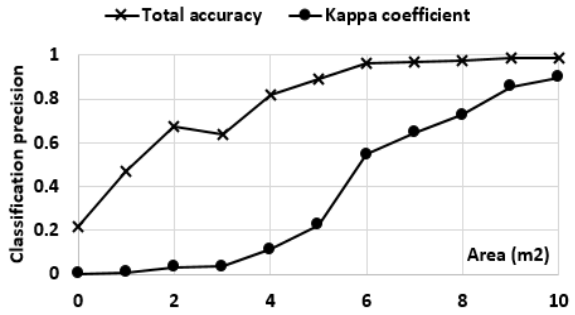

Fig.7. Classification accuracy depending on filtered objects by area

Completing filtering by 10 m^2 of area, 801 095 objects are removed, where 217 (0.03%) objects are buildings and 800 878 (99.97%) – noise objects. Remainder is classified by random tree, the accuracy is depicted in Table IV and sample in Fig.8.

Table IV
Confusion Matrix

A=0.99 *K*=0.90	Buildings	Noise
Buildings	0.050	0.005
Noise	0.006	0.939

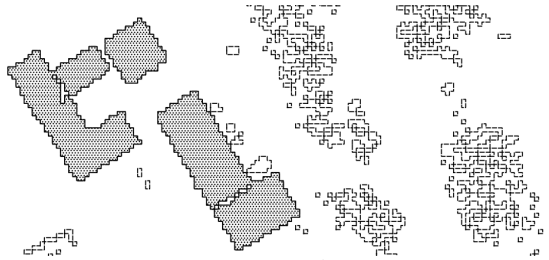

Fig.8. Buildings and filtered noise

VIII. RESULTS AND DISCUSSION

Eleven geometric features have been analysed under scope of this study. The correlation analysis reduced this number of features from eleven to five variables, where compactness index P/A (C_2) is the most important.

The distribution analysis showed that noise objects contains two groups of noises. One is similar to "salt and pepper" noise, which contains some pixel objects with square and rectangle shapes, for example, cars, poles and tree trunks. Other contains objects like bridges, walls or relatively big shapes of robust vegetation. The first group must be simply removed or ignored using area filter (area < 11 m^2), but the second group can be classified using geometric shapes (see Fig.7) with precision: total accuracy 0.99 and Kappa coefficient 0.90 (see Table III and IV).

IX. CONCLUSIONS

The geometric features have been analysed using the immediate output of 2D classification algorithm - the borders of shapes have toothed form. If line simplification algorithms are applied, the correlation and importance of features may be different.

The geometric feature "rectaliniarity" has not been analysed together with other features under scope of study, because it requires to use line simplification algorithms. Therefore it must be discovered independently to compare the best combination of algorithms and their input parameters with features researched under this study.

The combination of statistical, spatial and geometric features belong to different groups of parameters. Therefore correlation among them must be minimal, but clusters are located in sufficient distance one from other providing good conditions for automatic classification.

X. ACKNOWLEDGMENTS

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Customer behaviour doing online shopping: Latvia's case

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Abstract. E-commerce is an important branch of economics, and it is the fastest growing retail market looking forward to reach more than 250 billion EUR in 2017. Sucessfull online business has impact on customer behaviour. The aim of the article is to study customer behaviour doing online shopping. The article contains analyses of theoretical approaches to consumer behaviour and results of the customer survey which was carried out to find out the Latvia's customer behaviour doing online shopping.

Keywords: customer behaviour, e-commerce, logistic.

I. INTRODUCTION

From the point of view of marketing, consumer behavior is the process of product choice, purchase, and consumption in order to meet consumer's wishes and needs [1]. There is a difference between the concepts of cosumer behaviour and connsumer action. The authors consider that the consumer behaviour is the individual's external manifestation, conduct, and attitude that are usually defined by vital needs and environmental conditions, while consumer action is an activity and its result which is socially significant and/or envisage independent choice and decision-making.

It is not simple to predict customer behavior, as it is influenced by many factors, for example, a customer says one thing on his/her preferences and needs, but acts quite the opposite in the trading venue. Age, income, and level of education, mobility, tastes etc. differentiate customers from each other. Marketing decision-making is no longer dependent solely on direct contacts with customers due to the increased number of trading enterprises and the emergence of specialized markets.

Appearance of the Internet at the end of the last century has introduced major changes in the business processes. Fast development of equipment and tehnologies, the foreign – political interests of countries, economic globalization, and many other external circumstances stimulate the changes in marketing and management [2]. Relevant changes were promoted in customers as well. Online shopping is a convenience that suits the busy lifestyle of today's consumers. Online brands that provide a positive and personalized online experience will win the loyalty of online shoppers [3].

It is very topical for entrepreneurs to study customer behavior during online shopping in order to ensure that supply meets demand. Scientists and practitioners increasingly research and explore customers behavior in the market (i.e., [4], [5] [6], [7], [8], [13].

The aim of the study: to research customer behaviour doing online shopping: Latvia's case.

The tasks set to achieve the aim:

- Explore the theoretical aspects of customer behavior;
- Analyze the survey data on the Latvian customers behaviour during online shopping;
- Draw appropriate conclusions, based on the results of the study.

II. MATERIALS AND METHODS

Scientific (article) and practical (law) information was used in the research.

A set of general scientific methods (monographic, logical constructive, graphic) and sociological research method (survey) were used to carry out the research.

The article has been prepared within the framework of the international research "Importance of customer preferences doing online shopping" that was carried out by Rezekne Academy of Technologies (Latvia), Kaunas University of Applied Sciences (Lithuania) and Bialystok University of Technology (Poland). A survey was conducted in all three countries during the period from September to December, 2016 with aim to study the customer behaviour during online shopping. In total, 1 713 valid questionnaires (617 – in Poland, 558 – in Latvia and 538 – in Lithuania) were collected. The questionnaire consisted of 20 questions that could be relatively divided into several groups: characteristics of respondents (age, gender, education, etc.), search, choice, order, payment, delivery, and guarantee.

The research data on Latvian cutomers' online shopping will be analyzed in the article. Consequently, the analysis of data will be carried

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out, based on 558 questionnaires obtained from respondents in Latvia.

According to the Central Statistical Bureau, the number of permanent residents of Latvia was 1 968 957 in 2016 [9]. Applying a simple random sampling method, it was calculated that the required number of respondents, in order to confirm the data obtained is reliable (with probability of 95%) and represents the general sample, is 385. Since, in fact, larger number of respondents (558) was surveyed, it can be stated that the data obtained with a probability of 95% demonstrates the customer behaviour doing online shopping [10].

All answers in the questionnaire were modelled according to a Likert scale. The range of the responses was the following: absolutely disagree; disagree; rather agree than disagree; agree; aboslutely agree.

The authors have applied SPSS software for data processing using descriptive statistics, means, frequencies.

Characteristics of the survey's participants. 25.8% of the respondents are 18-24 years old, 21.3% - 25-34, 38.9% - 35-49, 14.1% - 50 and more. 64.1% of the respondents have graduate (higher) education, 18.2% - secondary education, 14.1% - vocational education, and 3.6% - primary education. In the research, a significant part of the respondents' characterization refers to the frequency of online shopping. 37.1% of the respondents do shopping few times per month, 31.5% - few times per year, 22.5% - less often, 8.5% - few times per week and 0.4% never.

III. RESULTS AND DISCUSSION

When researching the existing market or identifying a potential new market, marketing specialists have to put forward a number of questions and find answers that form a base of customer behaviour [1], [14] (Table 1).

Table I
Questions and objectives of the research of customer behaviour [1], [14]

Research question	**Research objective**	**Research example**
What is bought?	Purchase items	Products
Why is it bought?	Purchase motif	Description of a product, price, service
Who buys?	Characteristics of a customer	Roles in a purchasing process
How buys?	Purchasing actions	Choice, selection, decision-making
When buys?	Purchasing time	In a day, week, season
Where buys?	Purchasing place	Traditional stores, online shops, agents

In order to study the relationship between the market incentives and the responsiveness of customers, a model of customer action is designed. The model includes the following interrelated parts:

- External factors influencing customer behaviour (economic, political, technical, natural);
- Internal factors influencing customer behaviour (social, cultural, personal, psychological);
- Customer's decision-making process (emerging of needs, search for information, evaluation of alternatives, decision to buy, behaviour after the purchase);
- Customer's choice (product quality, product assortment, brand, price, place, and time of purchase, purchase form and payment) and decision [1].

The online retail sector is the main driver of growth in European retailing. While e-commerce growth rates hit 18.4% in 2014 and 18.6% in 2015, growth is not expected to cease in the coming years with Retail Research predicting 16.7% growth in 2016 and 15.7% in 2017 [11], [12].

E-commerce is the fastest growing retail market segment in Europe, with growth expected to reach £215.38 bn [€250.28 bn] in 2017 (Centre for Retail Research). Shoppers and their habits are ever-evolving and it can be a daunting task for retailers to stay in front of expectations [3]. There is absolutely no doubt that Europe is a key market in terms of e-commerce. With significant year-on-year growth, yet much potential still to come, online retailers should not dismiss the opportunities Europe holds [12].

One of the most important indicators explaining frequency of shopping is the income level of the respondents (see Table 2). It can be stated that the increase of incomes leads to the increase of frequency of the respondents' online shopping.

Table II
Frequency of shopping according to the respondents' income level (by the authors, based on the survey data)

Often of shopping online	Respondents' salary		
	Less or minimum	Between minimum and average	Average or more than average
Few times per week	2.86	8.75	11.06
Few times per month	42.86	34.17	37.98
Few times per year	33.33	34.17	26.92
Less often	20.00	22.50	24.04
Never	0.95	0.41	0
Total	100	100	100

Four times more respondents with incomes "average or more than average" rather than those with incomes "less or minimum" do shopping online with frequecny "few times per week".

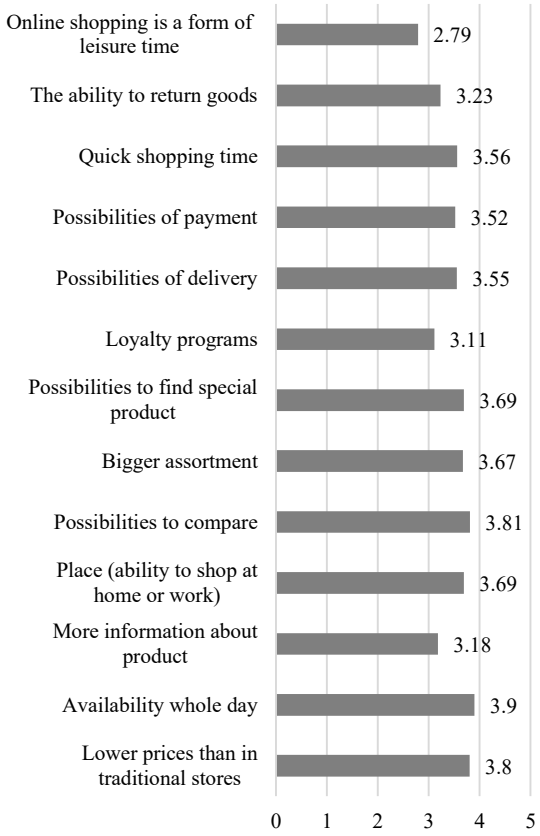

Fig.1. Respondents reasons for shopping online (by the authors, based on the survey data)

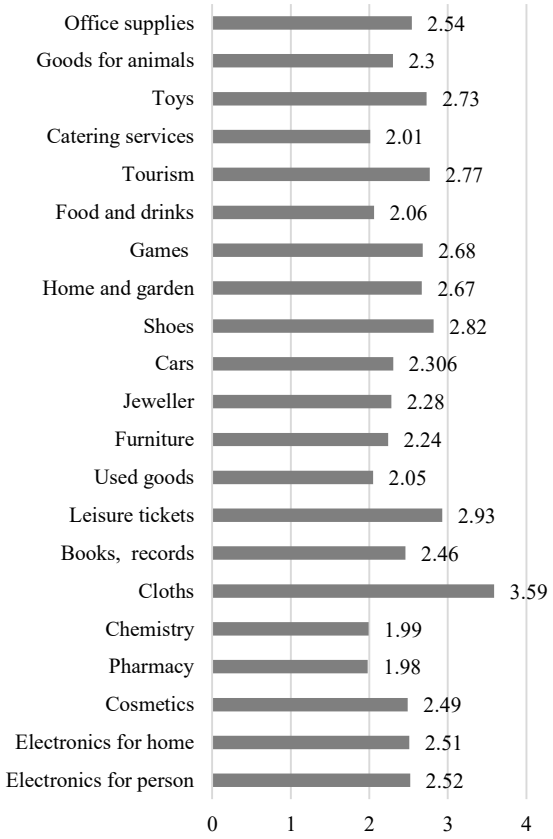

Fig.2. Goods most often bought by respondents (created by the authors, based on the survey data)

The respondents admit that availability whole day, lower prices than in traditional stores, and possibilities to compare are the main reasons for online shopping (Fig.1.). The respondents often do shopping in their free time that is probably even late at night or early in the morning. Price is one of the key indicators that determine customer behaviour and choice. In fact, the price comparison in traditional stores is time consuming and also money consuming process; and practically impossible for employed people. Accordingly, online shopping provides this opportunity. The least part of respondents perceive online shopping as a leisure activity. This means that online shopping has become an integral part of life for the satisfaction of needs. Hence, it is an opportunity for entrepreneurs to develop e-commerce.

The most online purchased items by the respondents are the clothes and tickets for leisure time (Fig.2.). Clothing has become the main product of online shopping due to availability to approach different manufacturers, providing choice by brand, price, and also taste.

Event organizers mostly offer to purchase tickets using online services, for example, *Biļešu paradīze*. The purchases are easy to be carried out and user-friendly, as they do not require detailed analysis of product characteristics.

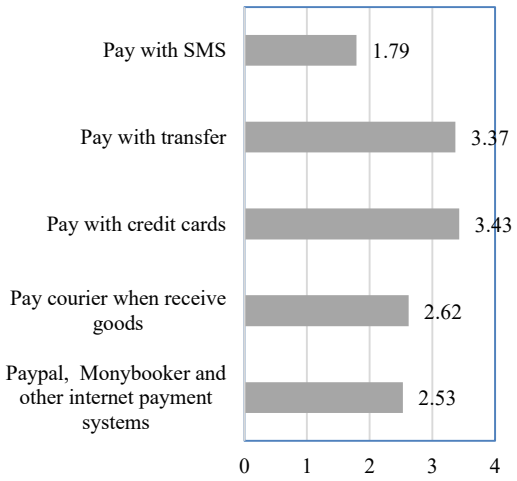

Fig.3. Payment methods used in online shopping (by the authors, based on the survey data)

The most popular forms of payment in online shopping are a transfer or payment by credit card (Fig.3.). These two are also the most common

payment methods offered in e-environment. Fig.4. shows the reasons why these types of payment are so demanded.

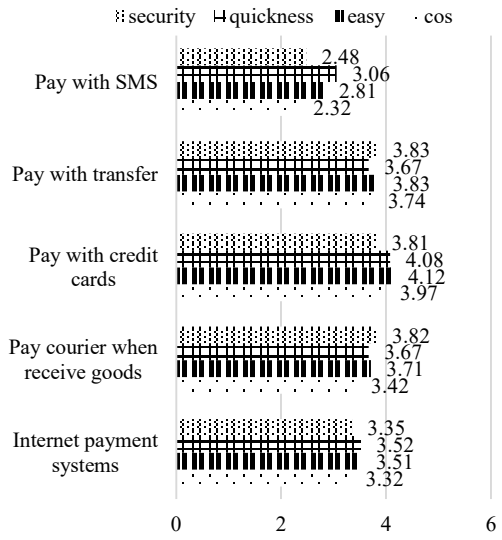

Fig.4. Assessment of the payment methods used in online shopping by cost, easiness, quickness, security (by the authors, based on the survey data)

Despite the fact that technologies are still developing, the respondents consider paying with transfer to be the most secure method of payment (Fig.4.) for purchases on the Internet (mean – 3.83). Payment with credit card is seen as the easiest method of payment by the respondents (mean – 4.12). A relatively large number of respondents (mean – 3.83) consider payment with transfer as a simple method of payment. Payment with credit card has lower costs (mean – 3.97), and it is the fastest method of payment (mean – 4.08). The relatively low assessment by the respondents is provided for the payment with SMS. The authors believe, that is due to the relatively low popularity of this form of payment, preventing the possibility to fully assess it.

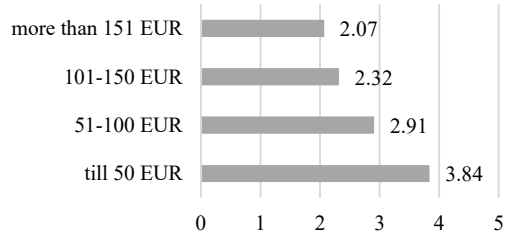

Fig.5. Money the respondents spend per one shopping session (by the authors, based on the survey data)

The respondents spend generally up to 50 EUR per one shopping session, since the income level of most of the respondents (43.4%) is in the range from minimum to average (Fig.5.).

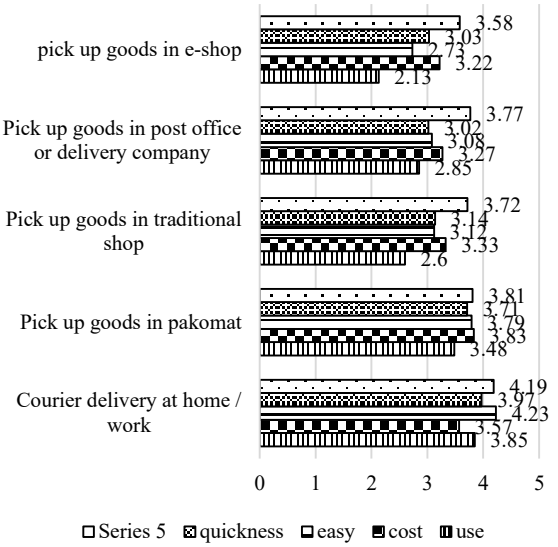

Fig.6. Assessment of types of delivery by frequency of use, cost, ease, quickness, security (by the authors, based on the survey data)

The most common type of delivery (Fig.6.) is the delivery of goods by courier to home or workplace (mean – 3.85). According to the respondents, this delivery method is the simplest (mean – 4.23), fastest (mean – 3.97), and also the most reliable (mean – 4.19).

The method of courier delivery at home/work indicates the customer's desire to save time and get the purchased goods in a place he/she finds comfortable. Pick up goods in pakomat gains a relatively high popularity. In Latvia, the pakomat are located in the parking lots of shopping centers providing a very convenient collection of goods. Going to a shopping center is also an opportunity to pick up goods ordered on the Internet. The respondents state it is one of the cheapest (mean – 3.83) delivery methods.

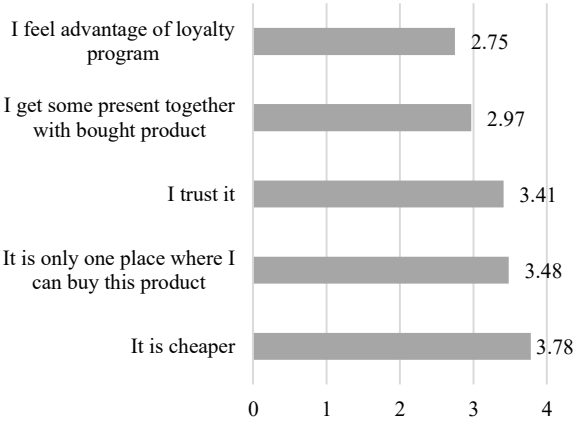

Fig.7. Reasons why respondents are ready to wait longer when doing online shopping (by the authors, based on the survey data)

Respondents state that the goods on the Internet are cheaper compared with traditional stores (Fig.1.), determining that they are willing to wait longer for

delivery (Fig.7.).

Shopping online provides that money is paid at the beginning, goods are received only after some period of time, and a seller is unknown. This means that online shopping is associated with many risks (a product description or image in reality may be different, a seller could be fraudulent, etc.). Therefore, a customer needs guarantees in order to feel safe when doing shopping online.

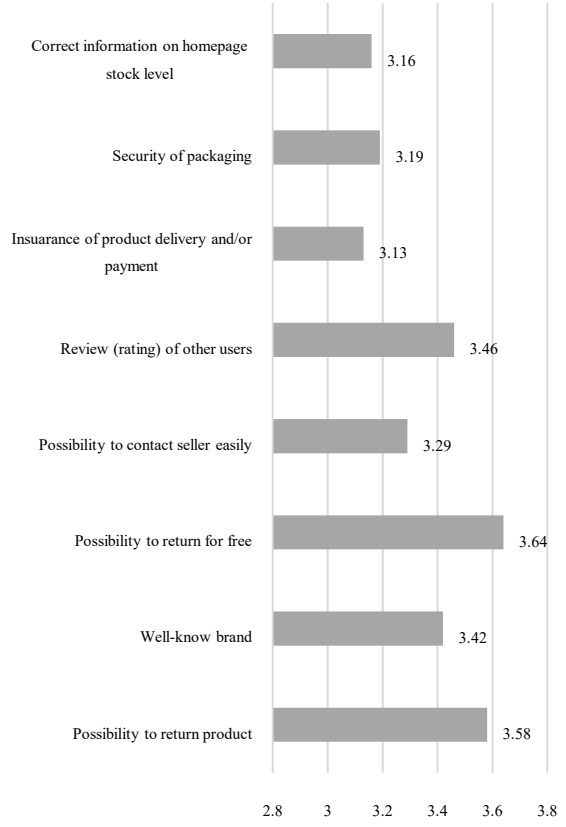

Fig.8. Guarantees the respondents pay attention to when doing shopping online (by the authors, based on the survey data)

One of the most important guarantees is the possibility of free return of goods (mean – 3.64), and the posibility of return (mean – 3:58) (Fig.8.). The respondents pay attention to the reviews (rating) of other users (mean – 3.46). This evidences that respondents are not certain about the ordered products and there is a probability that it will be necessary to return a product back to a seller, using the options prescribed by law.

However, it happens very often that an item is selected, but the order is not executed. There are several significant reasons for that (Fig.9.).

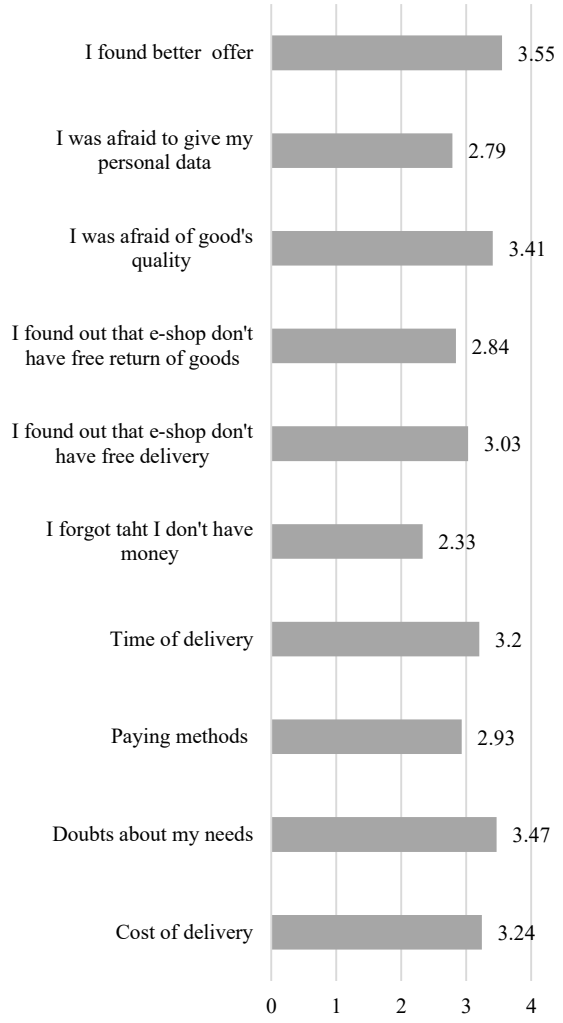

Fig.9. Problems the respondents face with when shopping online (by the authors, based on the survey data)

Most of the respondents do not complete the ongoing purchase (do not buy), because they find a better offer (mean – 3.55) (Fig.9.). Considerinng that the ability to do online shopping at any time is recognized as one of the advantages by the respondents, it also provides an opportunity to compare goods by criteria that are important to a customer (price, time and cost of delivery, quality, etc.).

IV. CONCLUSIONS

The frequency of online shopping and the amount of money spent is related with the income level of the customers. A higher level of income contributes to a higher frequency of online shopping and also increases the amount of money spent per one shopping session.

Customers are pretty conservative because most of then do online shopping just a couple of times per year.

Still the most popular are the traditional payment methods which are also perceived by clients as the

most secure and convenient. The least popular are mobile payments.

Online shopping stores need to pay attention to delivery issues because the competitiveness among e-commerce companies increase.

Cost and quick delivery will be one of the main reasons for successful online business.

The best guarantee is good image and opinion about e-business.

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Research of Guidelines for Designing E-study Materials

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Abstract. E-study use is increasing; its main content is information for self-education and it is delivered to the user through modern technologies that provide greater opportunities. In order to reach the user, information must be presented in a comprehensible and easy to remember way. The article focuses on the recommended ways of information presentation in e-studies, so that it would be possible to perceive and memorize information more efficiently, it also focuses on technologies that could help in building and analysing ways of presentation. There are analysed several technology products and presented various examples. The authors offer recommendation Guidelines for development and presentation of e-study materials, their assessment and presentation considering user needs and requirements of research, as well as literature study research, and, also, based on the foundations of visual science. The focus for the development of Guidelines was particularly on the visual function importance in the reading and learning process, as clear and stable text perception primarily is provided by near visual functions. In a structured manner, there are recommendations presented for a user-friendly e-study material design - style, size, spacing, position, colour - which should be applied for easy perception with visual processes, thus helping the learning process and facilitating memorization.
As nowadays there is a growing need for teaching methods and learning environment that is user-oriented, guidance specifics may be different for each of the e-study targeting groups that are divided primarily into three groups: children, adults, and seniors because each group has a different needs, requirements, and visual perception, as well as it is necessary to consider other features of the user which may differ from the standard and affect efficiency of recommendations. This work deals with part of the target group – adults (16-38).

Keywords: e-study, e-study environment, technologies, visual perception.

I. INTRODUCTION

Technology is all around us and no one can feel comfortable daily without using modern technology. Technologies are developing. And it is not surprising that many of them serve us in delivering visual and textual information. Increasingly, screens are used for learning - in extra-curricular education and self-education and in the integration of technology in everyday standardized full-time education and there is a widespread use of e-learning and e-study. Research about reading on the screen has been going on for more than 30 years [1], but still the acquisition of new knowledge about the effects of various parameters is moving slowly [2] and still many things are incomprehensible. Researchers have identified differences in reading from the screen and paper by both complex [1] and simpler tests. [3, 4] Reading digital texts and materials from a computer screen is considered to be much more difficult than reading a printed text. [5] On the computer screen the text is read 25% slower than from paper. [6] Therefore text formatting parameters which improve reading on the screen are essential. Studies indicate that the text presentation of the parameters to be used are those that are easy and comfortable to be received and natural for people's eyes and human mental development level. [5]

During literature research, it is revealed that many recommendations of the screen texts continue to rely on the printed material developed parameters.

The purpose: establish appropriate recommendations for guidelines about e-material parameter formatting in Latvian

Tasks: 1. literature review paying attention to current recommendations and guidelines, and carrying out analysis of the mentioned parameters; 2. carry out research on users' habits and preferences; 3. develop recommendations for guidelines; 4. carry out research and analyses of applications and browsers based on the elaborated recommendations.

II. MATERIALS AND METHODS

Literature review

There have been viewed and analysed more than 100 different literature sources. They deal with the recommendations of web development and statistics on the most important parameters which are used in the e-environment, and recommendations and guidelines for e-study courses and e-learning materials, as well as various studies in which researchers have tried to find out the best solution.

A list of most often mentioned formatting parameters has been created. Then there have been written out all mentioned values of parameters and

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marked in which sources values have been mentioned and recommended for use. After that analysis was made.

Survey

Research on users' habits and preferences was done by a survey. For this purpose, an e-survey was made. It consisted of several parts. During the first part, there was obtained general information about the respondents - gender, age, education level and occupation. The second part consisted of questions about respondents' technology usage habits and knowledge of e-materials. Third, the main part consisted of questions about formatting options of e-materials where respondents had to provide answers of their own choice. The fourth and the final part was to obtain additional information about respondents' eye health and reading difficulties, if they had any, to be accurately interpreted the responses received. It was a closed-ended questions survey.

For the purpose of this research there was selected an e-questionnaire because it was appropriate not only because it can be quickly carried out, but also because the third part of the questionnaire could be viewed and accurate choices could be made. It had to be done directly on the computer screen. E-survey in this case had a positive effect on the results, as the respondents could act whenever they wanted and in familiar surroundings – at their own screen without additional conditions. Furthermore, it did not have any additional stress that could arise from the presence of the surveyor and changes in the environment or circumstances.

Respondents

The survey involved 50 respondents aged 16 to 38 (Mean = 24.8, SD = 4.6) years old. From those 6 were men and 44 - women. They were young people with different levels of education and different current occupation. Respondents were without significant visual defects and without reading difficulties, but 24 participants had vision correction. They joined the survey on a voluntary basis.

Recommendations for guidelines

There were recommendations for guidelines prototype developed based on literature study of the recommended parameters of different sources and on survey data collected, and on results of previous studies and vison science-based research.

Applications and browsers research

The research was made about developers' imposed default formatting settings of font type and size in the most popular applications and browsers. The most popular applications were found: Microsoft Office, OpenOffice.org and LibreOffice products, and open access web editors available online: Google, Zoho, Quip products. The most interesting products were word processors, spreadsheets, and presentation programs. After that analysis based on the elaborated recommendations was made. A similar analysis was performed in the most popular browsers - Google Chrome, Mozilla, Microsoft Edge, Opera, and Safari also.

III. RESULTS AND DISCUSSION

Text formatting suggestions in the literature

One of the e-learning design guidelines started with the fact that information must be presented from top to bottom and from right to left. It is recommended to limit the amount of information that is displayed on a single page. [7, 8]

The text is recommended to be left align [7] to avoid problems with understanding the beginning of the line, and enhance understanding about where the line ends. It isn't recommended to use text justify, as for part of the readers, especially people with dyslexia or other types of reading difficulties, it may disturb the reading process. [9] For splitting a long text, it is recommended to use bullets, numbering, tables, and charts. [7]

The recommended font size and type only of printed educational materials in Latvian national methodological recommendations are mentioned there. [10] They are based on researcher M. A. Tinker's, the University of Minnesota, recommendations that are made from his research in the 30-60's. Furthermore, font size is not the only parameter, that we must pay attention to formatting learning and study e-materials. Textual information presentation and formatting parameters - row length, letter font, font size, line spacing, spacing between letters and combinations of font colour and background colour are very important.

Text line length

The optimal text line length is quite difficult to determine because it depends on the relationship between various formatting factors. [11] Text line length selection is also based on readers' choices and habits. It is important to know about the eye movements, visual angle, and retina usable area per fixation, as well as blinking places. [5]

Saccade is from 1 - 20 symbols, average it is 7-9 symbols. [12] For making fixation movements eyes usually choose 1-6 characters, and then fix 7-12 characters. [13] Blinking is performed to relax the eye muscles, which is making the eyes focus on the reading text, but after blinking to resume reading, it needs again to focus on a reading point. If there is a need in blinking too often and line lengths are too short, then every time the accommodation must be run by again and when it turns out that the muscle all the time is in operation, and it can get tired. Row length needs to be adjusted to the end of the row to coincide with blinking places. It needs to ease the process of reading and reduce eye fatigue. [14] Blinking places will be longer with smaller font sizes, thus creating a positive result for using longer text line. [5]

Although most results of the research about the row lengths show a faster reading at a longer row

length, [2] however, it is recommended to use short lines of text, [7] because it eases the ability to concentrate to the read-row [15] and readers in research prefer shorter lines. [15, 16]

By analysing more than 50 literary sources – it was found out that there is no unambiguity about the text line length because in reviewed literature it varies- they should be defined and quantifiable. There are three most popular types - characters per line (CPL), number of words in a row and line length in units' inch or centimetres.

In reviewed literature line length CPL mentioned in 40 sources and its value can be found from 24.7 to 140 characters. It is assumed that the most popular are the ones that are mentioned in more than 10 sources - from 45 to 85 CPL. The most common recommended 55 CPL (n = 23), followed by 60CPL (n = 19), 75CPL (n = 17), 50 and 65CPL (both n = 15).

In reviewed literature, row length in words is mentioned in 6 sources and the number found varies from 7 to 20 words. Most commonly recommended 12 words (n = 4) and equally often recommended 13, 14, 15 and 16 (n = 3) word use.

In reviewed literature, line length in units mentioned in 10 sources and their value can be found from 3.3 in or 8.5 cm to 10.5 in or 26.7 cm (or more without a maximum value set). They are divided into two groups, which are most frequently recommended: short lines of 3.3 - 4in or 8.5 to 10.2 cm and long rows 10 in or 25 cm and longer. Short lines are more contributing to concentrate on the text, [15, 17] but long lines - allow quicker review of the text as there is less need to be scrolled, [14, 15] it also shows a higher reading speed [18] and accuracy of the fixation. [19]

Only rarely we find a reference to the reasons why there is such a wide range of these parameters and why the optimal length of the text is quite difficult to determine. That is because it depends on relationship between various formatting factors. [11]

Font or typeface

Font is a specific representation of text characters with its own style that is based on the defined parameters. [20] Each language has its own specific typographic approach. For example, if a font looks typographically good for English, it does not mean that the same font will make such effects in Arabic and Hindi languages. [21] This also applies to the Latvian language because we have specific symbols - cedilla and lengthening marks which change the total font X-height. Therefore, the same recommendations for guidelines cannot be applied in all languages. [22]

It should be remembered that on-screen characters are displayed in a way that pixel sizes limit them, and what looked well in printed form may not be as good on the screen. [23] Because of it, many fonts at smaller or much larger size tend to blur. [24]

Analysing more than 35 literary sources it was found out that there is no unambiguity also in text fonts, which should be used for screen reading. A lot is used out of habit and transferred from printed material typographical recommendations.

However, one of the most common and general recommendations is that through the whole e-material there should be maintained a consistent font style. [7] It is recognized that for printed material it is best to use a serif font TimesNewRoman (TNR) and for digital material – a san-serif font Georgia, as both are designed as equivalent. [25]

Sans-serif fonts are mostly mentioned in references (in 30 from 35 sources) as recommended for use. Most mentioned sans-serif fonts are Arial (n=15), Verdana (n=15), and Helvetica (n=6), Trebuchet MS (n=3), and Calibri (n=3). Cedilla and lengthening marks in the Latvian language are not supported by Helvetica and Trebuchet MS fonts, therefore these are not included in recommendations for e-learning materials in the Latvian language. In just 15 out of 35 sources serif fonts are mentioned as recommended for the use in digital materials. The most commonly referred serif fonts are Georgia (n=9) and Times New Roman (n=7).

Font size

Size use depends of screen width used, [26] as well as on which browser the page is run or document is viewed, if the parameter default settings work. [27] One of the most common and general recommendations is that through the whole e-material a consistent font size should be maintained. [7] In earlier research more often there were found references to the smaller font size than in latest. [27] It is scientifically proven that a larger font size for reading is more favourable but there are very few studies that have studied the letter sizes, which are above 14 pt. [28] These sizes are also mentioned in different sources differently, basically points (pt), and pixels (px), and for e-materials also in percentage (%), and EMS, which are used by web page programmers.

For body text in different sources (n~40) it is advised to use a font size of 8 pt and 28pt. However, the most common - from 12pt to 19pt. 12pt (n=28) size as initial for main body are more often mentioned in sources in which comparison with information about it is used, which is currently being used in e-environment and where the target audience is young people. However, more often it leads to the size 14pt (n=34), as minimum useable, especially when the target audience is wider and content is intended for the elderly and/or children. Furthermore, studies have been performed with larger font sizes, as a reading distance on screen is larger than the standard reading distance for printed materials. With a larger distance of watching, a smaller font size reaches the retina, so the same size that is used in printed texts, could not be applied.

For Headlines, of course, it is recommended to use larger font size, but about this there is much less information. In the literature, letter size from 12pt to 32pt can be found. Top suggestions are from 14pt to 26pt font size to use, but most recommend use 18pt (n = 3) and 24pt (n = 3) size.

Line spacing

Multiline readable content must be placed in such a way that the distance between one row symbol lower edge to the next line upper edge should be enough and it makes the text readable. [29] There are also studies which have not shown significant difference in reading speed between the different line spacing sizes. [30] Choosing the size of line spacing the size of the font should be considered. [31]

In the literature (n = 12) line spacing is displayed in units and px, and mm, and the percentage of the font size. In units, it varies from 1.15 to 2, and most commonly it is recommended to use from 1.5 (n = 2) to 1.6 (n = 2). As the percentage varies from 90 to 160%, the most commonly recommended to use is at least 120% (n = 7) line spacing.

Colour

One of highlighted prerequisites: through the whole e-material to maintain a common text and graphics colours. [7] It is recommended to use the maximum contrast between the text and the background [32] and use less than 4 colours in one textual material, [10, 21] in some cases up to 5-6 colours. [10]

Most often it is recommended to use a dark text on a light background. [33] A black text on a white background is always a good solution, [34] it is visible and legible, [35] as this combination has a high contrast and is called a positive text. [6] A green text on a white background is being considered for use because the human eye has a natural tendency to green colour, as well as the rays are converged on the retina of the eye without the lens adjustment and adaptation that might induce eye fatigue. [36] A grey background increases the saturation of any colour in its foreground. [37] A black text on a grey background is also advisable. [38]

Also, it is recommended to use white letters on a black background because they are high-contrast. [35] They are suitable for higher resolution and awareness raising activities, but for long-term reading, however, they do not fit, like any light-coloured text on a dark background, as tiring the reader's visual system, [5] in addition, the dark background makes the pupil open more to get more light thus creating a larger eyes focal outflow. [39, 40]

Survey

Samples for survey questions was made based on information from previous literature research. Text samples can be seen on web-page http://www.phd-km.lv/fonti.php .

Font

There was presented a text sample by 14pt size. Respondents were shown a text in 5 different fonts - Times New Roman (TNR), Arial, Verdana, Georgie, Calibri. They had to take look at all 5 examples from which respondents had to choose 3 fonts that seemed the most acceptable to use for on-screen text.

In general, Top3 fonts are Verdana (n = 35) Arial (n = 34), Georgia (n = 33). There is near also the TNR (n = 28) that had the greatest number of choices as the first choice, and it coincided with the Arial (n = 15). (Fig. 1)

Font size

Each participant had to see the text where each of the previously used 5 fonts were displayed in 4 sizes - 10pt, 12pt, 14pt un 16pt. Respondents had to choose one size for each font that seemed the most acceptable to use for on-screen text.

In general, most respondents chose 14pt size (n = 87) and 12pt size (n = 81), but it was different for each of the fonts. TNR - 14pt (n = 20) and Arial - 12pt (n = 19), Georgia - 14pt (n = 18), Verdana - 12pt (n = 20) and Calibri - 14pt (n = 20) (Fig. 2)

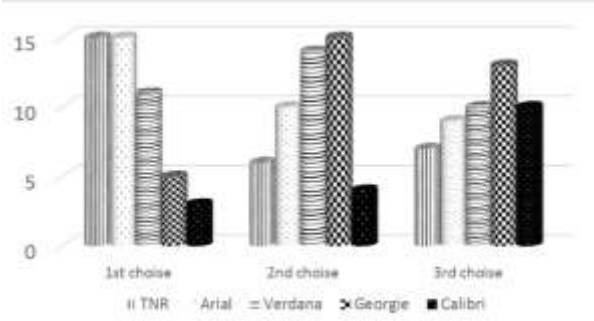

Fig.1 Respondent font choice

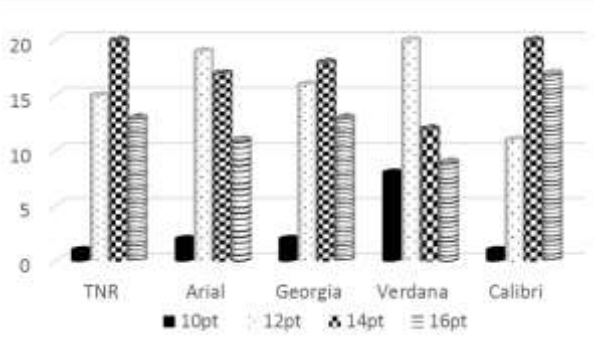

Fig. 2 Respondent font size choice

Line spacing

Each participant had to see the text where each of the previously used 5 fonts were displayed in 14pt size, but line spacing was changed - 1.0, 1.15, 1.5 and 2.0. Respondents had to choose one line spacing size for each font that seemed the most acceptable to use for on-screen text.

In general, most preferred were 1.15 (n = 126) and 1.5 (n = 103) The size of the space between the lines, but the choice was different for each of the fonts. TNR - 1.15 (n = 31) Arial - 1.15 (n = 26), Georgia -

1.5 (n = 28), Verdana - 1.5 (n = 20) and Calibri - 1.15 (n = 29). (Fig. 3)

Colour

Each participant had to see the text written with TNR 14pt font size, each of the options changed text font colour and background colour combination. It was created in 7 different versions: black text on a white background, white - on black, grey - on white, blue on white, green - on white, green – on blue and yellow - on a red background. Respondents had to choose 3 colour combination that seemed the most acceptable to use for on-screen text.

In general, Top3 colour combination is black and white (n = 40) grey to white and green (n = 32) and white (n = 21). 9 respondents decided that there are only two options, which should be applied when displaying text on the screen. (Fig. 4)

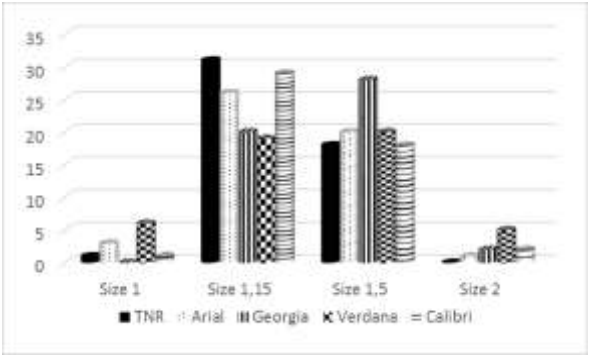

Fig. 3 Respondents line spacing choice

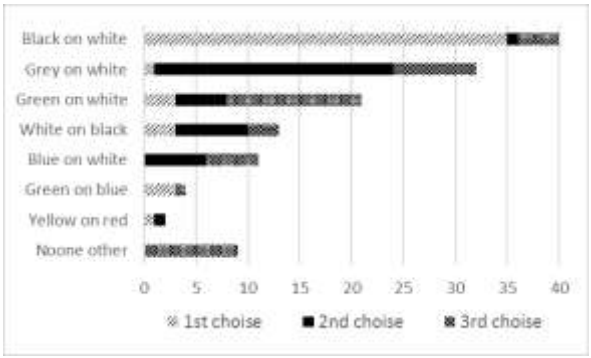

Fig. 4 Respondent colour choice

Recommendations for guidelines

These recommendations have been developed for e-learning materials and studying for one target group - young people - without reading difficulties and without any significant vision problems. Recommendations are shown in table 1.

Table 1 Recommendations

FORMATTING PARAMETERS	RECOMMENDATIONS
Text layout	Left align
Line length	55 – 75 CPL ~15cm
Font	Body text: Arial, Verdana, Georgia un TNR Heading: Can use also other fonts
Size	Body text – min. 14pt Headings – min. 18pt
Line spacing	1,15 or 1,5
Colour	Black text on white background Grey text on white background Green text on white background

Applications and browsers research

There is no single standard to be applied by developers. There is seen a use of different fonts and sizes for both body text and headings in applications and browsers. It is shown in table 2 un table 3.

Table 2 Applications default formatting settings

	WORD PROCESSOR	
APPLICATIONS	BODY TEXT	HEADING
Microsoft Office	Calibri 11pt	TNR 24pt
LibreOffice	Liberation Serif 12pt	Liberation Sans 18,2pt
OpenOffice.org	Calibri 12pt	Arial 16,1pt
Web editors		
Google	Arial 11pt	Arial 20pt
Zoho	Arial 11pt	Arial Black 18pt
Quip	Calibri 12pt	Calibri 24pt
	SPREADSHEETS	
Applications	Body Text	
Microsoft Office	Calibri 11pt	
LibreOffice	Liberation Sans 10pt	
OpenOffice.org	Arial 10pt	
Web editors		
Google	Arial 10pt	
Zoho	Arial 10	
	PRESENTATIONS	
Applications	Body Text	Heading
Microsoft Office	Calibri 28pt	Calibri Light 60pt
LibreOffice	Liberation Sans 32pt	Liberation Sans 44pt
OpenOffice.org	Arial 32	Arial 44pt
Web editors		
Google	Arial 18pt	Arial 52pt
Zoho	Roboto Normal 18pt	Roboto Thin 51pt

Table 3 Browsers default formatting settings

	DEFAULT FORMATTING SETTINGS		
BROWSERS	Standard font	Serif font	Sans-serif font
Google Chrome	TNR 12pt	TNR 12pt	Arial 12pt
Mozilla	TNR 16pt	TNR 16pt	Arial 16pt
Microsoft Edge	Segoe UI 12pt		
Opera	TNR 12pt	TNR 12pt	Arial 12pt
Safari	TNR 16pt		

IV. CONCLUSION

Analysing more than 100 literary sources - publications, recommendations for e-learning materials and web page creation – it was found that there is no unambiguity about all formatting parameters.

Most respondents chose a larger font size, even young people. This shows that for e-materials there cannot be used standard printed material recommendations directly.

Based on all information, research and survey, recommendations for adult people were made.

These recommendations must be checked experimentally in the target group by combined complexes in the context of e-material to confirm their effectiveness. Recommendations are supplemented by additional parameters. Also, there is a need to develop complementary recommendations, depending on the individual in addition to human factors, which may significantly affect reading and text perception - depending on their age, visual status, reading difficulties, and so on - because each person has different needs and opportunities.

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On the Formation of Student's E-portfolio

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Abstract. Using a technology of portfolio in higher education contributes to realisation student-centered education. Long-term researches in the field of quality and competence-oriented approach to education, which are conducted by the authors, allowed to develop and test two approaches to formation of student's e-portfolio: with using hypertext technology based on cloud storages and e-Learning System Moodle. These approaches, their advantages and disadvantages are analyzed in this article. The authors suggest issues for further consideration.

Keywords: cloud storage, electronic information-educational environment, e-portfolio, Moodle.

I. INTRODUCTION

The student must be an active subject of the educational process, his motivated and interested participation in the educational process is necessary for effective implementation of the educational program [1], [2]. One of the ways for motivating students to personality-oriented education is a technology of portfolio which will demonstrate the personal and professional growth of the student in the learning process.

Numerous works of European, American and Russian researchers are devoted to using portfolio in education, including e-portfolio [3]-[12]. J.A. Arter, V. Spandel, and R. Culham note: "Portfolios are scarcely a new concept, but renewed interest, fueled by the portfolio's perceived promise for both improving assessment and motivating and involving students in their own learning, has recently increased their visibility and use" [3].

The purpose of this article is to compare the of approaches to forming a student's e-portfolio using hypertext technology based on cloud storages and e-Learning System Moodle based on an analysis of the experience accumulated by the staff of Laboratory of quality problems of higher education (the authors of the article).

To achieve the goal, the following tasks were set:

1. To identify the available approaches to the formation of e-portfolio based on the analysis of publications of researchers.
2. To analyze the experience of the authors in forming an e-portfolio using hypertext technology based on cloud storages.
3. To analyze the experience of the authors in forming an e-portfolio using e-Learning System Moodle.
4. Compare the opportunities and limitations of these approaches, draw conclusions.

The structure of the article is the following: in the second part the authors describe the portfolio technology and tools for its formation. The experience of e-portfolio's formation is described in Sections 3 and 4. The comparative analysis of the used tools is presented in Section 5 and conclusions are provided in the last section.

II. BASES OF RESEARCH

The work of G. Lorenzo and J. Ittelson [4] gives an overview of the using e-portfolios in higher education, describes types of e-portfolio, particularly student e-portfolio, which reflects students' achievements during their studies. This kind of e-portfolio is covered in this article. E-portfolio is both a collection of works and a reflective learning tool.

The purpose of the portfolio's creation is to present the documented results of the training and other forms of student activities, to trace his individual progress in the learning process, to evaluate educational achievements and to supplement results of traditional forms of education quality control. The portfolio stimulates active and conscious attitude of the student to the process and the results of training, self-assessment. Portfolio reflects social activity and intellectual progress of the student. The process of portfolio creation promotes for rising of student self-esteem, development of motivation for lifelong learning [5].

The most modern and easy for using form of e-portfolios is online portfolio, which assumes placing information on the Internet.

E-portfolio (online portfolio) is an organized (structured) collection of personal results of educational and extra-curricular activities with using web technologies (including student's work, certificates, diplomas, testimonials, reviews, assessment), in which provided quick access.

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Online portfolio usually involves:

- selection, organizing, convenient placement of achievements of users;
- storage of results of student performance in digital format in the form of text, graphics, sound files, video, etc.;
- updating of content, managing it using the appropriate software;
- possibility to share your portfolio or sections with other users.

Doing this e-portfolio provides access to personal results, regardless of the place of work or study, in order to avoid wasting of time and effort for repeated collection and submission of the same information for different purposes [5].

Various tools can be used to create and manage e-portfolio:

- content management systems, including website builders (Google Sites, uCoz.ru, Wix, Weebly, Jimdo, etc.), specialized designers sites for portfolio (4portfolio.ru, Mahara, etc.), e-Learning System, for example, the Moodle;
- hypertext technology (including cloud storage, for example, Google Drive, or Yandex Drive);
- multimedia HTML-tools (for example, Macromedia Dreamweaver, Microsoft Office SharePoint Designer, Aptana Studio).

Each group tools makes certain demands to the user's information competence. It is preferable to use the tools that do not require much time, financial and other costs for their implementation, and do not require extensive training.

III. MATERIALS AND METHODS

The first version of the e-portfolio – a portfolio of competencies based on cloud storage.

Since 2011, first-year students of the Faculty of Physics and Mathematics of the Pskov State University in the number of 30 people have started formation of e-portfolios of competencies. The purpose of this portfolio is self-assessment and confirmation of the level of formation of competences according to the educational standard.

The authors have created a template student e-portfolio based on online table. Each student posted documents in a cloud storage (on Google Drive, or Yandex Drive), systematizing them by type of activity or another. When filling out the e-portfolio, each student conducted self-esteem of formation his or her competence, exhibited score from 1 to 5, reflecting, in his or her opinion, the level of formation of a competence, self-esteem confirmed commentary and links to documents [5], [6].

The authors note the positive aspects of formation of e-portfolio based on cloud storage:

- place on the university server is not required;
- student self-structuring documents, creating folders system;
- student fully own his portfolio, he can use it after graduation to represent it to the employer.

However, it should be noted that there are some problems in working with this type of e-portfolio:

- each student must have an account in one of cloud storage to accommodate his portfolio;
- if you don't provide the template of e-portfolio for students, in a result you can get unstructured portfolio;
- design of this portfolio is very limited.

The second version of the e-portfolio – a portfolio based on e-Learning System.

In connection with the adoption of new educational standards, prescribing the formation of e-portfolio based on electronic information-educational environment of high school, in 2016 the authors decided to form an e-portfolio at University e-Learning System http://do.pskgu.ru/ (Moodle).

Moodle contains a block of «Exabis E-Portfolio», which provides a place for student to store the files, and the ability to form different versions of the e-portfolio of downloaded files.

The authors determined the structure of e-portfolio according to the type of student activity (teaching, research, cultural, artistic, social, sporting and vocational). Students collect documents that confirm the results of their activity in their e-portfolio, and distribute them into folders corresponding to the types of activities.

At the end of each year of studying, students form a new version of the e-portfolio by choosing from the downloaded files the most important documents to illustrate their achievements. This makes it possible to trace the dynamics of the learning outcomes achieved.

Figure 1 shows a fragment of the section "Research activities" e-portfolio of the student.

The positive side of this approach to formation of e-portfolio, in our opinion, is the ability to develop rapidly different types of e-portfolios. However, the creation of e-portfolio at Moodle has several drawbacks. Plugin Exabis E-Portfolio does not provide for automatic placement in its portfolio of work performed in Moodle, as well as the placement of teachers' evaluations and reviews of its work. In addition, there are no tools to monitor and analyse the process of filling the e-portfolio.

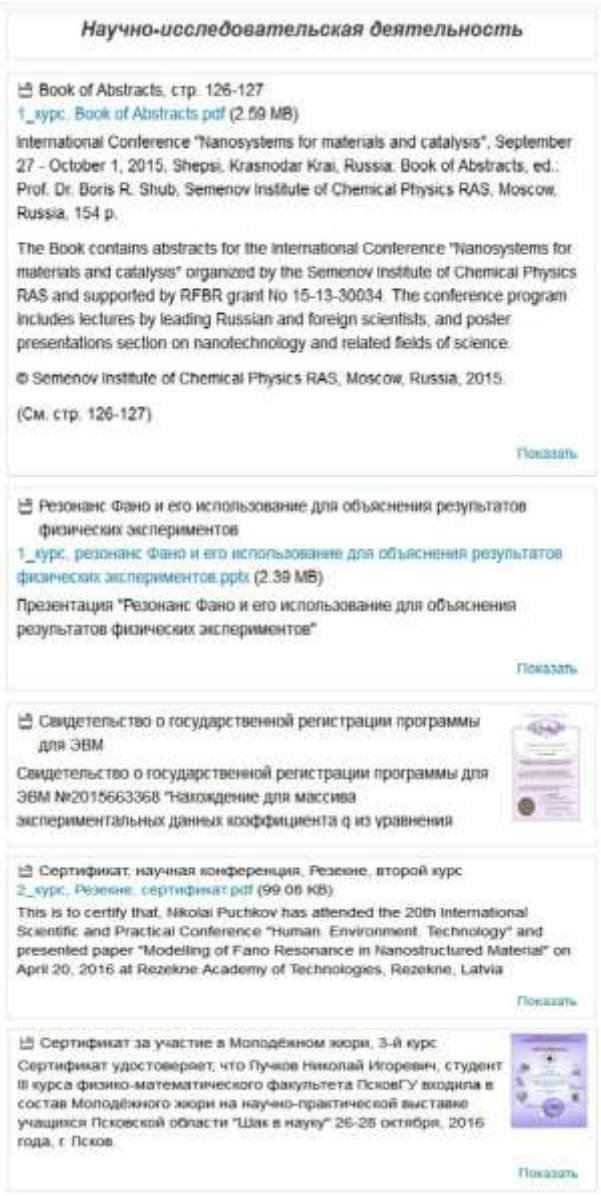

Fig. 1. The fragment of the section "Research activities" e-portfolio of the student

IV. RESULTS AND DISCUSSION

The experience of formation of student e-portfolio has allowed to perform a comparative analysis of tools for e-portfolio according to some important options. The results are shown in Table I.

Table I.
Comparative analysis of tools for e-portfolio

OPTIONS	CLOUD STORAGE	MOODLE
Necessity of the place on the university server for storage portfolio	Not required	Is required
The need for technical support, maintenance	Not required	Is required
Portfolio owner	Student fully owns his portfolio which can be used after graduation to represent the employer	Portfolio is in electronic information-educational environment of high school
The possibility of other users to access to the e-portfolio	It is possible to open access including specific users, but we need to know their e-mail	It is possible to open access including specific users registered in moodle
The capacity of the personal document repository	The capacity of personal document repository is limited to 15-20 gb	The capacity of personal document repository is limited by administrator
The possibility to other users to comment portfolio or some documents	It's possible if the document is open for comment	It's possible
Availability of opportunities for students to interact with the teacher within the system	It's not possible	It's possible
Design portfolio	There are no limitations and templates	Design is limited by moodle tools

Table 1 shows the differences of the instruments used. Systems have identical options:

- they provide an opportunity to structure a document repository, download documents in various formats, links to other resources;
- in these systems it's impossible for teacher to see the whole repository, only documents which are presented in the e-portfolio can be seen.

Thus, each instrument for the formation of e-portfolio has advantages, allowing to choose the most suitable. At the same time, the using of any kind of e-portfolio requires consulting support for students, both technical and contentful.

V.CONCLUSIONS

The experience gained by the authors has shown that e-portfolio is a way to reflect personal students' achievements in a variety of activities: learning, research, social, professional, etc. It is an effective form of self-presentation and self-evaluation of the results of the student activity.

The article [13] presents the results of a questionnaire on the quality of the university's electronic information-educational environment of 17 graduate students, conducted in 2015. The results showed that the most important for the students functions of the university's electronic information-educational environment are: information support (100%) and the opportunity of forming an e-portfolio (83%). The students could express their satisfaction with the choice of one of the answers: "fully satisfied", "partially satisfied", "not satisfied", "difficult to answer". The students noted that they were fully satisfied with the opportunities to form an e-portfolio (83%), partially satisfied (11%), dissatisfied (6%).

There are various tools for formation of the student's e-portfolio. Each of the instruments which have been used by the authors has its own advantages and disadvantages. Each of them does not satisfy all the needs of users. The selection of tools for student e-portfolio requires further research.

The experience allows us to formulate the following questions:

What system for e-portfolio needs the least resources?

What system for e-portfolio is most convenient for the users and less demanding to their ICT competencies?

How to provide the security of personal information?

Should the e-portfolio be kept in university after graduation?

Should the list of required documents be prescribed for placement in the portfolio?

Should be controlled the process of formation of e-portfolio?

Should the portfolio be evaluated? Where and how this evaluation will be considered?

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Method for Color Laser Marking Process Optimization with the use of Genetic Algorithms

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Abstract. Optimization of color laser marking process mostly depends on effective identification of optimal values of laser marking parameters. This is a difficult combinatorial optimization problem, which is still essential for companies that use laser marking systems. The study proposes a new approach to the process optimization through the use of genetic algorithms, carrying out preliminary experimental investigation, analyzing the laser marking results, and presenting possible improvements to the current implementation of genetic algorithms.

Keywords: color laser marking, combinatorial optimization problem, genetic algorithms, machine learning.

I. INTRODUCTION

Laser marking systems basically are composed of three main components: control unit, laser source, and scanner. Control unit interprets laser operator's commands and manipulates both laser source and scanner. Laser source generates beam and is controlled by using such input parameters as pulse repetition frequency, pulse energy, pulse duration. Scanner directs laser beam and is controlled using such input parameters as scanning speed, line step, defocus. Input parameters of both laser source and scanner are collectively referred to as laser parameters [1][2].

Color laser marking of stainless steel is complicated physical process. Complexity becomes apparent when one compares and interprets values of laser parameters used during experiment and stainless steel laser marking results [4][5][6]. To make things even more complicated, the producers of laser marking systems usually do not provide pulse energy laser parameter to manipulate directly. The value of pulse energy can be set indirectly using average power and pulse repetition frequency, but then again laser marking systems usually do not allow to set value of average power laser parameter directly. Instead, arbitrary power regulation coefficient is provided, which gives different control for each distinct type of laser marking system. Thus, for some laser marking systems the maximum value of power regulation coefficient always corresponds to the maximum possible value of average laser power, but for others it does not mainly due to the limitations of maximum possible pulse energy that system can generate for specific low pulse repetion frequencies.

Nevertheless, the number of possible combinations of laser parameters values is vast, although for each specific combination there is only one possible physical outcome (laser marking color), given properties of environment and material stay the same. Therefore repeatability of experiments can be ensured [4][5][6]. All things considered, the combinatorial optimization problem still persists, as it is quite difficult to determine correct combination of laser parameters values for desired laser marking result.

We propose using genetic algorithms for solving this problem. Genetic algorithms come from the field of machine learning algorithms and help imitate the iterative process of natural selection of fittest solutions. Basically genetic algorithms are search algorithms that, given the objective function, stochastically and iteratively generate new solutions based on information gathered from previous generations of solutions. Genetic algorithms are commonly used to solve different kinds of combinatorial optimization problems, i.e., in economics, design, scheduling, artificial neural networks, music [3][7].

The resulting solutions are coded using sequences of numeric values (codes) before actual marking, as it so happens that values of laser marking parameters can be represented in such form. Initially, a number of random codes are generated. These are applied to metal surface using laser and the resulting solutions are evaluated. Best laser marking results are selected and used to produce the next generation of solutions by crossing and mutating codes of selected solutions. In each new generation current possible best solutions, which are better than previous ones, may

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emerge. Solutions that are more fit get to pass their codes to next generations of solutions. This way only best solutions tend to survive.

To sum up, some basic assumptions were made before experimental investigation:

- there is vast amount of possible combinations of laser parameters values;
- two identical combinations of laser parameters values will produce the same marking color;
- small change in laser parameter value will not cause big change in produced marking color;
- the functional relation between power regulation coefficient and average power is not linear;
- there might be some very unique construction specifics or errors in laser marking system.

The aim of this study is to use genetic algorithms in order to produce a set of high quality laser marking colors in shortest possible amount of time.

II. METHODOLOGY

A. Experimental set-up

Preliminary experimental investigation was carried out on Rofin PoweLine F-20 Varia laser marking system, which has laser source with maximum average power of 20 W, pulse repetition frequency of 2-1000 kHz, and adjustable pulse width of 4-200 ns. The system provides five main laser parameters to manipulate: power regulation coefficient, pulse repetition frequency, scanning speed, pulse duration, and line step. The stainless steel used for color laser marking was of type 4301 18-9E 304. The diagram of experimental set-up is shown in Fig. 1.

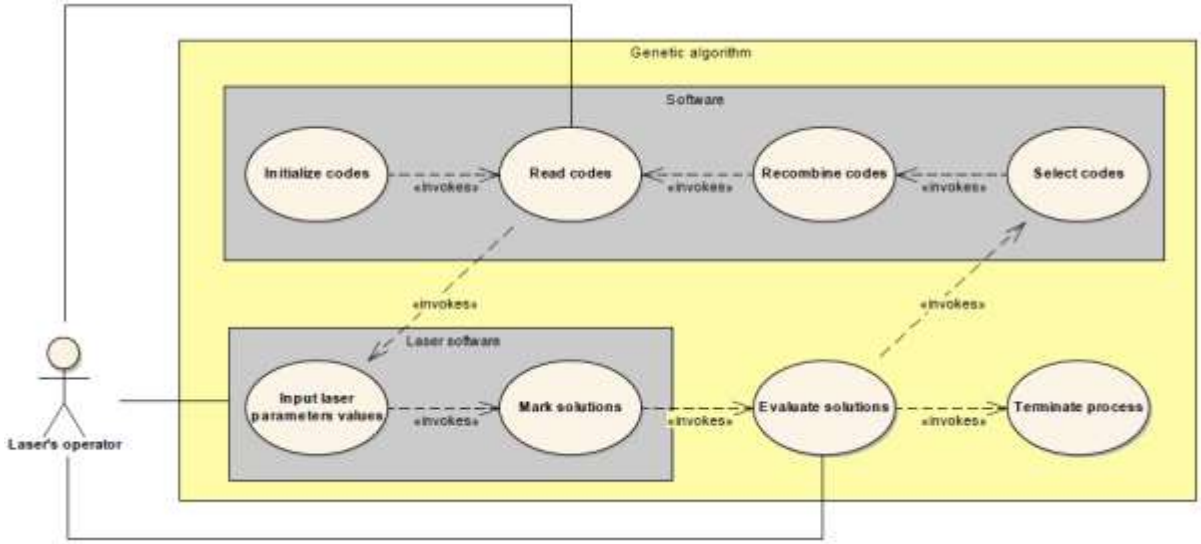

Fig. 1. Experimental set-up diagram – laser operator reads codes from computer program, operates laser system, and evaluates solutions

As shown in Fig. 1, the plan of experimental investigation is to iteratively use genetic algorithms to produce new marking colors until termination criterion is met.

B. Mathematical model

The aim of this study was to be achieved by using the computer program based on our implementation of genetic algorithm. There exist many variations of implementation of genetic algorithms. Basically, they all differ in how each stage of genetic algorithm is implemented. There are five main stages of any genetic algorithm: initialization, evaluation, selection, recombination, and termination (Fig. 2) [3].

Our implementation of genetic algorithm includes a computer program responsible for initialization, selection, and recombination stages, while evaluation and termination stages are done outside the computer program. Each stage is described below.

Initialization - in this stage initial 48 random codes were generated by genetic algorithm and grouped into first generation. As a result each code represented distinct combination of values of five main laser parameters. Genetic algorithm was configured so that for each laser parameter only values within allowed range were generated.

Evaluation - the process of evaluation included laser marking of current generation's codes and then evaluating produced solutions individually and all solutions as a whole. Each solution was ranked as either good looking marking color or not. If current generation's solutions converged (i.e., became similar), the process was terminated, otherwise the information about all the rankings was passed to selection stage of genetic algorithm.

Selection - here information about rankings of solutions was used to sort associated codes in such order that codes associated with good looking colors would have higher probabilities of being selected to later take part in recombination stage. Nonetheless, it was ensured that codes associated with bad looking colors still had at least some probability of being

selected. Then 24 combinations of two codes were selected and sent to recombination stage.

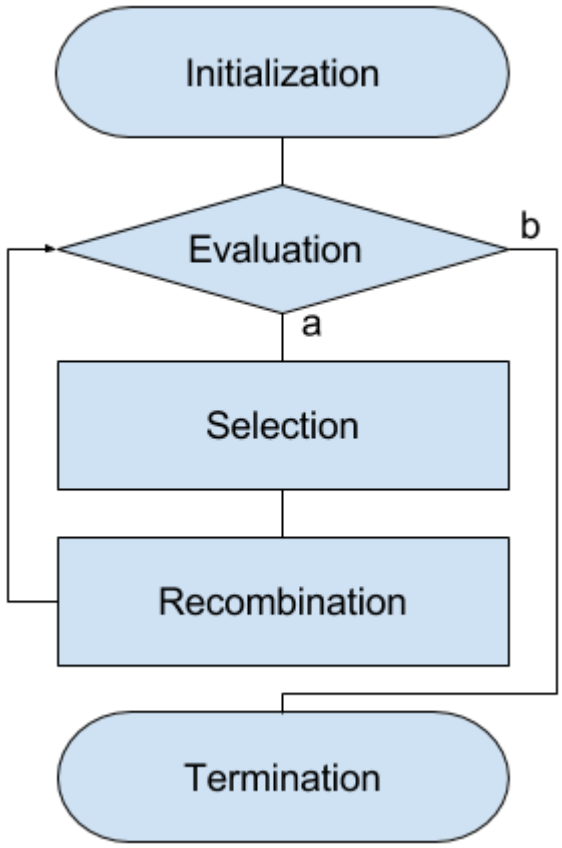

Fig. 2. Schematic view of the stages of the iterative process of genetic algorithms (where *a* path is taken when new generation of solutions is required and *b* path when no more generations of solutions are required)
Fig. 3.

Recombination - here each retrieved combination of two codes was used to produce new code by the process of crossover and mutation (Fig. 3). As a result, 24 new codes were produced and grouped into new generation. This generation was then sent back to the evaluation stage of genetic algorithm.

P1	P2	P3	P4	P5
47	187315	461	4	0.048
15	615015	188	8	0.039

↙ Crossover

47	187315	188	8	0.039
15	615015	498	4	0.048

Mutation ↗

Fig. 4. Example representation of how two new codes are formed from two previously selected codes through crossover and mutation

Termination - when no more new generations of solutions are required or solutions have converged, the iterative process of genetic algorithm is stopped.

III. RESULTS

It is important to mention that our implementation of genetic algorithm "knew" almost nothing about the laser marking system we used and completely nothing about the physical process of color laser marking. All it "knew" was that codes represented 5 parameters (Fig. 4), values of which had to belong to some allowed sets of possible values, and whether codes produced good solutions or not.

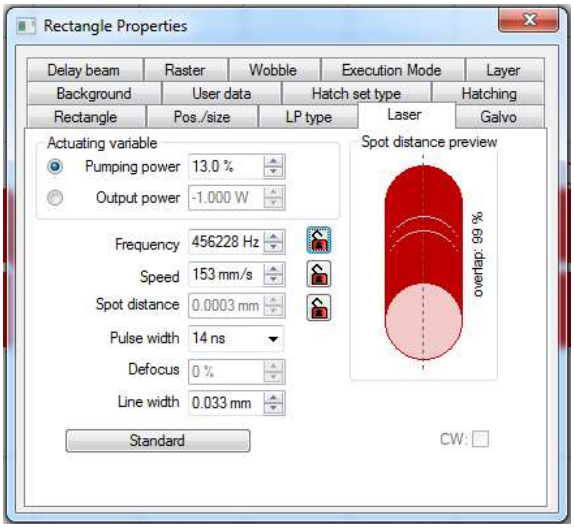

Fig. 5. Five main input laser parameters and their values as enetered by laser operator in Rofin VisualLaserMarker computer program

All marking colors (solutions) were grouped into generations with first containg 48 initial random solutions and all consecutive having 24 solutions each. Each solution represented specific combination of laser parameters values (code) and was laser marked as a filled square of some color on a surface of stainless steel (Fig. 5). The objective function of genetic algorithm was to select only best looking marking colors in each generation of produced solutions.

During preliminary experimental investigation it was observed that values of some laser parameters had a tendency to converge quicker. Such laser parameters included power regulation coefficient, pulse repetition frequency, and pulse duration. Still, convergence was not complete, i.e., multiple distinct values for each of these parameters were present.

The values of other laser parameters, that were less prone to convergence, varied across wider ranges of possible values and made associated codes more diverse. Besides, many of these diverse codes contributed to diferent looking laser marking colors.

In Fig. 5 one can see that color laser marking results on average tend to get better in each new generation – more new colors appear. Although, one

can also see that beginning with generation G13 green marking colors start to dominate, and it is a sign that solutions can soon converge.

Interestingly enough, it was also observed that sometimes two good looking solutions can result in a really bad looking solution, as the program was developed in such a way that information about the origins of each solution was always logged. Another observation was that after one seemingly bad generation (G9) there still can emerge a reasonably good one.

IV. DISCUSSION

The results of preliminary experimental investigation helped us draw some very important conclusions, mainly, that diversity among each generation's solutions must be always ensured. Still, current version of the program lets us identify subsets of optimal values of some laser parameters very efficiently due to the effect of convergence described in previous section.

The results certainly look promising, but more research is required. The program developed by our team as well as the overall methodology is to be further improved. Thus, this study is only the first part in the coming series of articles on using machine learning algorithms in order to optimize different kinds of laser materials processing problems.

Ideally, genetic algorithms should "know" very little if nothing at all about the problem they are utilized to find solution(s) to. The purpose of genetic algorithms is to find optimal solutions within the hyperspace of all possible solutions without using domain-specific knowledge during the process. That is why they can be used for optimizing different kinds of problems, to which solutions are coded in a form of a symbolic sequences, and color laser marking is truly compatible with this approach.

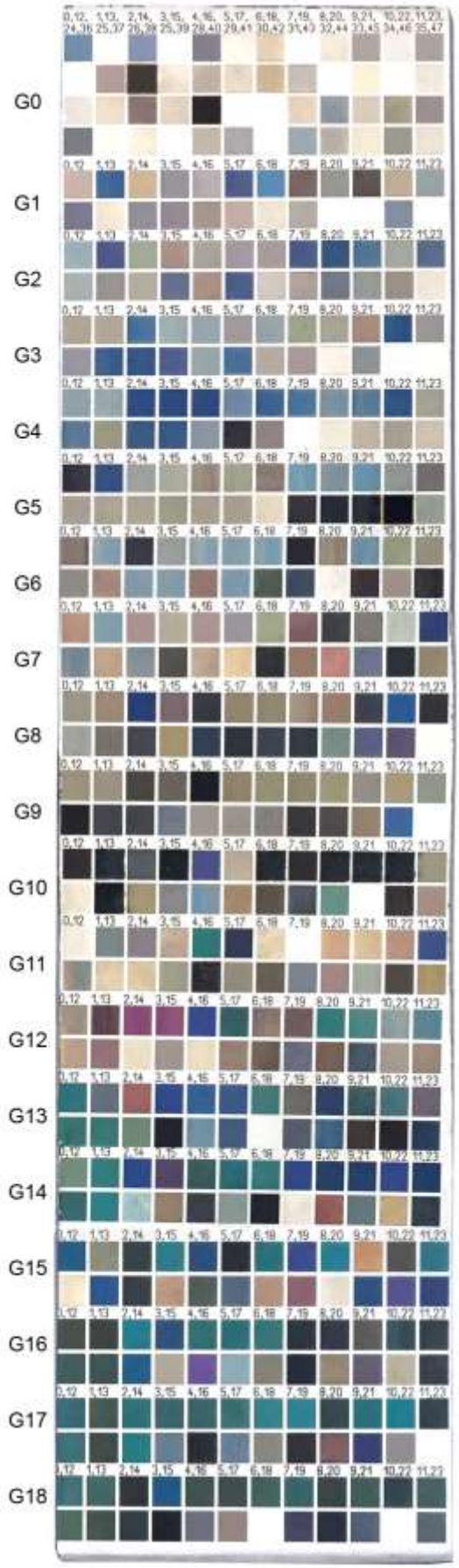

Fig. 6. Total of 19 generations of produced solutions

There exist many objective functions one can define for genetic algorithms in order to optimize color laser marking process, for example, determining combinations of laser parameters values for one particular color or for marking colors at higher scanning speeds. Furthermore, as genetic algorithms "know" nothing about the construction specifics of laser marking system itself, lack of information about the pulse energy or about the presence of some errors within a system or its software has less significance, as long as for each distinct combination of laser parameters values the color laser marking result is the same.

The great thing about genetic algorithms is that they can process multiple parameters at once as well as produce multiple distinct solutions in parallel. This helps solve very complex problems, the objective function of which can change in time. Bad solutions are quickly discontinued, while mostly good solutions keep getting recombined to produce even more new candidate solutions. Because genetic algorithms do not try to optimize for only one solution, diversity must be ensured at all times [7].

V. REMARKS

To better ensure diversity among produced solutions, first, the way these solutions are encoded must be reviewed. Thus, the values of laser parameters must be normalized and then converted to binary form so that there emerge more new ways to apply crossover and/or mutation to codes during recombination stage of genetic algorithm (Fig. 6).

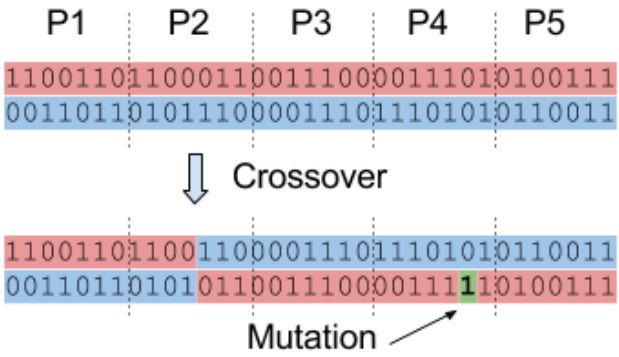

Fig. 7. Example representation of laser parameters values in a form of normalized binary code

Now each individual bit itself can be interpreted as parameter, and the more there are parameters, the more there are ways to split code for crossover (see Fig. 2 for comparison). Because values of laser parameters are normalized, every laser parameter has equal probability of being split. In addition to that mutations become much simpler. Still, each such simple mutation can have a significant impact on real laser parameter value when converted back do decimal.

Next, it can be allowed for crossover to take place in multiple positions within a code (Fig. 7). Thus, the number of possible combinations of candidate codes formed from two old codes certainly becomes larger and can be calculated as $C(n, m)$, i.e., the number of ways that m split positions can be chosen from n possible positions, where $n + 1$ is also a number of bits forming a code. Here, $C(n, m)$ approaches the largest possible number, as m approaches $n / 2$. In such case new code is formed from two approximately equally long parts of old codes.

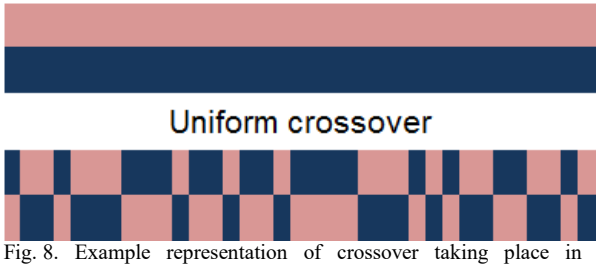

Fig. 8. Example representation of crossover taking place in multiple positions at once uniformly so that each of two new-formed codes consists of approximately equal halves of two previous codes

Then, crossover taking place in multiple positions at once can be applied to multiple codes at once (Fig. 8). Such approach can also increase the number of possible candidate solutions dramatically. This way search within solution hyperspace can be even more complete.

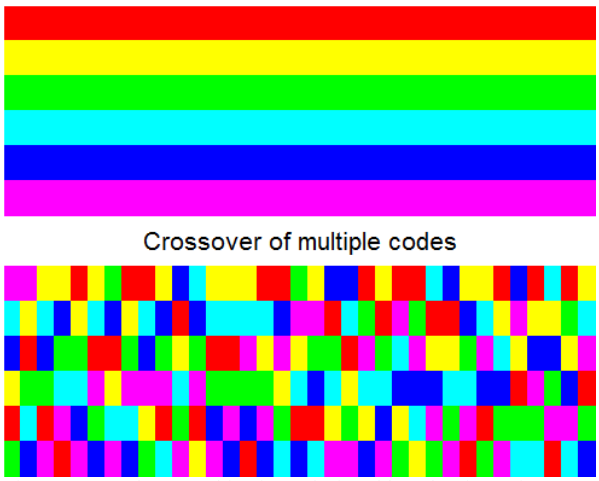

Fig. 9. Example recombination of six old codes into six new codes by applying crossover in multiple positions

Though, it may still occur that two selected codes share identical parts (Fig. 9).

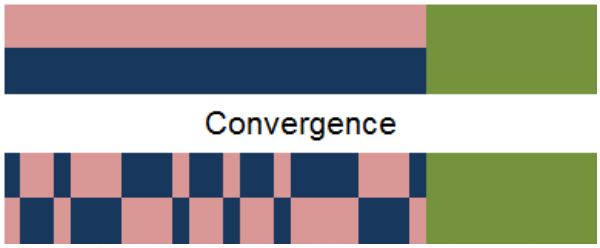

Fig. 10. Solution to convergence problem must involve mutation

The implementation of genetic algorithm can include a mechanism, which would allow introduction of new random codes at each new generation. This could further ensure maintaining diversity among solutions. Although diversity is very important for efficient search throughout hyperspace of all possible solutions, sometimes there might be a need to turn the diversity off. Such mechanism would allow to quickly converge solutions and terminate genetic algorithm.

In the future, it is also planned to study the introduction of optimal solutions in the initialization stage of genetic algorithm. Furthermore, because genetic algorithms help generate many diverse solutions (marking colors), these solutions are to be associated with their encodings by the process of training an artificial neural network. Such artificial neural network would then be able to predict color laser marking outcome for input parameters, and vice versa.

VI. CONCLUSION

The program developed by our team may be useful for laser operators, as it simply helps determine values of laser parameters for producing high quality laser marking colors in shortest possible amount of time without requiring deep understanding of laser parameters and actual physical processes that occur during stainless steel color laser marking. Thus, laser operator does not need to do exhaustive search for optimal combinations of values of laser parameters, but instead he/she needs to define objective function and evaluate marking colors according to it. The process of evaluation for some objective functions can further be automated.

Finally, it is worth mentioning that genetic algorithms do indirectly posess some kind of learning memory, as information from previous good solutions reappears in form of parts of code associated with new solutions. This seems to be really important emergent feature of genetic algorithms.

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Towards Utilization of Lean Canvas in the DevOps Software

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Abstract. The growth of technology made human to depend more on the software applications in his daily life and nowadays software companies focused more on building robust error free software to end customers in very short time. Software development companies facing one side growth of technological complexity and another side build the products fast to win a competition in business. In recent years growth of a DevOps given lot of new growth opportunity for the software companies.

DevOps basic principles focused on the collaboration and communication as a key in between software development information technology professional. It is concentrated on the automating the most of the routine tasks such as development, delivery, infrastructure, support, software testing in software development process. DevOps also emphasize on the building, testing and releasing the software more quickly and in a reliable way.

Keywords: devops testing, software testing canvas model design, software testing.

I. INTRODUCTION

In daily life, growing dependency of human on software embedded devices made a human more flexible to manage daily tasks. In recent years software development tools, technology and process changed a lot, it affected directly or indirectly traditional software development process. From the last few years, DevOps become buzzwords in the software development industry and most of the companies gradually focusing their projects adopting towards the DevOps to build the software fast and reduce the cost [11]. DevOps is an approach based on the lean and agile principles, practices in which teams are working in a collaborative way and communicate [1] more constantly to deliver the product or services in a continuous manner to get fast customer feedback and fulfill their needs. Considering DevOps toolchain [9], it involves the develop a code, build, test, package, release, configure, monitor. DevOps concepts are more emphasized more on the communication, collaboration and integration between all teams [2]. This entire process bridges the gap in between development, operation and quality assurance teams contribute to one platform to speed up software development and delivery process with the help of cutting edge tools and automation process.

The core lean process [3] focus on the removing unwanted things in process, tools and improve the effectiveness of the development process, this can impact straight on the process deliver speed and help to reduce the development cost. Lean can influence directly to traditional development and documentation methods in a process and more than that, it can bring new ideas for the customer / stakeholder-centric software development. A short time of delivering the software and cost saving for the overall project makes "lean" as the best strategy for software development.

In recent years, the word "lean" not only limited manufacturing it now also used in software companies to get rid of the waste in process and tools. The same lean concept also used by Ash Maurya for the lean canvas design for the business. Using the lean canvas for the business, anyone identifies the or create their own business model, business plan, possible solutions, key metrics.

In DevOps software development software validation and verification play a key role to fulfill the customer expectation with the error free software. The develops focused more on using the automation in testing using possible cutting edge tools, in this process for improving the testing process, we can adopt the lean canvas board to overcome many problems.

II. THE PROBLEM STATEMENT

In DevOps process, software verification and validation play a key role to ensure that the software is working according to the requirements. Quality assurance, tester role can be merged in either development or operation teams, most of the time they merged with the development team so they can work in parallel [4] [15].

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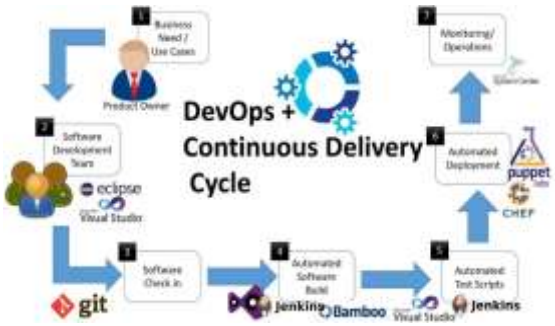

Fig. 1. Old SDLC and New DevOps SDLC overview

The most common DevOps challenges [11], [14], [15] related to software testing are:

Continuous integration: tester may have lesser knowledge about tools such as SVN, GIT, Docker,

Testing in Agile	Testing in DevOps
Test as early and as often as possible	Test continuously
Automate testing as much as possible	Automate almost everything
Continuous integration and testing is a step forward	Continuous integration and testing is mandatory
Potentially shippable code at the end of a sprint	Potentially shippable code following every integration

Fig. 2. DevOps continuous delivery cycle overview

Jenkins for code management and unaware of continuous integration practices.

Continuous testing: tester may find himself not educated with 100% automation for testing and at the end user notice still software bugs found after continuous testing using automated tools and process such as Test-driven development (TDD) & Acceptance test driven development (ATDD).

Configuration management: tester may not be able to use continues integration (CI) tools such as Chef, Puppet or Ansible to create the run-time environment according to different requirements.

Continuous delivery [10] or continuous deployment: tester can notice many repeated bugs due to continuous delivery or continuous deployment in the code and face difficulties with managing test automation frameworks.

Cultural change: tester needs to have many, mixed skillset and utilization of several tools such as Vagrant as a virtualization platform.

Test strategy: hard to define the test strategy from beginning of the project.

Test estimation: human resource estimation & testing time estimation for the project may get wrong.

Test planning: creating simple test plans in complex testing environment.

The biggest challenge company need to address in two main areas [14], [15], first developers need to look over more on production system and operation team need to learn and implement to program the system.

III. SCIENTIFIC NOVELTY OF PAPER

The business lean canvas evaluates the business model, it's a simple white board blocks design with several segmentations on it that help to identify the business plan to marketing strategy to end customers. Lean business canvas is a one-page document with several blocks. It is a template that helps to describe the business and its overall strategy and nowadays it's most of the time used in stats up, business case design and in restructuring the existing products.

Old SDLC	New SDLC
Directive	Adaptive
Task-oriented	Goal-directed
Specialized roles	Empowered teams
Resistant to change	Optimally responsive
Outsourced	Automated
Project optimization	Portfolio optimization

Fig. 3. DevOps vs Agile overview

The blocks of lean canvas start with problem definition, key metrics, customer segments and unique value proposition.

Use the lean canvas model as a base our core contribution is to focus on the finding the test metrics and investigating how we can adopt the lean canvas models in develops software test process.

Specifically:

Identifying and finding the suitable lean canvas porotype in DevOps.

Improving the DevOps test planning with help of lean canvas.

Simplifying the DevOps software test strategy.

Utilization of lean principles and lean canvas as the base model for the design of the new DevOps compatible lean canvas.

Find the appropriate lean canvas blocks in the design of the lean board.

A. Related research

Alexander Osterwalder and his co-authors in early 2000 published the business model canvas, and it is very attractive for the plan of activities and strategy management for any business [6].

The life cycle of the lean canvas is starting with the idea, followed by building, product, measure, data and learn this continues the process.

B. Lean canvas core principles

The core principles are used to identify the risk part of the created plan for the specific project.

Developing a document for your project idea/plan.

Analyze/Measure and remove the waste process in your project plan.

Continuous repeating test cycles for idea/plan.

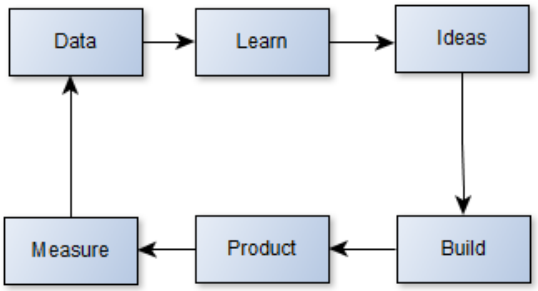

Fig. 4. Lean canvas life cycle

As above showed in fig 4, lean canvas life cycle, following steps - Ideas, build, product, measure and learn, we can recognize and generate the lean canvas model for the business. Now from gathering all core life cycle and lean principals able to generate the similar teams for the DevOps testing.

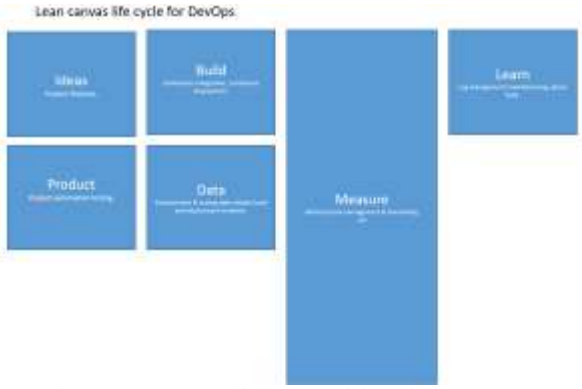

Fig. 5. Prototype of lean canvas life cycle for DevOps

Ideas - product features

Build - continuous integration, continuous deployment.

Product - automation testing.

Measure - infrastructure management & monitoring.

Data - development & testing data related build and deployment incidents.

Learn - log management, load balancing, about tools.

IV. DEVOPS SOFTWARE DEVELOPMENT LIFE CYCLES & LEAN TEST LIFE CYCLE

In DevOps, testing quality engineering is closely coupled [8] with software engineering and operations teams. In such environment software testing is not at the end of the release cycle it merged with beginning of the development. Development team and system engineers team make the code avaiabale in the approperiate envioment and testing team start validating the software.

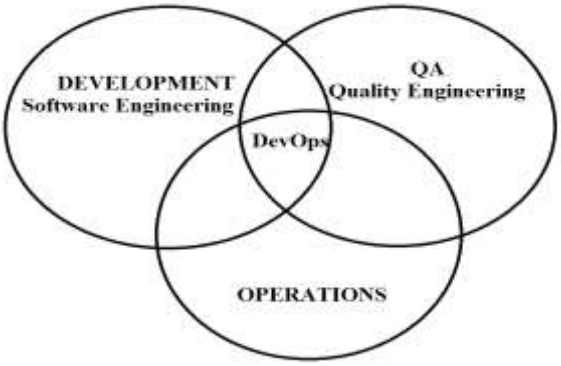

Fig. 6. DevOps venn diagram

Testing team needs to work on action bases testing to align the test design, test automation and test case

Fig. 7. Lean canvas life cycle

development and need to fix the code chnages to make sure do not break the product test cases.

All seven lean principles [5], we try to classify different metrics regarding DevOps.

Transport – In the DevOps testing process, the tester needs to stay in an ideal mode when nothing to test and not considering for to take other tasks. DevOps say nothing about what a person can do in his free time within the project.

Inventory – If the test automation [11] is failed or under testing any item, then tester not able to confirm about software quality.

Motion – In DevOps test team human resources are frequently changing due to any reason, then replacement of knowledgeable team member required additional processing.

Waiting – Changing testing scope with reference to project development requirements and agile environment, tester need to wait for software delivery for the test.

Overproduction – In DevOps tester can finish his task early then as before planned.

Over processing – It is possible may be due to the wrong estimation of the test planning or selecting the not appropriate tools for the testing.

Defects – In DevOps lack of having appropriate test environments and failing test cases in automation with no reason can raise more software logs and bugs.

A. Identifying Relevant Test Metrics for Lean Canvas Board

Considering above lean principles, we able to recognize different possible test metrics in the DevOps software testing. In DevOps, testing test metrics can be further utilized as an indicator for the lean canvas white board design. Although identified key metrics name titles are not standard [7], in further, we can use rename and use according to the subject.

Test metrics raw data come mainly from process, tools or documentation part and these will be further improved with lean core principles [16] [17].

V. DEVOPS TESTING PROCESS WASTE IDENTIFICATION USING LEAN PRINCIPLES TO DETERMINE RIGHT TEST METRICS

Software quality is key component to make software product successful and bridge the gap product and user satisfaction. In DevOps, testing quality engineering is closely coupled with software engineering and operations teams.

The study explains the possibilities for the utilization of the lean canvas design in the DevOps for software testing purpose this can impact on the software testing process and improve the software quality. The figure 7 show us what are the possibilities, in the input phase considering all related terms where testing involved in develops lifecycle will extract the needed basic test metrics. Transformation

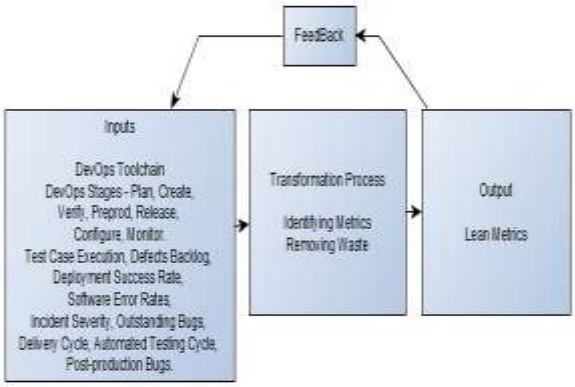

Fig. 8. DevOps test metrics identification.

phase will optimize metrics removing the waste from it with core lean principle. Third stage give us lean metrics those are more meaning full for further use for design of the lean canvas. In this process feedback,
will be always there to improve metrics with each process.

Example test metrics [12] are test case creation, test case execution, defects backlog, deployment success rate, software error rates, incident severity, outstanding bugs, delivery cycle, automated testing cycle, post-production bugs, toolchain, DevOps stages - plan, create, verify, preprod, release, configure, monitor. Such metrics can be extracted from availability of data and these metrics will be used to build the lean canvas board [13]. Collective and individual metrics will give detailed information in each step DevOps.

VI. CONCLUSION AND FURTHER RESEARCH

To continue the design testing lean canvas for the DevOps, it is necessary to accomplish the following research activities.

Need to carry out an experiment in DevOps for identifying the lean metrics in a testing process.

Identified lean metrics need to be tested to define the criteria.

Need to find out more about transformation models.

Design appropriate prototype for the DevOps lean canvas.

Need to develop algorithms to optimize the lean metrics.

Need to investigate with practical wok test metrics fit with input considerations.

Need to develop the framework and tool these can be used for development of the lean canvas board according to DevOps testing process.

Need to analyse and build the road map for one page

DevOps software testing canvas model design from the experiment.

The new idea and approaches proposed in this article emphasize on rethinking about traditional approach about long test documentation method in software development life cycle. The lean canvas one page documentation design strategy can save time and money with software testing.

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University IS Architecture for the Research Evaluation Support

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Abstract. The measuring of research results can be used in different ways e.g. for assignment of research grants and afterwards for evaluation of project's results. It can be used also for recruiting or promoting research institutions' staff. Because of a wide usage of such measurement, the selection of appropriate measures is important. At the same time there does not exist a common view which metrics should be used in this field, moreover many existing metrics that are widely used are often misleading due to different reasons, e.g. computed from incomplete or faulty data, the metric's computation formula may be invalid or the computation results can be interpreted wrongly. To produce a good framework for research evaluation, the mentioned problems must be solved in the best possible way by integrating data from different sources to get comprehensive view of academic institutions' research activities and to solve data quality problems. We will present a data integration system that integrates university information system with library information system and with data that are gathered through API from Scopus and Web of Science databases. Data integration problems and data quality problems that we have faced are described and possible solutions are presented. Metrics that are defined and computed over these integrated data and their analysis possibilities are also discussed.

Keywords: research evaluation, research metrics, data integration, information system, data quality.

I. INTRODUCTION

Evaluation in science is necessary as in other fields. From peer performed unique review process, evaluation of research results is turning into a routine work based on metrics [1]. The number of different metrics is increasing rapidly, so it is very significant that they should be correctly chosen, computed and applied by organizations that are implementing their own evaluation framework. Therefore, the good praxis examples and guidelines that would allow to avoid different traps in such metrics based evaluation should be provided.

For the science evaluation, different methods including quantitative ones are applied, also the evaluation results are used for different purposes. Research indicators can be used starting from state level political decisions till individual researchers' decisions in his everyday work.

The usage of research indicators can be classified into five main groups [2]:

- General science policy group's typical activity is setting state level goals, for example, stating how many universities should be among top universities in the world.
- Funding allocation describes activities that use indicators in different calculations to compute the amount of funding.
- Organization and management is the group of activities that use indicators, for example, in Human Resource Management for career development or recruiting new research staff. The potential candidates to apply should have certain number of publications indexed in Web of Science.
- Content management and decisions refer mostly to individual researchers' activities, for example, the choice of journal where to publish is based on indicators.
- Consumer information, for example, attracting new students can be based on different university rankings that use also science indicators among others.

This classification [2] takes into account the usage of research performance indicators, but input indicators, such as number of researchers are out of the scope.

Later in this paper the data integration architecture oriented toward the collection and retrieval of bibliometric indicators is proposed. Therefore, let us take a closer look at this type of indicators. Bibliometric indicators can be divided into three main groups [3]:

- Quantity indicators or productivity indicators, for example, number of publications.
- Performance indicators or quality indicators, for example, h-index.
- Structural indicators allow to evaluate connections, for example, co-authors from different fields, institutions or countries.

The principles characterizing the best practice in metrics-based research assessment are given in the

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"Leiden manifesto" [1], where 10 principles with explanations and examples are described.

Some of these principles [1] should be considered when designing a data integration architecture to support later effective research evaluation process, for example:

- Keep data collection and analytical processes open, transparent and simple.
- Allow to verify data and analysis by those, who are evaluated.
- Account for variation by field in publication and citation practices.
- Recognize the systemic effects of assessment and indicators
- Scrutinize indicators regularly and update them.

The authors of principles [1] state that not only journal publications, but also books for historians, conference proceedings for computer scientists, and national-language literature for social scientists should be considered.

When different sources are used to provide the needed data for different fields, the problem arises, are the results comparable. The authors [1] discuss this question also and argue that normalized indicators should be used, for example, the ones based on percentiles that are computed according to the citation distribution within the respective field.

When designing institutions' internal system, it should be taken into account that indicators change the system, therefore instead of one indicator, a set of indicators should be chosen, to avoid different biases.

Today there are many efforts trying to evaluate research results objectively and develop information systems to support these activities. Institutions develop their own or use commercial or non-commercial products to maintain data about research results.

A research information system in Scandinavia [4] is an example of such system that is implemented and used in Denmark, Finland, Norway, and Sweden and mostly contains integrated, high quality bibliometric data. The system is used for performance-based funding. Remarkable, that this system has also its own publication indicator that by weighting the results from different fields allows to compare them.

The requirements for research evaluation in Latvia are formulated in the regulations issued by the government and prescribe how the funding for scientific institutions is calculated [5], [6]. According to these regulations, the productivity of scientific work is evaluated according to the number of publications indexed in Scopus or Web of Science (WoS).

II. MATERIALS AND METHODS

The goal of this research is to develop and implement an architecture for bibliometric data collection for metric-based research evaluation support that takes into account the best practice principles and as a result provides a qualitative and comprehensive data collection.

This paper presents the components of this architecture, discusses the main integration problems that we have faced during implementation and solutions that we have chosen to overcome the shortcomings. This architecture is developed at the University of Latvia (UL) and the main component is implemented as a module of UL information system (LUIS).

A. Types and Choice of Evaluation Indices

Our architecture is discussed in detail in the later sections, but it must be mentioned that one distinguishing feature of it is the usage of external data sources Scopus API [7] and Web of Science API [8] provided by both largest publication citation indices.

Because one of the external data sources is Scopus, the data analysis possibilities directly in Scopus database were evaluated. Scopus provides SciVal tool that is based on some groups of metrics [9], for example: Productivity metrics measure the volume of output, Citation Impact metrics describe the influence of the output, for example, citation counts, Collaboration metrics give information on the research partnerships. The particular metrics that are used in SciVal are Scholarly Output, Journal Count, Journal Category Count, Citation Count, Cited Publications, Citations per Publication, Number of Citing Countries, Field-Weighted Citation Impact, Collaboration, Collaboration Impact, Academic-Corporate Collaboration. It must be mentioned that SciVal tool uses only publications indexed by Scopus as a data source. Metrics e.g. "Scholarly output", "Citation count" and others quantitatively measure different aspects of research activities. These aspects can be associated with the groups of measures e.g. productivity or citation impact.

Scopus API provides all data about UL publications, so all these metrics can be calculated also in LUIS. However, not all publications in LUIS have the same set of data due to different data sources, so not for all publications all these metrics can be calculated. The above-mentioned metrics and also some derived metrics can be calculated at the extent that the data are provided. As an example of derived metrics, the Scopus quartiles can be mentioned, that are calculated based on Scopus percentiles for CiteScore [10].

B. Scenarios of Obtaining Publication Data

Data about publications of the staff and students of UL are stored in the information system of the university (LUIS). On one hand, these data are gathered from multiple other information systems and on the other hand, authors and faculty and library staff have an opportunity to enter publication data directly into the university information system (Figure 1).

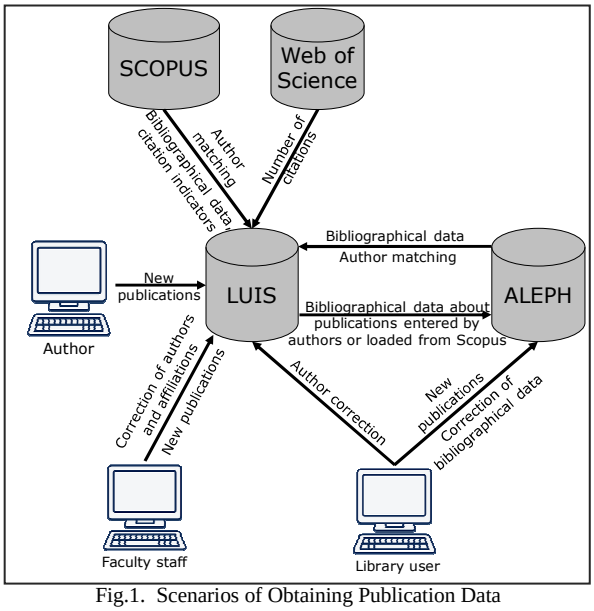

Fig.1. Scenarios of Obtaining Publication Data

C. Publications Added by Authors

The first and the preferred scenario of obtaining publication data is when these data are entered by an author of a publication. University employees, PhD and Master's degree students have a publications section of their profile in the university management information system (LUIS), where all publications are listed.

Before adding a new publication, an author must search for publications authored by him/her in the library information system (ALEPH) and LUIS with the purpose to discover whether the publication that the author planned to add to the system has already been entered in ALEPH or LUIS. In such case the author can just select it from the list and add it to the profile.

If the desired publication is not found, to add it an author must select a type of the publication and then enter bibliographical information, which includes: title of the publication, field, co-authors, affiliations of authors, year and place of publication, publisher, number of pages, ISBN, ISSN, web link, keywords. Besides, an author must indicate the status of the publication: published, submitted for publication, developed or under development, attach publication files (at least a book cover) and indicate whether the publication files may be made public. It is also possible to select databases where the publication is indexed and write any other additional information in comments.

In addition to entering new publications, authors also have an opportunity to unlink publications from their LUIS profiles that were erroneously automatically added to them during the synchronization process, when publication data are loaded from ALEPH or Scopus (see Sections E and F).

D. Publications Added by the Faculty Staff

Each faculty of the university can designate a person responsible for entering and editing information about publications authored by the faculty members: employees and students. Such faculty user can add new publications written by the faculty members by employing the same procedure as publication authors, which was described in the previous section of the paper.

Besides, a faculty user can change authors and author affiliations for the existing publications authored by the faculty members. This is necessary to correct authors that were erroneously automatically assigned to the publication during the synchronization process.

E. Publications Added by the Library Staff

Publications that are not indexed by Scopus can be also added to the library information system ALEPH by the library staff. This is done when a library user comes across a new publication authored by the university members in some journal or conference proceedings or when the information about a new publication is obtained from the list of recently indexed publications in Web of Science database, which is monthly distributed by Web of Science. The bibliographical information about a new publication is entered in ALEPH and during the synchronization process is also loaded in LUIS to ensure that LUIS always stores data about all publications available in ALEPH.

When the new publication is loaded in LUIS from ALEPH, the author detection is conducted, when for each author of a publication, a corresponding person in LUIS is searched for. If the person is found, the publication is added to his/her profile. For author matching, names and surnames of authors are used. Since authors tend to use different spelling versions of their names and surnames, when special characters of the Latvian language are present in their names or surnames, Jaro-Winkler similarity [11] is used to find the most similar name/surname combination of a person. After process testing and evaluation of experiment results, it was discovered that the most appropriate threshold for Jaro-Winkler similarity to perform name and surname matching is 0.93 and this coefficient is currently applied to consider name-surname combination similar.

In addition to entering new publications to ALEPH, library staff are also responsible for correcting and supplementing bibliographical data of publications added by authors and by faculty staff and of publications data imported from Scopus database (see Section F).

F. Publications Loaded from Scopus

Another data source that is used to populate publication data in LUIS is Scopus database. Data about articles published during the last 2 years are loaded from Scopus to LUIS daily and data about all other articles are loaded weekly. The synchronization

process uses Scopus API to obtain bibliographical data and citation metrics of articles authored by UL staff and students indexed by Scopus. The following information is extracted from Scopus about each publication: unique identifier, publication title, journal or proceedings title, ISSN, ISBN, DOI, page range, volume, issue, publishing date, type and subtype of a publication, as well as author information: unique author identifier, name, surname, author affiliation, H-index and publication affiliation information: name, city, country. Affiliations are associated with authors as well as with publications directly. In addition to bibliographical information, citation metrics are also obtained that include the following information: number of citations, Source Normalized Impact per Paper (SNIP) [12], the SCImago Journal Rank (SJR) [13], CiteScore. The last 3 metrics are calculated and obtained for the particular joirnal or conference proceedings (not for the particular publication) and for the particular subject areas. Previously, it was possible to obtain Impact per Publication (IPP) metric [14], which is not available from Scopus anymore, so this number is retained for previously loaded publications.

The first step of the Scopus synchronization process is publication recognition phase, when publications obtained from Scopus are mapped with the existing publications in LUIS to avoid creation of duplicates and detect new previously non-existing publications. The recognition is firstly based on the Document Object Identifier (DOI) which is unique for every publication. If the matching publication with the same DOI is not found in LUIS the recognition based on the title and publication year is applied, i.e. for each publication obtained from Scopus for the first time, the process searches for a publication with the same year and similar title in LUIS. Jaro-Winkler similarity is used again to detect the existing publication in LUIS with the most similar title, because variations of title spelling as well as data quality issues are sometimes present in data. To perform title matching, we use the same threshold for Jaro-Winkler similarity (0.93) and this coefficient is currently applied to consider titles similar.

If the matching publication record is found in LUIS, its citation metrics are updated and the link between this publication and Scopus record is established. If the publication is new, it is added to LUIS with all its bibliographical information and citation metrics. In case of a new publication, author matching is also performed, when for each author of a publication affiliated with the University of Latvia, a corresponding person in LUIS is searched for. If the person is found, the publication is added to his/her profile. For author matching, firstly author Scopus identifier is used, which allows to find authors that were previously loaded from Scopus. If a corresponding person is not found by author Scopus identifier, names and surnames of authors are used. Since authors tend to use different spelling versions of their names and surnames, when special characters of the Latvian language are present in the name or surname, Jaro-Winkler similarity with the threshold of 0.93 is used to find the most similar name-surname combination of a person. If a corresponding person is found by his/her name and surname, author Scopus identifier is saved for the person for matching future publications.

After a new publication record is loaded from Scopus to LUIS, it is also automatically added to ALEPH and later checked by the library staff, the bibliographical information is supplemented and possible errors are corrected.

G. Publications Loaded from Web of Science

We are also using Web of Science web services as an additional source of information about publications. The information obtained from WoS includes: unique identifier, title, issue, pages, publication date, journal or proceedings title, volume, book series title, DOI, ISSN, ISBN, number of citations. The information about authors includes just author names, surnames and in some cases also Researcher identifier in the web services version, which is available to the University of Latvia. Since the affiliation of authors is not available, we have discovered that author matching process for Web of Science data produces too many incorrectly identified authors, therefore, it was decided to add new Web of Science publications manually.

However, we match Web of Science data with existing publications in LUIS, loaded from Scopus or entered previously by authors, faculty staff or library employees. Just as for publications loaded from Scopus, we use DOI as the primary data unit for matching and title and year of publication as the secondary data unit for searching for publications that are not found by DOI. For all matched publications, we update Web of Science citation number.

H. Internal UL Index for Publication Evaluation

Due to different types and levels of publications in addition to the ones indexed in Scopus or WoS some system that at institutions level systematizes publications can be introduced.

In 2013 the University of Latvia introduced their own internal index [15] for evaluation of publications. This index is calculated from all publications in LUIS system. Index can be calculated at the individual researcher's level or the faculty level. Index considers a publication type, publication level and number of authors. According to the type and level, points are calculated and divided with the number of authors.

For example, a publication type can be "Journal publication", and within this type publications are classified according to their significance. So for this type some level examples are "Indexed in WoS Q1 or Q2" or "Indexed in WoS or Scopus".

On the one hand this index considers all publications, differentiates their significance according to their type, but there are also some controversial issues, e.g. division with the author count, that need to be discussed and improved. At the moment, this index is calculated, the LUIS system provides also the interface for analysis of this index, but in praxis this index is not used yet for evaluation of the research results.

Alternative ways how to evaluate the research output are being searched due to several reasons. Despite the fact that the calculation of state budget financing for the institution depends on the publications count indexed in Scopus or WoS, these indexes show uneven distribution among different fields. According to the UL's publication count for time period 2012 -2015, physics, natural sciences and engineering are prevailing [5]. However, it does not mean that researchers from other disciplines do not work or their results are not significant.

I.Analysis Tools in LUIS for Research Evaluation

Analysis tools in LUIS provide the possibility to evaluate an individual researcher or a faculty. For the faculties, the internal UL index can be also calculated (see Figure 1). The publication registration module allows to gain an insight about the quantity and quality of publications of the faculties' researchers.

Publikāciju sadalījums pa veidiem un līmeņiem

Struktūrvieniba: Datorikas fakultāte
Laika periods: 2014.-2017. gg.

Publikāciju veids/līmenis	Publikāciju skaits				Indekss	Skaits kopā
	A(4)	B(3)	C(2)	D(1)		
Recenzētas zinātniskas un citas monogrāfijas	0	0	0	6	2.50	6
Sastādīti zinātniski izdevumi	0	0	0	0	0.00	0
Trešo personu pasūtināti pārskati par pētījumiem	0	0	0	0	0.00	0
Raksti zinātniskos žurnālos	30	34	4	0	373.30	68
Raksti zinātniskos krājumos, nodaļas kolektīvās monogrāfijās, redaktora ievadvārdi šādām monogrāfijām un krājumiem	17	2	0	0	57.50	19
Konferenču ziņojumi vai tēzes	101	17	0	5	457.20	123
Enciklopēdiju rakstu vai šķirkļu publikācijas	0	0	0	0	0.00	0
Mācību-metodiskās un populārzinātniskās publikācijas	1	0	1	1	13.00	3
Publicētas recenzijas un uzrunas, publicistika	1	0	0	3	3.40	4
Tulkojumi	0	0	0	0	0.00	0
Zinātniski recenzēti rakstu krājumi	1	0	0	0	0.00	1
Promocijas darbi	0	0	0	2	0.00	2
Kopā unikālās publikācijas					906.90	226

Fig.2. Report about faculties' results in LUIS publications module

Another useful tool provides the possibility to select and extract detailed information about publications, that is collected and integrated from all information sources that are included into previously described architecture including WoS and Scopus. In most cases the information added to the publication records is the actual citation count, the information about the Journal or book series e.g. SJR, SNIP, IPP, and Cite Score. Originally Cite Score provides percentiles that are used in LUIS publication module to compute Scopus quartiles.

III. RESULTS AND DISCUSSION

To demonstrate the volume of data collection used for research evaluation at the University of Latvia, we are will provide several statistical indicators. The total number of publications by UL members for the last 30 years is 42417. 6967 publications out of them are indexed in Scopus and 7764 publications are indexed in WoS.

Further in this section 3 different analysis scenarios for research output evaluation that can be implemented with the new publication module and data integration infrastructure are described.

The following parameters were applied for the data extraction for all research questions: Faculty name "Faculty of Computing" and Time period "2013 – 2016".

For the 1st analysis scenario the following research question was formulated: "How many faculty publications are indexed in Scopus or WoS comparing to all faculty publications?". Figure 3 shows the trend that the whole number of publications decreases and the number of indexed publications increases and in the year 2016 there are only 7 publications that are not indexed.

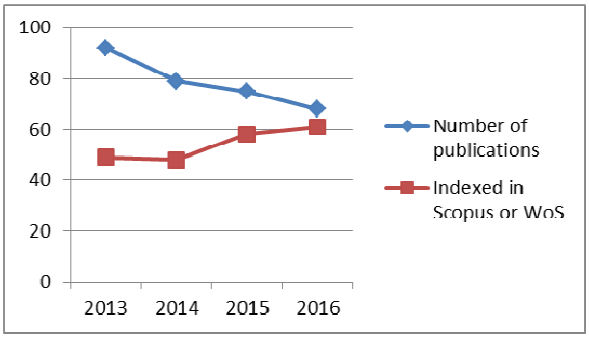

Fig.3. Indexed publications vs. all publications

For the 2nd analysis scenario the following research question was formulated: "How many publications of the faculty are indexed only in WoS and not in Scopus". In Figure 4 two measures to compare are given: the number of publications indexed in WoS and the number of publications that are indexed only in WoS, but not in Scopus. The proportion between both metrics persists over time, which may indicate a relative stability of authors choice where to publish their results and which conferences to attend.

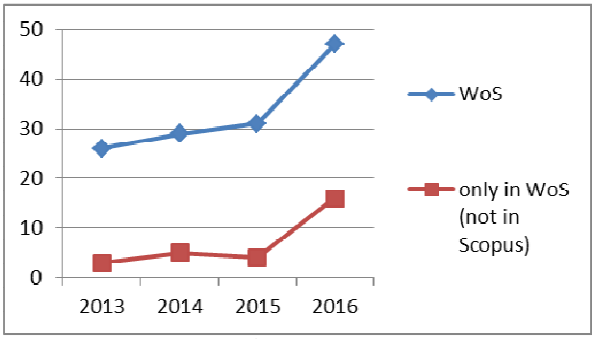

Fig.4. Overlapping of WoS and Scopus publications

For the 3rd analysis scenario the following research question was formulated: "How many publications out of all faculty publications indexed by

Scopus have Scopus quartiles computed according to Cite Score and how many of them have Q1 or Q2?". The results in Figure 5 show that over the time period the number of publications of the faculty indexed by Scopus is getting closer to the number of publications that are published in journals or book series that have CiteScore percentiles, from which we computed quartiles. Among the last ones, the proportion of publications that have Scopus quartiles Q1 or Q2 remains unchanged over the time period.

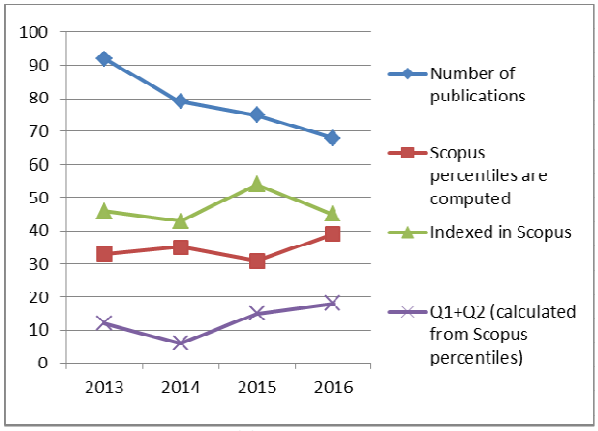

Fig.5. Analysis of faculty's Scopus publications

The analysis results can be used not only for research results evaluation but also as an information for more careful choice of journals or conferences where publications should be submitted with respect to indexing in Scopus or Wos, and also the best possible quartile. This can be useful for young scientists and doctoral students.

IV. CONCLUSIONS

We have developed and implemented the architecture for research evaluation at the University of Latvia. The data collection contains a wide variety of different publication types, fields and sources. The data collection is automatically updated from external data sources Scopus and WoS on regular daily basis.

Not all data quality and identification problems were solved, therefore, special user interface was developed and provided for faculties and scientific institutes to control the automatic data integration and to make corrections if needed. So the users will have more confidence that the evaluation decisions are made over correct data.

However, the different analysis possibilities can be used more intensively, mostly different publication lists, e.g. for study programs accreditation purposes, are produced and used. Also each researcher can see the list of publications in his or her LUIS profile and during the automatic CV generation option in LUIS the actual publication list is added. These, of course, are not the goals why the system was produced, but in the starting point, while all stakeholders are getting familiar with the provided features, also some operational usage is acceptable.

Some examples of the intended usage of the system were also demonstrated in this paper.

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Performance Evaluation of Software Development Project Team

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Abstract. The necessity of finding the connection between the planning, decision making, actions and results create project management interest to an evaluation of the project team performance. By analyzing the team performance, determining successful projects and assessing results, members of such project will have the necessary information to avoid failures, to monitor the progress, to compare similar projects and move to defined goals.

The objective of this paper is to provide guidelines for evaluation of the project team performance in the software development project. This paper summarizes measures for evaluation of the team performance, an evaluation objectives and it benefits as well as factors that may have an influence on the team performance. Demonstration example of the guideline usage has been provided.

Keywords: Software development project management, human resource management, project team performance, sociometric method.

I. INTRODUCTION

Almost every of us is oriented to archive some goals (in work or life) or successful outcomes and want to keep track progress of achievements and results. Similarly, also software development (SD) organizations, project managers, and team members would like to evaluate a performance of projects and project teams [1]. Finding of connections between planning, decision-making, actions and results creates interest of organizations and project management to an evaluation of the project team performance [2].

The SD project mainly includes cross-functional team-intensive work that creates new software products [3]. The most part activities in these projects have been based on people so the team development, evaluation, and management activities are important.

An objective of this paper is to provide a guideline for evaluation of the project team performance in the SD projects. The guideline has been created based on a literature review about the team performance, the project success and an evaluation measures (qualitative, technical and social) and demonstrated with an example. The main contribution of this research is the evaluation of the qualitative team performance together with technical and social influencing factors. The sociometric methods are used for evaluation some of the social factors. Existing researches focuses on measurement of time, cost, and quality [1], [3], [4], [5] and discusses social factor impact to the team performance [6], [7], [8].

The rest of the paper is structured as follows: Section 2 presents literature overview of the team performance and evaluation of the team performance. Overview of the guideline is described in Section 3. Evaluation example of the team performance using the guideline is demonstrated in Section 4. Conclusion and future work is presented at the end of the paper.

II.LITERATURE OVERVIEW

In this section, we discuss the results of the literature review about the team performance and it influencing factors (Section II.A.), and evaluation of the team performance, its objectives and metrics (Section II.B) with a focus on the SD projects.

A. Team performance

For the team performance measurement uses objective and subjective measures [1]. Objective measures include team productivity (e.g. function points, time variance, cost variance, complexity metrics etc.) [1], [9]. Subjective measures of the team performance include a perceptual rating of the team performance by team members and stakeholders (e.g. team effectiveness, system viability, professional growth, user satisfaction, teamwork satisfaction, output quality etc.)[1], [9].

The team performance and its success are related to the project success. So, before analysing the team performance, we review the definition of the project success. The project success can be defined in different levels [10]:

- It delivers all or most of what it said it would, regardless of schedule or budget performance;
- It delivers what it said it would, on schedule and/or within the agreed budget;

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- It delivers what it said it would, on schedule, within the agreed budget, and to the expected quality standards;
- It delivers on all agreed project objectives, be they scope, schedule, budget, quality or outcomes based;
- The product produced by the project creates significant net value for the organization after the project is completed.

The project success and the team performance can be reviewed from two perspectives: project management success (process view) and product success (product view) [11]. The process success evaluates time, cost, quality of technical specifications, stakeholder satisfaction, and development and quality management process [11]. The product success is evaluated based on lessons learned, used innovative technologies, achieved organizational objectives, possibilities to uses product in the future [11].

The team performance is part of the project performance and also noticeable impacts the project performance as the project team is the main implementer of project [2]. Two terms are used for description of project performance - effectiveness and efficiency [3]. Effectiveness refers to the extent to which customer requirements are being met, while efficiency is a measure of how economically a firm's resources are being used, providing a given level of customer satisfaction [3], [12]. Efficiency is easy to measure as it also focuses on time and costs [3]. There is a wide variety of researches related to the SD project performance, e.g., earned value method [2], performance evaluation practices used in SD projects [3], measures of the SD project performance [4] etc. The team performance also is defined as the degree to which team completes the project efficiently and effectively [6], [7].

So, the SD project team performance can be interpreted as a set of criteria that characterize results of activities performed by all project team members during an SD lifecycle. The team performance more focuses on the one project team (in a case of the multi-team project), its performance from project phase to phase and from one project to other.

During evaluation of the team performance, it is also important to analyze factors that may have an influence on the performance. These factors are technical and social (including psychological and organizational). Summary of influencing factors and related researches is given in Table I.

B. Evaluation of team performance

Measurement of the project team performance can be defined as the process of quantifying action, where measurement means the process of quantification and the performance of the operation is assumed to derive from the actions by its management and the project team interaction (adapted from the definition used in [3]). Main functions of the performance measurement are alignment and prioritization, evaluation and incentives, operational control, and learning and improvement [3], [13]. And one of the main benefits of the performance measurement and evaluation is learning [14]. In its simplest terms, the performance evaluation is a process of assessing the results of the project team to determine how effective the operations are, and make changes to address performance gaps (adapted from the definition used in [4]). Evaluation of the team performance not radically different from other organizational measures systems, e.g. Plan-Do-Check-Act [15] etc.

Table I
Influencing factors

FACTORS	REF.
Technical factors	
Team size	[4], [16]
Requirement and it priority changes	[4]
Product size	[4], [16]
Specific of programming language	[4], [16]
Reuse of software artifacts	[4]
Development method	[16]
Social factors	
Communication and coordination processes in team	[1], [5], [6], [7], [8], [9]
Focus on goal	[6], [7], [8], [17]
Team cohesion, internal relationships, and team climate	[1], [5], [6], [7], [8], [9]
Organizational and mutual learning	[6], [7], [8], [17]
Management support	[7]
Rewards	[7]

Evaluation of the project team performance can be performed in three levels (based on principles defined in [17]):

- Level 1: Measurement and evaluation of specific numerical measure;
- Level 2: Measurement and evaluation process as defined algorithm that includes both numerical and qualitative measures;
- Level 3: Comprehensive strategic planning process of setting the appropriate team performance targets and evaluating their achievement in order to validate or revise the organization's/project goals.

Organizations can perform the evaluation of the project team performance with different purposes. Some examples:

- Increase productivity [17];
- Evaluation of organizational capability to archive defined business or project goals [3], [4];
- Benchmarking [3], [4];
- Increase motivation and client satisfaction [3], [17]
- Identify resource underload/overload [3], [9];
- Evaluate performance of individual team member [9];
- Performance prediction [4];

Different measures that can be used for evaluation of the team performance and other factors in the SD projects are summarized in Table II.

Table II
Measures

MEASURE	DESCRIPTION
Qualitative performance measures [4]	
Project effort	Total project team time ($Team\_Member\_Hours_i$) that is spent on project-related activities during the life cycle of the project $= \sum_{i=1}^{n} Team\_Member\_Hours_i$
Productivity	Expressed as size per hours. Project size defined in logical lines of code, function points, story points etc. $= \frac{Size}{ProjectEffort}$
Project duration	Measure of the length of a project in work days (num_days), excluding times when the project is not active due to work stoppage ($stoppage\_days$) $= num\_days - stoppage\_days$
Schedule predictability	Measure of how much the original project duration estimate ($EstimProjDuration$) differs from the actual project duration ($ProjDuration$) that was achieved $= \frac{ProjDuration - EstProjDuration}{EstProjDuration} * 100$
Requirements completion ratio	Measures the extent to which planned functional requirements ($PlannedReqs$) were satisfied ($SatisfiedReqs$) in the final product implementation $= \frac{SatisfiedReqs}{PlannedReqs} * 100\%$
Post-release defect density	Number of unique defects per unit size discovered during the first six months after initial deployment of the software $= \frac{Defects}{Size}$
Team velocity [18]	How many story points team have done during an iteration. Used in Agile SD projects.
Social indexes [19], [20]	
Sociometric status of team member	Calculated depending on the number of positive choices (B^+), negative choices (B^-) and count of respondents (N). $= \frac{B^+}{N-1} - \frac{B^-}{N-1}$
Team mutual relation index	Calculated depending on the number of mutually positive choices (R) and count of respondents (N). $= \frac{R}{N-1}$
Team cohesion degree	Calculated in accordance with the number of mutual positive choice pairs (P) and count of respondents (N). $= \frac{P}{((N-1)/2)}$
Team integration index	Calculated in accordance with the number of respondents who do not receive any choice (S). $- \frac{1}{S}$
Subjective measures	
Client, team member and teamwork satisfaction	Different surveys. E.g. team motivation based on based on a Maslow hierarchy of needs [21], customer satisfaction surveys, retrospectives [18] etc.

Qualitative performance measures evaluate results of activities performed by all project team members. Social measures help to understand social factors in the project team that is expressed as different social indexes [19], [20]. Social measures are measured with surveys that fix employees given advantages to one of the other team member in given situations (formal and/or informal) [22]. The social indexes are used together with sociomatrices and sociograms [20]. The client, team member, and teamwork satisfaction is analyzed with different surveys.

For team performance prediction, Stochastic Automation Network model has been used as modeling method for evaluation of different scenarios [23].

III. GUIDELINE FOR EVALUATION OF TEAM PERFORMANCE

The guideline for evaluation of the team performance has been designed based on the best practices identified during literature review. The guideline needs to include following requirements:

R1. Evaluation needs to be done in the comprehensive strategic planning level (Level 3.). In accordance with the best practices from the enterprise-wide formal performance measurement systems, evaluation of the team performance need to take following steps (adapted from an idea used in [4]):

1. Set clear and achievable evaluation objective of the team performance;
2. Define measures and measurement indicators to characterize performance relative to the objectives;
3. Establish measurement targets that reflect the desired condition or expectation for each performance measure;
4. Collect the measurement data;
5. Evaluate data and use results to adjust team related processes that will improve the probability of reaching the targets.

R2. The guideline needs to promote learning activities as it is one of the main benefits of the performance evaluation process.

R3. The qualitative performance measures of team activity results need to be measured.

R4. The subjective performance measures of the team can be collected if needed based on the evaluation objectives.

R5. The technical and social factors need to be measured and evaluated together with the qualitative/subjective performance measures.

The proposed guideline process for evaluation of the team performance is given in Figure 1. The proposed guideline focuses on the overall evaluation process, data collection, and its evaluation but doesn't propose how to use results for the team problems solving or performance improvement because data interpretation based on the context situation of team,

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project and organization, and evaluation objectives. All metrics/factors can be evaluated in different combinations.

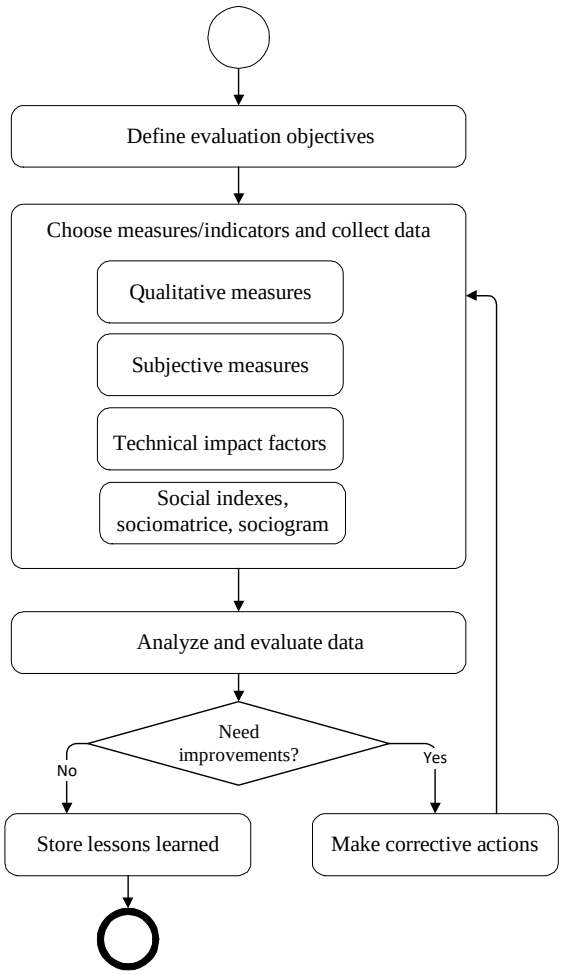


Fig.1. Process for evaluation of team performance

Some very general examples of the evaluation results analyze and usage:

- Social environment in the project and individual productivity/post-release defect density/team velocity – communication processes and atmosphere, and individual integrity can impact individual/team performance.
- Team size and communication network in the team – if the team is large then possible exists subgroups in the team that can be identified by analyzing sociogram.
- Product size and schedule predictability can be analyzed together as is possible correlations.
- Defect density, programming language, and individual productivity can be analyzed together as is possible programming language specifics.
- The schedule predictability can be impacted by estimated and actual reuse of artifact.

Additional aspects of the evaluation process:

- Not all qualitative metrics can be collected at any time, e.g., the schedule predictability and the requirements completion ratio are available at the end of project or project phase and the post-release defect density is available after the release of the SD product. Social indexes are easy to measure and evaluate during the project. So, based on the evaluation objectives possible different metric collection frequency.
- Between metric collection or evaluation iterations (e.g. after corrective actions) possible that team members or project/SD product have been changed. So basically, need carefully evaluate possibilities to compare results between iterations.

IV. EXAMPLE OF PERFORMANCE EVALUATION

For demonstration purposes of the proposed guideline private IT company team has been chosen and already finished team project has been used for qualitative measurement and technical factor analysis.

The objectives and expected results of evaluation of the team performance:

- Understand team technical performance in the previous project. Also, two measurement target has been defined: 1) the schedule predictability is less than 10%; 2) the post-release defect density is less than 20 defects per 100 LLOC;
- Identify less integrated team member and possible reasons as this team continue work on other projects.

Values of measures and indicators have been summarized in Table III. This example doesn't include subjective measures of the team performance.

Evaluation summary about example team:

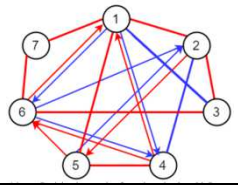
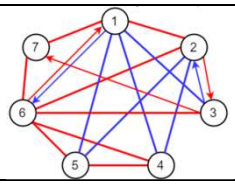
- The team technical performance is positive – project duration and effort is close to estimated, all requirements are completed, values of productivity and defect density are satisfactory.
- Programming language impact to individual productivity / defect density has been seen in the results. Ruby is more productive language that shows also results with better productivity for Team member 3 and less defect after the release (after 2 months).
- Team cohesion degree is below 0.5 both formal and informal relation that means communication environment is not healthy.
- The best sociometric status is for Team member 6 (performs project manage role) but the worst for Team member 2 (programmer).
- By analyzing sociogram of formal relations can be concluded that Team members 1, 2, 3, 6 and 7 are good relation, no relation between

3 and 4 and mutually negative relations between 1 and 3, and 2 and 4.

- A little different situation is in informal relations. There are two subgroups – 4, 5, 6 and 1, 2, 6, 7 that have been connected through Team member 6. Team member 1 is mutually negative relations with 3, 4, 5 that means no common interest.

The main recommendation for this team is to try to increase the team cohesion and more integrate Team member 2. Possible corrective actions – team buildings, pair programming, and knowledge share events.

Table III
Results of evalution of Example team performance

MEASURES/FACTORS	VALUE
Technical factors	
Team size	7
Requirement and it priority changes	15% of total project effort estimation
Product size	DB – 796 LLOC; Oracle Forms – 1511 LLOC; Ruby – 1125 LLOC
Programming language	Oracle Forms, PL/SQL, Ruby
Reuse of software artifacts	6.1 %
Development method	More waterfall
Social factors	
Formal relation sociogram	
Formal sociometrical status of team member	1. – 0.67; 2. - -0.17; 3. – 0.33; 4. - -0.33; 5. – 0.5; 6. – 0.5; 7. – 0.33;
Formal team cohesion degree	0.33
Formal team integration index	0
Informal relation sociogram	
Informal sociometrical status of team member	1. – 0.00; 2. - -0.17; 3. – 0.17; 4. – 0.00; 5. – 0.00; 6. – 0.67; 7. – 0.50;
Informal team cohesion degree	0.38
Informal team integration index	0
Qualitative performance measures	
Project effort	718h (Estimated 700h)
Productivity	4.78 Separate productivity is evaluated for programmers: 1.(PL/SQL) – 6.03; 2 (Forms). – 8.48; 3 (Ruby) – 10.41
Project duration	32 days (Estimated 30 days)
Schedule predictability	6.67
Requirements completion ratio	100%
Post-release defect density	After two months: PL/SQL – 0.04; Forms – 0.01; Ruby - 0

V. CONCLUSIONS

Evaluation of the team performance needs to be systematic and comprehensive strategic planned similar as suggesting the best practices from the enterprise-wide formal performance measurement systems. Evaluation of the team performance includes measuring of subjective and objective measures. Objectives measures are easy to evaluated as it is related to time, cost and quality and has been widely evaluated during existing researches about the performance evaluation of team and project. Subjective measures are no so easy to evaluate and the most used approaches are surveys or interviews.

For correct analyze and evaluation of the collected performance metric also context situation or the performance influencing factors are important for understanding of the team success criteria and compare with other teams. These factors can be divided in technical and social. The impact of social factors has been widely discussed in different existing researches.

The proposed guideline for evaluation of the SD project team performance includes the collection of measures (qualitative and subjective) and influencing factors (technical and some of social). The sociometric method has been proposed for social factors evaluation that can help to understand communication and coordination processes in the team, the team cohesion, internal relationships and the team climate.

Demonstration example of the guideline has been given in the paper with a target to show how to use the guideline. But as previous already has been mentioned, data collection and analyze depends on context situation of team, project and organization, and evaluation objectives.

Possible directions of the future research on this topic are the analysis of including more subjective measures (currently qualitative measures are evaluated); the analysis of other social factors (currently only the sociometric method is used); and the guideline evaluation with other industry case studies.

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IT Risk Identification and Assessment Methodology

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Abstract. There are numerous methods for risk identification and risk assessment phases. Which for risk identification includes historical and systematic approach and inductive or theoretical analysis. One of the main reasons why risk identification is very helpful is that it provides justification in many cases for any large IT investment and other large undertakings. Without it organization probably wouldn't be able to come to conclusion. Also in this phase business recognize the threats, vulnerabilities, and assets associated with its IT systems. Together with risk assessment phase risk management specialist is responsible for determining asset value, what's the value of the asset business is protecting, and risk acceptance level.

Risk assessment on the other hand examines impact or consequence, as well as examines and evaluates the likelihood or probability of that adverse event happening. Risk assessment includes methods like Bayesian analysis, Bow Tie Analysis, brainstorming or structured interviews, business impact analysis, cause and consequence, cause-and-effect analysis, Delphi method, event tree analysis, fault tree analysis, hazard analysis, hazard and operational studies, and finally structured what if technique or SWIFT process. Risk assessment has two distinctive assessment types- quantitative and qualitative assessment. Quantitative assessment tries to put a monetary value on all risks. Qualitative assessment on the other hand rather look at it from a range of values like low, medium, high. The results of these phases are going to be documented in the risk assessment report and reported to senior management.

Keywords: IT risk, risk identification methodology, risk assessment methodology, risk practitioner, qualitative risk, quantitative risk.

I. INTRODUCTION

Nowadays every business who wants to be innovative and be competitive in the global market must utilize at least some form of risk assessment. On a daily basis business has to evaluated short to long term strategic development plan. And the further in the future anyone tries to plan, the greater the risk of unexpected outcome which for business can be devastating. Including financial loss, reputation loss or even bankruptcy. In order to avoid this, it is necessary to know what kind of risks business is facing. And what are possible solutions to greatest risks. To find this out risk management specialist must identify, assess business risks and provide cost effective mitigation solution. After which business management can continue to monitor those high priority risks to be able to react if situation changes to the worst.

To gain knowledge and experience in this field it is necessary to know the procedures and methodologies to accomplish necessary goals on achieving desirable risk level. This article will help you do that. There are many methods and techniques, and it is not possible to cover them all in this article, but author thinks this article has managed to capture most relevant methods.

II. METHODS

IT risk identification methodologies

There are a number of different ways to identify risk. Probably the most common is historical[1]. This is what the insurance companies tend do. They can look at, what is the risk, based on the empirical data they already have many years of what's happened previously. During risk identification and assessment RMS (risk management specialists) should always use historical data when possible [5]. What's happened in the past can greatly help RMS to make sure the same problem doesn't repeat in the future that was not anticipated. But for everyone in the IT that doesn't always work[2].

Sometimes RMS is going to have to use a systematic approach[3]. Process involves bringing in the people that are the subject matter experts, the people that really have an understanding of technology, have an understanding of the threat environment and can offer an expert opinion on what some of the problems could be based on the technologies subject currently have. Even in some cases forecasting events that have not yet happened. This is where it is necessary to look at not only single points of failure, but sometimes even aggregated risk where the risk comes from several different things that work together to form a risk event.

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The third type is what RMS calls them inductive or theoretical analysis[4]. Similar to building upon systematic approach, but inductive tries to find what is needed to be done, especially when looking at something where no one in yet an expert. Like when there is a new technology and a new business process. Because of this it's not possible to always know what types of threats will occur. But using that expert opinion systematic approach, imagination and the ability of people to see what things are going to look like, it is possible to perform successful inductive analysis [127]. New ideas can be induced and in some cases, be able to deduce the types of events that could lead up to a risk event in the future. Then what is the objective of doing IT Risk Identification? First of all, RMS helps providing justification in many cases whether or not an organization should make that IT investment. An IT investment is very often a very large capital investment. It's also a very large operational expense. Either way by looking at current risks business management should be able to determine if that new system, is worthwhile investment? Its necessary to understand that as business relies more and more on its IT investment there is a whole new area of security that is important too.

Business have the problem that a person may gain unauthorized access to its sensitive data. Sensitive data theft of course could lead to very severe financial penalties as well as reputational damage. Clients also have to understand what are the risks related to integrity. Is there a chance, for example, that the data employee has in his system would be inaccurate?

So these are all these sorts of things that have to be looked at in risk identification phase. What's the risk of making a poor investment? What's the risk related to improper access and lack of security? What are the risks related to a loss of integrity? Business also have to ensure that its systems provide timely information. Some information can be incredibly time sensitive.

During the risk identification phase, business recognize the threats, vulnerabilities, and assets associated with its IT systems. Risk identification together with risk assessment is responsible for determining asset value, what's the value of the asset business is protecting, and risk acceptance level.

Risk Assessment

What would risk assessment do to the organization? This means RMS have to examine impact or consequence, as well as examining and evaluating the likelihood or probability of that adverse event happening. RMS will now be able to document and determine what our critical business operations are.

As most people know, IT risk is all about supporting business, and RMS want to know which of business IT systems are most critical in the dependency for the business to operate correctly. There are a number of different risk assessment techniques, but author will cover some of the ones that are commonly used.

RMS performs Bayesian analysis, Bow Tie Analysis, and process like brainstorming or structured interviews. RMS borrow from the area of business continuity and disaster recovery, and do a business impact analysis. RMS also can look at cause and consequence, and when that is done RMS will understand what might lead to an event, and what that impact would be. That is very similar to the next one, which is cause-and-effect analysis. In this case, RMS understand the root causes, and how that causes could affect systems. It is preferred to asset risks by simple checklists.

RMS could call on the expertise of the many people within organization who understand the impact on the business, and this is often done through a Delphi method, a Delphi method is where the input from all of the various stakeholders is sought, sometimes even anonymously to allow everyone to contribute to the data collection and analysis process. Many times, when something happens, it's because of a sequence of different events, and this is where event tree analysis can help RMS to determine what are the things that come together to lead to a risk event. Very similar to that is fault tree analysis method.

What are the things that could lead up to an unhealthy environment in which a risk might happen? RMS also could look at hazard analysis and critical control points, where high-level risk is identified within areas within the organization that could lead to a very serious adverse impact, often based on single points of failure. Continuing, some other risk assessment techniques its worth mentioning hazard and operational studies. RMS can look at people within business because many of our risks are related to our employees, and through human reliability analysis.

One of the things that is often done to allow RMS to truly assess risk effectively is to look at the impact of maintenance on the reliability of systems and products. Do business have a skilled staff that is looking after the systems on a regular basis, or are things beginning to deteriorate already?

Most people do not really understand risk assessment, but they do understand a scenario, or a story, or an example, and RMS can use those as a way to gather more accurate information where people now understand what the impact of various types of events could be. Final one is structured what if technique. So what if this happened, then what, what if this happened, and that is sometimes called SWIFT process. When RMS looks at risk assessment, often results are inaccurate. In many cases, that can lead to wrong decisions later on in risk response, so why is that? This is because in many cases, risk is unpredictable. A same event might happen 15 times,

and all 15 times could have a completely different level of impact. In fact even worse, the same event could happen 15 times, 14 times had exactly the same impact, and once it had a completely different result. So it's very difficult for RMS to examine a risk event in isolation. Risk assessment works on a larger population, but not on an individual case.

Because of this RMS should learn from every risk event what has happened in the past.

Risk Assessment Methodologies

So how do RMS perform risk assessment? There's two main ways, quantitative and qualitative. The idea of a quantitative risk assessment is that RMS try to put a monetary value on all risk. If this system went down, what would it cost to business, and there RMS would look at of course not only the impact on IT, of what it would cost business to recover our IT services, but RMS would also cover what would be the monetary impact on the business if business itself would be unable to support a certain business process, product, or service. Dealing with quantitative risk has the problem in that many things are not truly quantitative, things like customer confidence and employee moral are not really quantitative values [5]. It's hard to put a dollar figure on those. So quite often RMS will look at risk from a qualitative perspective.

A qualitative risk is where RMS looks at a scenario. If this system went down, how would that affect other departments. For example, let's look at it from the perspective of very low impact, moderate, high, or very high impact. Instead of putting a monetary value on it, RMS rather look at it from a range of values, and RMS talk to many departments, in order to find out how this scenario would affect not just one department, but might affect other departments within the organization as well. When RMS looks and compare those range of risk levels from the different areas, RMS can now set out priorities according to our risk, in result we're looking at it now from the perspective instead of just money, but we're looking at it in many cases from those non-quantitative values. Quite often RMS will use a range of 5 values, same goes for both the ISO 27005[6], and NIST Special Publications 800-30 revision 1[7] to try to determine what is the range of risk. RMS will use those to compare likelihood, impact, and asset value. Quantitative risk is calculated first of all by saying how much would any one single event cost business. Quite often we hear this written as SLE or single loss expectancy.

Qualitative risk looks at the non-monetary elements of risk quite often by looking at different types of scenarios, and in that scenario RMS can consider things that are outside monetary values such as moral, reputation, customer confidence. RMS calculate risk by looking at those factors of how likely or how probable is a risk event compared to of course the level of impact and if this risk actually happens. How much damage or what would be the consequence, and in order to truly determine a risk level, RMS needs to look at both of those factors, the likelihood of it happening compared with the impact and if it does indeed happen.

Author has reviewed both quantitative and qualitative risk assessment, they both have advantages, but they also both have disadvantages. That quantitative did not bring in some of those non-monetary elements, whereas a qualitative risk did not give us the dollar figures needed to justify the cost of controls. So what do organizations often do? They bring the two together into a hybrid, where RMS will now do a semi-quantitative risk assessment. RMS will compare both quantitative and qualitative, to get a more complete picture of risk, and the assessment provided to management hopefully will be more meaningful and actionable for them.

There is a direct relationship quite often between a technology-related problem and the organization's ability to deliver on its products and services. This helps business to put together a strategic plan, so RMS can say how to ensure that technology is built in a stable, reliable manner in order to support the organizational mission and goals?

Risk Areas to Consider

This phase of risk assessment is extremely important. The results of this phase will guide further the risk response in the next phase of the risk management framework like risk mitigation or risk respond and risk monitoring. For full risk management process please refer to (

Fig. 1). Rest of the phases will be reviewed in the future research.

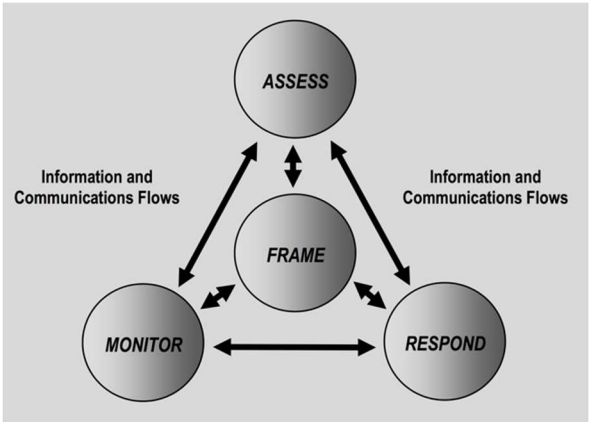

Fig. 1 Risk Assessment Within The Risk Management Process

There are many areas that needs to consider the risk in order to ensure that the risk assessment RMS perform is complete, accurate, and thorough. RMS must look at the risks related to the IT management, the management including the procurement, maintenance, and support of hardware, choice of software, including of course operating systems, as

well as keeping utilities and drivers up to date and patched, making sure that application program interfaces, our APIs are set up correctly. Current security standards built into them. RMS need to ensure that our applications are also secure, that they're robust and able to withstand an attack. Databases are correctly managed so that business have efficiency of the actual extraction of the data, as well as of course the security necessary to ensure the retention of business data, but also protection against unauthorized access. RMS also have to look at the risks related to our networks and network architecture, for example, does business have single points of failure, network architecture has a lack of adequate security to ensure that we are going to prevent unauthorized access to business network communications?

RMS should also examine the process of software development. This is often, of course, done through an SDLC, or Software Development Lifecycle. The SDLC is there to try to ensure better results of software development projects, software development projects hopefully that will meet the business needs more effectively.

III. RESULTS AND DISCUSSION

Final report and risk register

The results of this phase are going to be documented in the risk assessment report. The risk assessment report is the final results of the scoping, the identification, and assessment of risk. It is to provide management with an accurate report, documents what risks business face, and the prioritization or importance of those risks.

Risk assessment and risk identification should be brought together into the risk register, the risk register is one document that sources all of the risks that have been identified through things like incidents, vulnerability assessments, penetration tests, as well as the user complaints, and of course risk assessment itself[8]. By having all of the risk in one place, it gives business the ability now to track and monitor the progress RMS will be making and addressing these risks. RMS should provide in the risk assessment report recommendations, things that management can consider in the next phase of risk response, for what should or shouldn't be done about the identified and assessed risks. One of the things that's important to recognize is that risk is not owned by the risk practitioner. Risk is owned by management. They are the only ones who can determine what is an acceptable level of risk, and RMS needs to work with management what they understand and what is their responsibility. RMS advise them of the risk levels, but in the end, it's up to management what level of risk they would like to accept.

In summary, we must remember that RMS obligation as a risk practitioner is to assess and determine the severity of each of the risks facing the organization, all of the risks related to people, processes, and technology. All the risks that RMS have identified and assessed will be reported to senior management. To complete whole risk management cycle.

IV. CONCLUSION

Risk management specialist has a complex work which requires vast amount of knowledge. Starting from IT hardware, software, architecture to business processes, procedures and methods for risk management but is not limited to mentioned fields. Full risk management cycle includes risk identification, assessment, mitigation and monitoring (

Fig. 1). In order to provide good representation of risks for any given business extra attention and expertise has to be placed on risk identification (not forgetting any significant risks) and risk assessment to provide qualitative and possibly even quantitative values. Risk management has a many more methods and methodologies for accomplishing accurate results, but due to this article limit its not feasible to mention all of them.

Author thinks this article has managed to capture most relevant methods for risk identification and risk assessment phases. Therefore providing good base for further research which will be done on risk mitigation methodologies and risk monitoring.

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A Review of Information Technology Transfer Process, Its Topicality, and Related Models

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Abstract. The purpose of the research to provide an overview of technology transfer process to potential readers. The topicality of this issue in the world and the state of Latvian research works with the related topic was analyzed and presented in the paper. The author reviewed experiences of colleagues from other universities for identification main concepts used in this field and existing difficulties to perform technology transfer. The anticipated outcome of this review is the identification of information technology transfer model that could be used for transferring research results from Academia to Business Sector.

Keywords: Review, Information Technology Transfer, Technology Transfer Model.

I. INTRODUCTION

Nowadays the basis of technology is most commonly comprised of two large groups: a group of information technology and a group of information and communication technology which are based on the use of computers with the aim of processing, receiving, storing, reflecting and transferring information. The goal of information technology is to produce the information meant for making decisions by reducing labour-intensive processes of information resource use.

A lot of the success is directly dependent on a technological solution which could solve the problem more quickly by saving time, money and energy. The life cycle of any kind of information technology begins with its development and continues with transferring the results to the end user. The entrepreneurs of Latvia often cannot afford to invest their money and time in developing new solutions and conducting experiments. In the meantime, plenty of the already developed prototypes remain within university premises and are not passed onto the public. This is because scientists and technology developers are working on the quality and the progress of the technology, meanwhile the transfer process is not well-considered. Therefore, it is crucial to comprehend the process of the technology transfer, particularly from the perspective of the university that holds the role of the manufacturer of the technology and the role of the potential originator of the transfer.

The origins of technology transfer date back to the 1950s. Based on the literature analysis, it was concluded that scientists do not strictly distinguish between the concepts of technology transfer and knowledge transfer and this can be discovered through context. In a number of scientific articles and journals the technology and knowledge transfer carry similar meanings in terms of definitions and one definition can be replaced with the other. When summarizing the given definitions [1] - [12] the technology or knowledge transfer can be interpreted as the process of information transfer from the supplier to the recipient. Generally, this process includes at least two participants that would supply the information, knowledge, technology or experience and would anticipate a number of stages.

II. MATERIALS AND METHODS

Based on the study aim this research proposal investigates the following questions:

Question 1: What are key terms and concepts in technology transfer?

Question 2: Is there a relationship between “technology transfer process” and “knowledge transfer process”?

Question 3: What is the existing state of technology transfer in the world?

Question 4: What is the role of Latvia in the subject of technology transfer?

Question 5: What are the various models used in technology transfer?

Question 6: What are the most important factors that influence the technology transfer process?

Question 7: What is the future direction of technology transfer for further study?

The aim of this study is to give an overview of the field of technology transfer and show the current state of scientific research regarding this topic. For this

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purpose, a literature review and bibliometric analyse [13] of the scientific articles published between 1960 and 2016 years indexed in Thomson Reuters' Web of Science (WoS) [14] and Elsevier's Scopus [15] was conducted.

III. RESULTS AND DISCUSSION

The number of scientific researches related to technology or knowledge transfer is increasing worldwide every year. To reflect this trend, the bibliometric evaluation method was used [13]. The quantitative analysis was based on the data from the Thomson Reuters' Web of Science [14] and Elsevier's Scopus [15] internationally available databases. It should be pointed out that Elsevier's Scopus contains records of more than 21,000 journals, 86,000 e-books and 6,8 million conference materials as well as 27 million patents, but the Web of Science database contains the most important scientific information on more than 12,000 journals in more than 250 disciplines, offering the bibliographic and citation information, summaries and other information regarding the articles.

The information for the data analysis was compiled for the period from 1960 until the end of 2016 where the technology or knowledge transfer definitions are mentioned in several literary sources. The phrases "technology transfer" and "knowledge transfer" were selected for data processing. The results are reflected in Figure 1 which reflects the topicality of the themes in both databases.

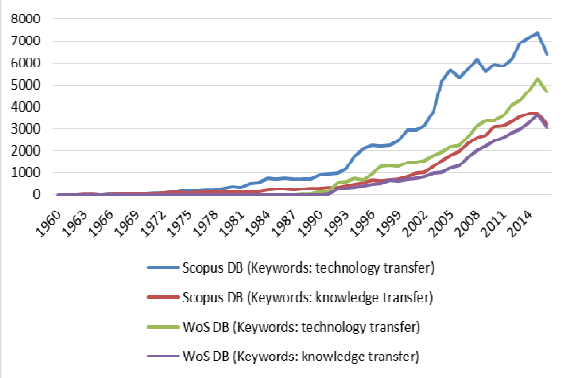

Fig. 1. The technology and knowledge transfer trends within the SCOPUS and Web of Science databases.

As can be seen, starting from 1985 there is a worldwide tendency to pay the most attention to the particular topic. Over the past decade only the SCOPUS and Web of Science databases have annually published about 15,592 scientific papers on average relating to the technology and knowledge transfer and the number of publications is increasing every year.

In terms of information technology, which is based on the use of computers, the information in the field of computer science alone has been collected over the past decade for further data analysis. The phrase "technology transfer" was selected for data processing and the filter "computer science industry" was applied for any searches done. Table 1 summarizes the results.

Table 1.
The number of publications within the SCOPUS and Web of Science databases by keywords "technology transfer" in the computer science sector.

Year	WoS	SCOPUS	Total
2006	331	897	1228
2007	387	1261	1648
2008	470	1548	2018
2009	498	1488	1986
2010	308	1395	1703
2011	288	1261	1549
2012	385	1218	1603
2013	420	1221	1641
2014	477	1239	1716
2015	608	1516	2124
2016	322	1548	1870
Total	**4494**	**14592**	**19086**

The bibliometric analysis showed that the theme in relation to the information technology transfer is topical and only the WoS and SCOPUS databases publish around 1,700 articles related to this issue annually. It is important to point out that most researches done in this area have been published by authors from China, the USA and Germany. Unfortunately, the scientists of Latvia still do not pay enough attention to this issue. Only 18 articles by Latvian scientists can be found for the period from 2006 to 2016 within both databases. The total number of publication during this period is reflected in Table 2.

Table 2.
The number of publications by countries for the period from 2006 to 2016 within SCOPUS and WoS databases.

Country	Scopus DB 2006-2016	WoS DB 2006-2016	Total
China	2940	969	3909
US	2575	795	3370
Germany	965	278	1243
Japan	776	178	954
United Kingdom	704	169	873
India	690	261	951
Italy	609	170	779
South Korea	555	192	747
Taiwan	457	170	627
...	...	...	...
Lithuania	38	10	48
Estonia	15	9	24
Latvia	11	7	18

In terms of technology transfer models that are used around the world it must be concluded that there is no single model which can be used and some researchers use different approaches and their experience varies significantly. A lot of new approaches related to technology transfer appear every day and this is influenced by many factors: the aims and the technology transfer policy, the industry needs, the technology quality, the engagement of funding, the government support and other factors. A number of publications were selected in order to compare the models and the scientific experience in the field of technology transfer. The results of the research were summarized in Table 3.

Table 3.
Technology transfer models.

Source	Type of Technology	Participants involved in the process	Difficulties to perform technology transfer	Solution
[16]	Information	1. College 2.Industrial partner 3.Third person	Lack of interaction of participants	1. Cooperation Technology Transfer in four programs: • Mediator • Direct transfer • Sharing ideas • The joint venture 2. The meetings twice a year
[17]	Selected lean manufacturing tools and techniques	1. Japanese automotive industry 2. UK local companies 3. Change agents	1. Time 2. Management	Quality control and Time-based competition Based on abstraction level of the transfer process and whether it is driven by supply or demand.
[18]	Aviation security technologies	1. Developer 2. End-user	Poor understanding of the private capital, unrealistic expectations of business innovation research grants, lack of understanding of university best practices.	TECHNOGY TRANSITION-TRANSFERCOMMERCIALIZATION MODEL that includes requirements development, assessment and evaluation, certification, qualification and approval to end-user application.
[19]	Research findings	1. Researcher 2. Practionier	1. Management 2. Size 3. Complexity 4. Stakeholder involvement 5. Criticality 6. Uncertainty	Risk assessment
[20]	Tools, products, methods, techniques, models, frameworks and others that enable or support the creation of software intensive products or services	1. Researchers 2. Practioniers	Lack of interaction between center and company	1. Open (Ended) Debate 2.Conclusions in specific post-conference reports
[21]	Research projects in Software Engineering	1.Academy 2.Industry	Reliability and feasibility of technologies, their applicability to industrial settings	Theory and set of hypotheses extracted from an exploratory survey with industrial and academic partners
[22]	Electric machinery	1. Producer 2. User	Readiness of its human ware	The measurement model based on characteristic of a person that have causal relationship with work achievement
[23]	Research results	1.Academy 2.Industry	Low perception of usefulness	Technology transfer maturity evaluating model based on Requirements Traceability
[24]	Innovation	1. Scientific research institutes 2. Local governments Enterprises	Lack of interaction between actors	Academy-locality cooperation patterns
[25]	IT & ICT technologies	1. Owners, developers, innovators 2. Users	Communication barriers	STAR (Communication) Model for technology transfer

By summarizing multiple sources it can be concluded that a number of technology transfer models include the following common parts:

- the transfer object;
- two or more participants involved in the technology transfer process;
- the interaction between the participants;
- the transfer method which involves a number of steps;
- the environmental factors influencing the technology transfer process.

In addition, several sources indicate that the technology/knowledge transfer is directly related to the concept of innovation. Many research papers [26] – [31] use terms such as "knowledge innovation", "technology innovation", "new knowledge", "new technology" in the context of technology/knowledge transfer. According to the definition from the Merriam-Webster dictionary [32], the "innovation" concept is to be understood as something new to the market and the synonyms to the technology transfer are substantial.

IV. CONCLUSION

As a result of the research it was concluded that the technology transfer is a topical theme worldwide and the number of scientific researches is only increasing annually. Most of the researches and the technology transfer models have been offered by the scientists from China, the USA and Germany. In Latvia the technology transfer process has not entirely been studied yet and, as a result, the scientists hardly ever communicate with the industry and everyone works separately. Based on the key concepts of the technology transfer, the foreign experience and the best practices, it has been decided to develop a new information technology transfer model and a way of its practical application, taking into account the environmental factors and the conditions within the Latvian market.

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Methodology of Group Work Organisation for Student Learning Performance Improvement

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Abstract. The article describes the methodology of learning programming for students of various engineering disciplines. The course "Algorithmization and Programming of Solutions" is taught to all first-year students of the Faculty of Computer Science and Information Technology in Riga Technical University and provides the basic knowledge of the principles of computational process algorithmization and software creation technology using Java programming language. There are 8 laboratory assignments in the course, where students have to develop a software programme and 2 group work assignments, where the student has to develop some algorithms to solve a given problem, write a programme, evaluate the speed of developed algorithms and prepare a presentation on the results of their research. The article describes the main principles of efficient student group work organisation that lets to increase their interest and motivate them to participate in the course in a responsible way. This paper is focused on research on how group work influences student learning performance.

Keywords: Java, student group work, survey, results.

I. INTRODUCTION

Nowadays, due to the increasing pace of scientific and technical progress, requirements to knowledge and skills of modern specialists continuously grow. As the result, need for quality education of specialists increases as well. However, the discrepancy between the capabilities of traditional teaching methods and the amount of actual knowledge that modern society demands from graduates of educational institutions indicates a problem in the system of modern higher education. Therefore, the issues of computer training and knowledge control are of interest for many researchers, in the field of both education and information technologies [1][2][3].

Usually, the solution of routine tasks requiring large amount of computations is assigned to computers. Although there are many programmes for solving similar tasks, computer cannot compete with human in solving creative problems. Many international scientific conferences (such as IEEE ICALT, IADIS e-Learning, IASTED CATE, etc.) and e-journals [4][5][6] are dedicated to research in the field of computer-based learning and knowledge assessment. Therefore, the need to teach future engineers the basics of programming is undeniable.

As is known, every learning course comprises three components: the main (theoretical) part (ideas and knowledge); the laboratory-practical part (skills, experience); the evaluation part (evaluation of skills). All these parts are obligatory and are traditionally taught by all teachers in higher education [7].

In the papers [8][9][10], results of influence of computer-based testing of knowledge on the learning performance of students were described.

Attendance of all the test lessons and use of computer systems for training and evaluation of knowledge (Learning Management system, ORTUS and IKAS systems) promoted more successful fulfilment of students' practical assignments and passing an examination.

The authors of this paper also assume that the addition of substantial new components to the course "Algorithmization and Programming of Solutions", specifically the addition of group projects, can significantly raise the motivation of students, their interest in improving their own professional competence and quality of their education.

II. THE CONTENT OF "ALGORITHMIZATION AND PROGRAMMING OF SOLUTIONS" COURSE

The course "Algorithmization and Programming of Solutions" is taught to all first-year students of the Faculty of Computer Science and Information Technology in Riga Technical University and provides basic knowledge of the principles of computational process algorithmization and software creation technology using Java programming language [11]. In this course, several practical works

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are envisaged. Organization of practical tasks takes place in the following way. Each student must develop an algorithm, write a program and submit it electronically to the study portal ORTUS. Once the program gets evaluated, the student must defend his or her work, i. e. write a report and answer teacher's questions about the program and the work in general. There are 8 laboratory assignments in the scope of the subject, where students have to develop a software programme. The first part of the course includes five (Branched programs; Development of a simple cyclical program; Processing one-dimensional arrays; Processing two-dimensional arrays; Ways of organization of nested loops), the second one – three laboratory works (Sorting arrays; Lines and text files; Creation of a file processing system).

Success of the mastering of bases of programming strongly depends on the acquisition of experience during independent solving of practical problems.

To increase interest and to motivate students to take responsibility for their own understanding of course materials, during the academic year students are offered to perform two group projects, one project in each semester. Each group project consists of developing a program to solve some problem and doing research on the efficiency of chosen algorithms for this solution.

III. THE CAUSES AND IMPORTANCE OF THE WORK IN GROUPS

The general scheme of group work is presented in Figure 1.

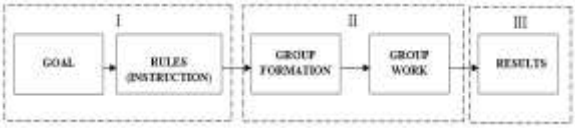

Fig. 1. Group work scheme

The basic purpose of the group project is to provide students an opportunity to exchange the acquired experience (Fig. 1, I stage). At this stage, the participants of groups receive assignments and deadlines, as well as criteria for evaluating the results of their planned research.

Students are allowed to freely divide into groups of 3 to 5 participants, and each one has to develop from one to two various algorithms for the solution of the offered task (Fig 1, II stage).

Once the program is developed, students must investigate empirically the speed of the chosen algorithms and the developed program and prepare a presentation on the obtained results. Students must also prepare a speech on the results of research at one of the practical lessons.

In the third stage (Fig. 1, III stage), all members of the group receive the same mark for the work they have accomplished. By student vote, the best presentation is selected. The authors of that presentation are awarded an additional point.

In the first semester, it is offered to students to solve the following problem as a group project. It is necessary to develop a program that would find a way through a maze. The description of the maze is stored in a two-dimensional array, whose elements are equal to zeros and ones (1 – a wall, 0 – pass). The entrance of the maze is the first element of the array (with indexes [0][0]), and the exit is the last element of the array (with indexes [R-1][K-1], where R is the number of rows and K – the number of columns in the array). For example, the description of the maze can look as showed in Figure 2.

0	1	1	1	1	1	1
0	0	0	0	0	0	0
1	1	1	0	1	1	1
1	0	0	0	0	0	1
0	0	1	1	1	1	1
1	0	0	0	0	0	0
1	1	1	1	1	1	0

Fig. 2. Maze description

Thus, the program should do the following:

- input from keyboard the size of the two-dimensional array containing the description of the maze (numbers of rows and columns);
- input from keyboard the elements of the array;
- output the information about the developed algorithms and allow the user to choose one of them;
- if a path exists, then output it in the following format: (0,0) (1,0) (1,1) (1,2) (1,3) (2,3) … (6,6).

Each member of the group is required to develop at least one algorithm for searching the path through the maze. Thus, the developed program must be able to find a path in the maze using at least three different algorithms.

Students must assess all of the developed algorithms in terms of passage speed and path length (if there are multiple paths in the maze), as well as determine, how the size of the maze influences the speed of the algorithms used in the programme. Students must present their solutions on one of practical lessons.

In the second semester, students are involved in developing and comparing various methods of array sorting. Students are offered to investigate at least six of the following methods: selection sort, insertion sort, bubble sort, odd-even transposition sort, merge sort, heap sort, counting sort, Shell sort, radix sort, tournament sort, quick sort. They are allowed to develop and investigate any other methods described in study literature or on the Internet.

In general, the second group project task is formulated as follows. 1) develop a program that inputs count of elements and array from keyboard, sorts the array in ascending order and outputs the array to the screen. Implement at least six different

sorting methods in the program. 2) Using the developed program, empirically determine the relation between program execution time and the amount of elements in the array (to construct the relevant tables and diagrams). 3) Make recommendations, which method is best used, if:

- the array contains a small amount of items;
- the array contains a big amount of items;
- the items of the array are arranged in reverse order;
- most items of the array are arranged.

To evaluate the effect of group projects on student learning performance and to improve the organisation student group work, a student survey was conducted. The results of this survey are presented in the following chapter.

IV. SURVEY CONTENTS AND RESULTS

The aim of the survey was to identify the principal reasons for participation or non-participation in group projects, because participation in group projects was not obligatory for all students. It should be noted that during the past two years 187 or 23% of the total number of students participated in group projects.

To increase the number of students participating in group projects, students were asked to select the main reasons preventing them from participating in a group project or successfully completing it. As the main reasons the students selected such factors as lack of time (74%), excessive complexity of the offered tasks (22%), difficulty in organising group (28%), unwillingness to work in a group (24%), unwillingness to prepare presentations and speeches (24%). The results of the survey are presented in Figure 3.

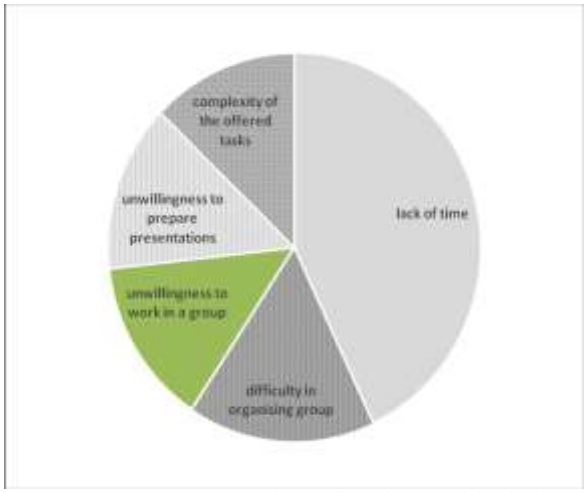

Fig. 3. Main reasons preventing students from partisipation in group projects

During group projects implementation, the students have more often faced such problems as lack of time (13%), refusal of some members of the group to do their part of the task (3%), difficulties in communicating with other members of the group (4%), difficulties in finding time and place for teamwork (19%), difficulties in preparation and presentation of the obtained results (6%) (Fig. 4)

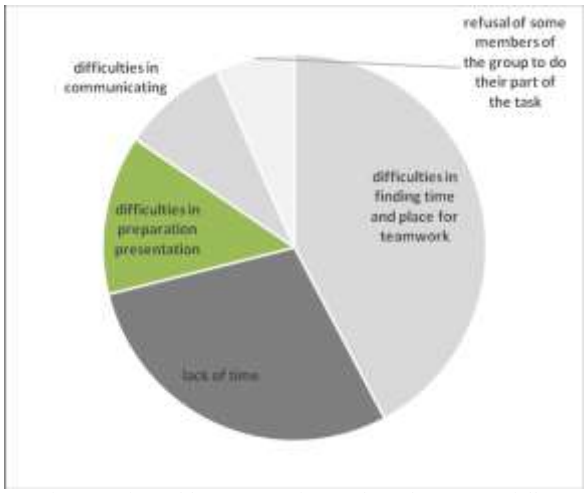

Fig. 4. Main problems preventing students from succesfully completing their group projects

The survey showed that 77% of students with no prior group project experience are ready to participate in the new group project if there will be such opportunity. Among those who have participated in at least one group project, 99% are ready to do it once again.

As the main reasons of participation in a group project, students have indicated the wish to learn something new (13%), interesting tasks to solve (19%), as well as the wish to get a higher mark (25%) (Fig. 5).

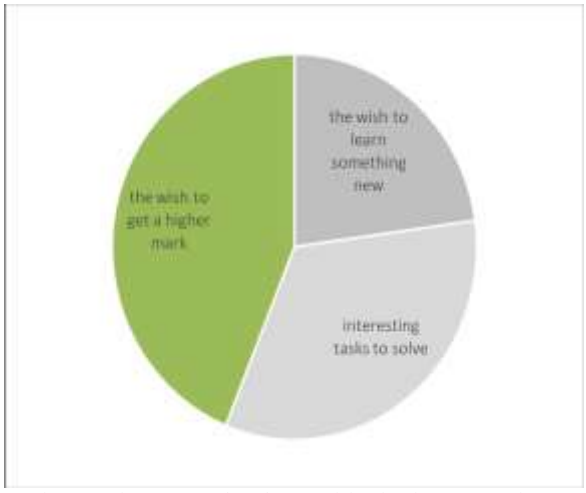

Fig. 5. Main reasons of student partisipation in group projects

During the survey, the students also noted that participation in a group project has allowed them to improve their programming skills (25% of students stated so), prepare presentations and speeches (11% of students), improve communication skills and learn to work in a group (15%), as well as find new friends (4%). At the same time, 6% of students have

indicated that the only benefit of their participation in the group project was a higher mark (Fig. 6).

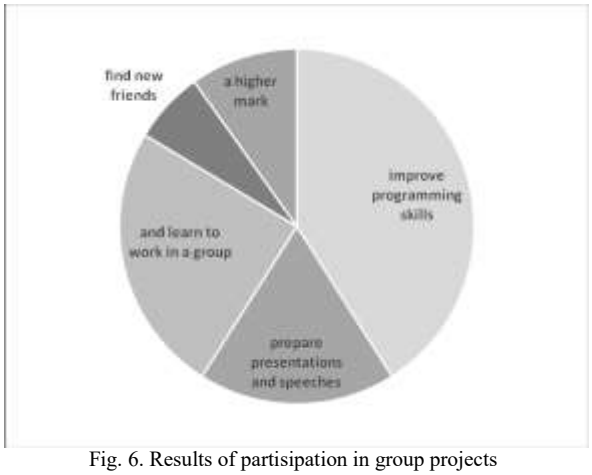

Fig. 6. Results of partisipation in group projects

V.CONCLUSION

Since the methodology of the group work is used only during last two years, there is not enough statistical data to precisely describe the relationship of work in groups and student learning performance. But the results of the survey have showed that 24% of students who have participated in group projects, have received very good (8) or higher at the examination, while only 12% of the students who did not participate in any group project have received the same high marks at the examination.

In the future work, it is planned to collect statistical data rich enough to mathematically determine the influence of group projects on the student's learning performance, as well as to develop more engaging and effective group tasks.

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Comparison of Different Fuzzy AHP Methodologies in Risk Assessment

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Abstract. Being able to evaluate risks is an important task in many areas of human activity: economics, ecology, etc. Usually, environmental risk assessment is carried out on the basis of multiple and sometimes conflicting factors. Using multiple criteria decision-making (MCDM) methodology is one of the possible ways to solve the problem. Methodologies of analytic hierarchy process (AHP) are the most commonly used MCDM methods, which combine subjective and personal preferences in risk assessment process. However, AHP involves human subjectivity, which introduces vagueness type of uncertainty and requires the usage of decision making under those uncertainties. In this paper it was considered to deal with uncertainty by using the fuzzy-based techniques. However, nowadays there exist multiple Fuzzy AHP methodologies developed by different authors. In this paper, these Fuzzy AHP methodologies will be compared, and the most appropriate Fuzzy AHP methodology for the application in case of environmental risks assessment will be offered on the basis of this comparison.

Keywords: fuzzy logic, risk assessment, fuzzy representation of knowledge, fuzzy analytical hierarchy process.

I. INTRODUCTION

Risks analysis is an integral part of the ecological risks management.

Usually the process of risks assessment includes objective data; however, the management of risks considers preferences and relations having both objective and subjective elements [1]. The risk management considers tasks of taking decisions, which includes the problem of choosing alternatives on the basis of numerous and sometimes conflicting factors. One of the possibilities of solving this problem is using a Multiple Criteria Decision-Making (MCDM) methodology. One of popular methods of the MCDM group is Analytic Hierarchy Process (AHP), which had been worked out and firstly published in papers [2] [3].

However, the AHP methodology is connected with human judgements and subjective opinions, which make the processes of taking decisions uncertain. In order to solve the problem a Fuzzy Analytic Hierarchy Process (FAHP) methodology can be used.

The main aim of this article is to investigate various FAHP methods, as well as to produce the risk analysis on the basis of one of the methods ranking the risk factors by their negative impact on ecology.

II. ANALYTIC HIERARCHY PROCESS

Analytic Hierarchy Process (AHP) was firstly offered in 1970s by American specialist in the sphere of operative analysis T.L. Saaty [4].

AHP method uses special mathematical methods for processing subjective preferences of person or group of experts of certain field on the basis of relevant factors while evaluating and analysing decisions. AHP method is based on precondition that the process of taking a global decision in complicated task, but it can be solved by dividing and structuring the complicated task into numerous simple tasks, illustrating them in a form of a clear hierarchical structure.

In the risk analysis AHP method may be described by 3 main stages: 1) creation of a hierarchical model of the risk factors; 2) calculation of weight of the risk factors; 3) a quantitative assessment of the risk level. As a result, for each risk level resulting assessment is calculated. The risks analysis is implemented on the basis of comparison of these assessments.

Currently there exist a number of researches aligning AHP methodology and the mechanism of fuzzy logic. Fuzzy logic methodology is being used with analytic hierarchy process to form a model for risk assessment. These methods of risk assessment are widely used in various fields, for example the risk assessment of floor water invasion in coal mines [5].

In majority of cases the fuzzy AHP method assumes that each risk factor is illustrated as an element of lower level of hierarchical structure and is expressed by fuzzy number, which represents a combination of the fuzzy assessment of possibility of a corresponding unfavourable event and of the fuzzy assessment of possible losses connected with the realization of this event.

In this paper three the most frequently used and the most popular FAHP methods will be analysed.

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These are: the van Laarhoven and Pedrycz, Buckley, Chang FAHP methods. While analysing these FAHP methods, it is possible to conclude that the main methodology and the action model may be formulated as a six-step sequence and is illustrated schematically in Fig. 1. Main differences for each method are represented by stages "Weight calculation for risk factors" and "Individual preferences aggregation". These differences, as well as the main characteristics, advantages and disadvantages of methods in total will be investigated further in the article.

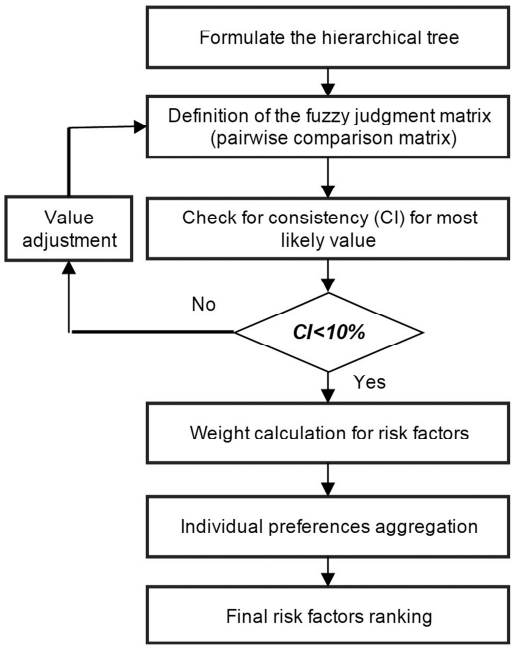

Fig. 1. Fuzzy analytic hierarchy process.

III. THE VAN LAARHOVEN AND PEDRYCZ METHOD

FAHP method was firstly offered in 1983 by van Laarhoven and Pedrycz. The main advantages of this FAHP method are the following:

1) The method is an extension of the Saaty AHP method, where instead of numerical assessment the triangular fuzzy numbers (TFN) are used in order to widen the standard AHP methodology.
2) The method supports the analysis and processing of assessments by numerous experts. It is reached by averaging the assessments of numerous experts in cells of matrix of pairwise assessments, arithmetic or geometric means may be used for this purpose, too.
3) Lootsma's logarithmic least square method is used to derive the fuzzy weight and fuzzy performance scores.
4) Approximate fuzzy multiplication is used in comparison of factors.

In accordance with [5] the offered by van Laarhoven and Pedrycz common structure of matrix for comparison of criteria (factors) looks as follows:

$$\tilde{C} = \left(\underline{\tilde{c}}_{ij}\right)_{K\times K} = \begin{pmatrix} (1,1,1) & \underline{\tilde{c}}_{12} & \cdots & \underline{\tilde{c}}_{1K} \\ \underline{\tilde{c}}_{21} & (1,1,1) & \cdots & \underline{\tilde{c}}_{2K} \\ \vdots & \vdots & \ddots & \vdots \\ \underline{\tilde{c}}_{K1} & \underline{\tilde{c}}_{K2} & \cdots & (1,1,1) \end{pmatrix} \quad (1)$$

where

$$\underline{\tilde{c}}_{ij} = \left(\tilde{c}_{ij1}, \cdots, \tilde{c}_{ijn_{ij}}\right)^T$$
$$\tilde{c}_{ijt} = (l_{ijt}, m_{ijt}, u_{ijt}) = \tilde{c}_{jit}^{-1} = \left(\frac{1}{u_{jit}}, \frac{1}{m_{jit}}, \frac{1}{l_{jit}}\right) \quad (2)$$
$$i, j = 1, 2, ..., K, i \neq j, \quad t = 0, ..., n_{ij}.$$

In (2) meaning $n_{ij}=0$ denotes an empty cell or the lack of comparison, however $n_{ij}>1$ in its turn implies a cell with numerous comparisons of factors provided by some experts. Therefore, for fuzzy weight vector (w), the fuzzy logarithmic least squares model is to be minimized using equation (3)

$$J = \sum_{i=1}^{K}\sum_{\substack{j=1\\ j\neq i}}^{K}\sum_{t=1}^{n_{ij}}\left(\ln \tilde{c}_{ijt} - \ln\left(\frac{\tilde{w}_i^{C|G}}{\tilde{w}_j^{C|G}}\right)\right)^2$$
$$= \sum_{i=1}^{K}\sum_{\substack{j=1\\ j\neq i}}^{K}\sum_{t=1}^{n_{ij}}\left((\ln c_{ijt}^{L} - \ln w_i^{L} + \ln w_j^{U})^2 + (\ln c_{ijt}^{M} - \ln w_i^{M} + \ln w_j^{M})^2 + \right.$$
$$\left. + (\ln c_{ijt}^{U} - \ln w_i^{U} + \ln w_j^{L})^2\right) \quad (3)$$

In (3) L and U parameters(indexes) represent a lower and a higher boarder of triangular fuzzy numbers respectively and M parameter denotes the mode. More detailed justification of the formula can be found in the papers [6] and [7].

Setting of $l_i = \ln w^L$, $m_i = \ln w^M$, $u_i = \ln w^U$, van Laarhoven and Pedrycz got the normalized result as equation (4), which they used as an estimate for w_i - a local weight vector.

$$\left(\frac{\exp(l_i)}{\sum_{i=1}^{K}\exp(u_i)}, \frac{\exp(m_i)}{\sum_{i=1}^{K}\exp(m_i)}, \frac{\exp(u_i)}{\sum_{i=1}^{K}\exp(l_i)}\right), \quad i = 1,..., K, \quad (4)$$

In order to calculate a global weight vector van Laarhoven and Pedrycz alternatively offered to use an equation, where a value is calculated through the aggregation of local weights.

$$(l_1, m_1, u_1) \otimes (l_2, m_2, u_2) \sim (l_1 l_2, m_1 m_2, u_1 u_2) \quad (5)$$

After the analysis of this method it is possible to distinguish one advantage comparing it to others: the options of multiple experts can be modelled in the reciprocal matrix.

Despite the characteristics of the van Laarhoven and Pedrycz FAHP method, in accordance with article [7] it has some significant disadvantages, too:

1) The equation (5), calculates the triangular fuzzy numbers only approximately, therefore there may occur serious uncertainties under certain conditions;

2) Not always there exists a solution for lineal equations used in the calculation of the weights vector.
3) In one comparison changing of priorities (in one direction) may cause a reverse of range in replication of the existing values.
4) Difficulties in calculation of equation (4), which is used to normalize local fuzzy weights. Therefore, for solving even a small task a lot of calculation expenses will be needed.
5) Uncertainty of local fuzzy weights at incomplete matrix of fuzzy comparisons.

IV. THE BUCKLEY METHOD

The FAHP method by J.J. Buckley [8] stands next in the chronological list. Its main idea, in comparison with Laarhoven and Pedrycz FAHP method, was to substitute the fuzzy ratios into the solution of the normal equations. Also, in order to get fuzzy weights J. J. Buckley offered to use geometric mean, as he wanted to use the method, which would be easy to widen into fuzzy inverse matrix. [8]

The main characteristics of the Buckley FAHP method are the following.

1) Similarly to the van Laarhoven and Pedrycz, the Buckley FAHP method is an extension of the Saaty AHP method where instead of numerical assessment the trapezoidal fuzzy numbers are used in order to widen AHP method.
2) The geometric mean method is used for analysis and calculation of the resulting vector in the factors comparison.
3) For matrix of comparison in equation (1), the geometric mean procedure takes the form of (6), and therefore the local weights are calculated by (7).
4)

$$\tilde{r}_i = (\tilde{c}_{i1} \otimes \cdots \otimes \tilde{c}_{iK})^{1/K},\ i = 1, \ldots, K \quad (6)$$

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \cdots \oplus \tilde{r}_K)^{-1},\ i = 1, \ldots, K \quad (7)$$

At the end, the equation (8) is used to calculate the final resulting vector.

$$\tilde{w}_i^{A|G} = (\tilde{w}_i^{A|C_1} \otimes \tilde{w}_1^{C|G}) \oplus \cdots \oplus (\tilde{w}_i^{A|C_K} \otimes \tilde{w}_K^{C|G}) \quad (8)$$

More detailed description of the method is available in paper [9]. After having analysed the method, it is possible to distinguish some its advantages:

1) It is easy to extend to the fuzzy case in the Buckley FAHP method.
2) It guarantees a unique solution to the reciprocal comparison matrix.

Despite the characteristics and advantages of the offered Buckley FAHP method, in accordance with research [10], it has got disadvantages, too:

1) If there is not a perfect consistency, the geometric row procedure can give different weights compared to the eigenvector method.
2) High computational requirements.

V. THE CHANG METHOD

Next in the chronological list stands the D. Chang FAHP method [11]. Here are the main characteristics of this FAHP method:

1) Triangular fuzzy numbers are used instead of numerical assessment in order to widen AHP method.
2) Arithmetic mean is used for determining the priority vector of factors.
3) Final ranking of results is implemented on the basis of numerical values.

D. Chang used a Fuzzy Extent Analysis for comparison of matrices, elements of which were represented by triangular fuzzy numbers. Applying this theory in fuzzy comparison matrix, one can calculate the value of fuzzy synthetic extent with respect to the i-th object as follows:

$$S_i = \sum_{j=1}^{k} \tilde{c}_{ij} \otimes \left[\sum_{k=1}^{k} \sum_{j=1}^{k} \tilde{c}_{kj} \right]^{-1} \quad (9)$$

where

$$\sum_{j=1}^{k} \tilde{c}_{ij} = \left(\sum_{j=1}^{k} l_j, \sum_{j=1}^{k} m_j, \sum_{j=1}^{k} u_j \right) \quad (10)$$

and

$$\left[\sum_{i=1}^{k} \sum_{j=1}^{k} \tilde{c}_{ij} \right]^{-1} = \left(\frac{1}{\sum_{j=1}^{k} u_j}, \frac{1}{\sum_{j=1}^{k} m_j}, \frac{1}{\sum_{j=1}^{k} l_j} \right) \quad (11)$$

The normalized row sums S_i are then compared using the degree of possibility values using (12)

$$V(\tilde{S}_i \geq \tilde{S}_j) = \begin{cases} 1, & \text{if } m_i \geq m_j \\ 0, & \text{if } l_j \geq u_i \\ \frac{l_j - u_i}{(m_i - u_i) - (m_j - l_j)}, & \text{otherwise.} \end{cases} \quad (12)$$

D. Chang offered to use equation (13) for calculating the global weight vector.

$$w_i = \frac{V(\tilde{S}_i \geq \tilde{S}_j \mid j = 1, 2, \ldots, K, j \neq i)}{\sum_{k=1}^{K} V(\tilde{S}_k \geq \tilde{S}_j \mid j = 1, 2, \ldots, K, j \neq k)}, i = 1, 2, \ldots, K \quad (13)$$

Despite the characteristics and advantages of the offered Chang FAHP method, it has got a disadvantage: instead of numerical assessments the method may use only triangular fuzzy numbers.

In accordance with article [12], despite possible limitations, the offered by Chang method includes the best elements of other methods, analysed in this paper. This fact is substituted also by a number of other papers, where the method is used in the analysis

and ranging of the risk factors, e.g. [13], [14]. A relatively low number of computational requirements is also an advantage of the method.

After having analysed the characteristics, positive and negative aspects of the methods mentioned in this paper, it is possible to conclude that the best methods for the risk assessment are the Buckley and the Chang methods.

The usage of the Chang method for the risk analysis ranking the risk factors by their negative ecological impacts is described further in the paper.

VI. CASE STUDY

The FAHP methodology for the risk factors assessment and ranking in the present paper is based on the Chang method is defined as the sequence of six steps and is presented in Fig. 1. Let's look through each of these steps in details.

A. Step 1: Formulate the hierarchical tree.

Identification of the risk factors is the first step in the ecological risk assessment.

In compliance with peculiarities of the ecological risk analysis and with the Chang method, on the basis of experts' experience, there were compiled 12 factors influencing the level of the ecological risks referring to the spread of invasive species. Also, in accordance with the FAHP methodology, the risk factors have been grouped into 4 categories. All factors and categories are illustrated in Fig. 2, where the categories of factors are marked as F = {F1, F2, F3, F4}, but the factors themselves as f_i, F_i = $\{f_{ij}\}$, i= 1,...,4, j=1,2,3.

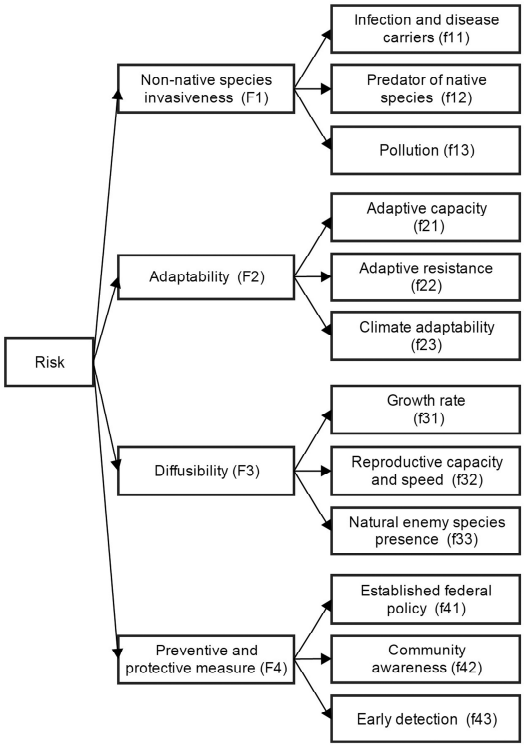

Fig. 2. The hierarchy of the risk factors influencing the level of the ecological risks referring to the spread of invasive species.

B. Step 2: Definition of the fuzzy judgment matrix.

The second step of the Chang FAHP method includes a pairwise comparison of factors in compliance with hierarchical structure illustrated in Fig. 2. The results of the comparison are represented by the judgement Tables II, III, IV, V and VI. Table I includes fuzzy values of a common scale, where each result of comparison is represented by a triangular fuzzy number and its backward equivalent.

Table I
Linguistic Scale For Relative Importance

Linguistic scale for relative importance	**Triangular fuzzy scale**	**Reciprocal of triangular fuzzy scale**
Exactly the same	(1,1,1)	(1,1,1)
Same importance	(1/2,1,3/2)	(2/3,1,2)
Slightly important	(1,3/2,2)	(1/2,2/3,1)
Serious importance	(3/2,2,5/2)	(2/5,1/2,2/3)
More serious importance	(2,5/2,3)	(1/3,2/5,1/2)
Absolute importance	(5/2,3,7/2)	(2/7,1/3,2/5)

Table II
Judgment Matrix For Risk Categories

F	F_1	F_2	F_3	F_4
F_1	(1,1,1)	(1/2,2/3,1)	(2/3,1,2)	(1/3,2/5,1/2)
F_2	(1,3/2,2)	(1,1,1)	(1,3/2,2)	(1,3/2,2)
F_3	(1/2,1,3/2)	(1/2,2/3,1)	(1,1,1)	(3/2,2,5/2)
F_4	(2,5/2,3)	(1/2,2/3,1)	(2/5,1/2,2/3)	(1,1,1)

Table III
Judgment Matrix For Risk Category- Non-Native Species Invasiveness

F_1	f_{11}	f_{12}	f_{13}
f_{11}	(1,1,1)	(1/2,2/3,1)	(1,3/2,2)
f_{12}	(1,3/2,2)	(1,1,1)	(1,3/2,2)
f_{13}	(1/2,2/3,1)	(1/2,2/3,1)	(1,1,1)

Table IV
Judgment Matrix For Risk Category – ADAPTABILITY

F_2	f_{21}	f_{22}	f_{23}
f_{21}	(1,1,1)	(2/3,1,2)	(1,3/2,2)
f_{22}	(1/2,1,3/2)	(1,1,1)	(1/2,2/3,1)
f_{23}	(1/2,2/3,1)	(1,3/2,2)	(1,1,1)

Table V
Judgment Matrix For Risk Category - Diffusibility

F_3	f_{31}	f_{32}	f_{33}
f_{31}	(1,1,1)	(1/2,2/3,1)	(1/2,2/3,1)
f_{32}	(1,3/2,2)	(1,1,1)	(1/2,2/3,1)
f_{33}	(1,3/2,2)	(1,3/2,2)	(1,1,1)

Table VI
Judgment Matrix For Risk Category - Preventive And Protective Measures

F_4	f_{41}	f_{42}	f_{43}
f_{41}	(1,1,1)	(1,3/2,2)	(1,3/2,2)
f_{42}	(1/2,2/3,1)	(1,1,1)	(1,3/2,2)
f_{43}	(1/2,2/3,1)	(1/2,2/3,1)	(1,1,1)

C. Step 3: Consistency test.

Consistency plays a big role in human thinking processes, it is important to ensure a consistency in pairwise comparisons of factors, too. It is significant because the results of pairwise comparisons may occur to be not consistent or correct due to unclear experts' judgements. Therefore, the third step in the Chang FAHP method is the check-up of the consistency of experts' judgements. For the check-up of consistency Chang used the same method as it was offered in papers [2] and [3] devoted to the T.L. Saaty for APH method. The main idea for testing the consistency is the calculation of maximum eigenvalue, values of which are further used in calculation of Consistency Index (CI). Consistency Index indicates whether expert provided the consistent values comparisons in a set of evaluations is calculated by equation (14).

$$CI = \frac{\lambda_{max} - n}{n-1} \qquad (14)$$

The final possible consistency of results of pairwise comparisons is determined by the consistency ratio CR = CI / RI, where RI is a random index got by averaging the CI of a randomly generated reciprocal matrix [3]. RI values for matrices of different dimensions (n) are presented in Table VII. In accordance with [3]: a maximally permissible value of the consistency ratio is 10%. In case if the consistency ratio exceeds the value, analysis should be interrupted and the results of pairwise comparisons returned to experts for determining and preventing the inconsistency.

Table VII
Random Indexes for N Dimensional Matrix [3].

n	1	2	3	4	5	6	…
RI	0	0	0.52	0.89	1.11	1.25	…

Results of calculations of consistency of pairwise comparisons represented in Table II are included into Table VIII.

As it is seen in the Table VIII, all values of the consistency ratio (CR) do not exceed the allowed value; therefore, the results of matrix of pairwise comparison may be correctly used in further calculations.

Table VIII
Results of Consistency Test for Matrix

	λ_{max}	CI	RI	CR
F	4.2619	0.0873	0.89	9.81%
F1	3.0192	0.0096	0.52	1.84%
F2	3.0744	0.0372	0.52	7.15%
F3	3.0192	0.0096	0.52	1.84%
F4	3.0192	0.0096	0.52	1.84%

D. Step 4: Weight calculation for risk factors.

This step includes the weight calculation of factors, where for this purpose, in accordance to the Chang FAHP method, Fuzzy Extend Analysis [11] is used, the main idea of which is to calculate the crisp weights from fuzzy comparison matrices. Necessary for calculation formulas are listed in part V.

Calculation results of equation (9) in matrix of pairwise comparisons are included in Table II and are represented as follows:

$$S_{F1} = (2.50,3.07,4.50), \quad S_{F2} = (4.00,5.50,7.00),$$
$$S_{F3} = (3.50,4.67,6.00), \quad S_{F4} = (3.90,4.67,5.67).$$

E. Step 5: Individual preferences aggregation.

Then, in compliance with the FAHP methodology, the crisp weight from the fuzzy triangular weights should be determined. For this purpose, D. Chang [11] offered to use a concept of the fuzzy numbers comparison in order to calculate crisp values from the fuzzy weights values. Next, for each fuzzy weight, a pair wise comparison with the other fuzzy weights are conducted (using equation (12)), and the degree of possibility of being greater than these fuzzy weights are obtained. The minimum of these possibilities are used as the overall score for each factor.

After applying the equation (12) towards results obtained at the previous stage, the following values were got:

$$V(S_{F1} \geq S_{F2}) = 0.53, \quad V(S_{F1} \geq S_{F3}) = 0.66,$$
$$V(S_{F1} \geq S_{F4}) = 0.64, \quad V(S_{F2} \geq S_{F1}) = 1.00,$$
$$V(S_{F2} \geq S_{F3}) = 1.00, \quad V(S_{F2} \geq S_{F4}) = 1.00,$$
$$V(S_{F3} \geq S_{F1}) = 1.00, \quad V(S_{F3} \geq S_{F2}) = 0.85,$$
$$V(S_{F3} \geq S_{F4}) = 1.00, \quad V(S_{F4} \geq S_{F1}) = 1.00,$$
$$V(S_{F4} \geq S_{F2}) = 0.84, \quad V(S_{F4} \geq S_{F3}) = 1.00.$$

Finally, these scores were normalized (using equation 13), and the corresponding scores of the 4 categories of risk factors obtained:

$W_F = (0.164,0.312,0.264,0.260)$

Similarly using extent analysis method, the weight vectors of the risk factors (F_1-F_4) were obtained:

$W_{F1} = (0.343,0.450,0.207)$,

$W_{F2} = (0.376,0.284,0.341)$,

$W_{F3} = (0.207,0.343,0.450)$,

$W_{F4} = (0.450,0.343,0.207)$.

F. Step 6: Final risk factors ranking.

On the last stage the risk factors ranking was done. Ranking is implemented on the basis of the overall weights' value, which is equal to correlation of the local weight to its "farther factor" weight. Weights of the category importance and the risk factors are shown in Table IX, as well as are illustrated by the diagram in Fig. 3.

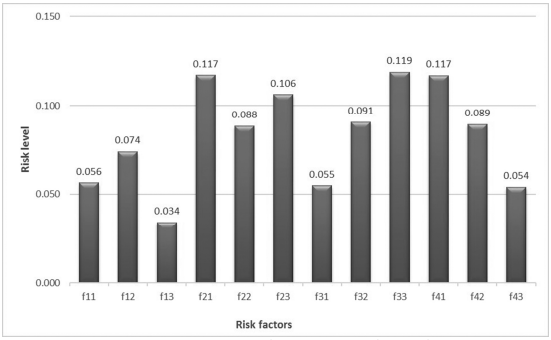

Fig. 3. The histogram of risk level of risk factors.

Table IX
Weight Table For Risk Factors

Risk categories	Local weight	Risk factor	Local weight	Overall weight
F_1	0,164	f_{11}	0.343	0.056
		f_{12}	0.450	0.074
		f_{13}	0.207	0.034
F_2	0,312	f_{21}	0.376	0.117
		f_{22}	0.284	0.088
		f_{23}	0.341	0.106
F_3	0,264	f_{31}	0.207	0.055
		f_{32}	0.343	0.091
		f_{33}	0.450	0.119
F_4	0,260	f_{41}	0.450	0.117
		f_{42}	0.343	0.089
		f_{43}	0.207	0.054

VII. CONCLUSION AND FUTURE RESEARCH

Characteristics advantages and disadvantages of the most frequently used and popular FAHP method have been investigated in the present paper. After having revised the methods, a decision to use the Chang FAHP method in the analysis of ecological risk in case of spread of invasive species in this paper was used. In accordance with the Chang FAHP method the hierarchy and regularity of factors were defined on the basis of experts' evaluations. It led to the calculation of the factors weights, reflecting the importance of each factor and categories of the risk factors, using the complex FAHP method for the risk assessment. Then the quantitative analysis of the risk factors was done. Finally, factors were ranked in accordance with their influence on the overall level of risk and the determinative risk factors, influencing the ecological risk in case of spread of invasive species, were defined.

It is shown by the application in definite cases that the risk assessment Chang FAHP method is easy and effective in engineering, which can provide technical support in the ecological risk assessment process. Also, the application of the FAHP method allows making a complex algorithm of analysis more affordable in order to obtain the risk assessment given an incomplete and reduced input data. The methodology can be used by government since it is a method that allows the evaluation of the risk level and also to see whether the safety measurements are suitable. This application can be used as a preliminary risk assessment tool, being able to highlight critical situations and the need for more in-depth and complete analysis. Also it can be used to help to take a thoughtful decision for reducing the risk level.

In future research is planned to analyze the ecological risk by using the van Laarhoven and Pedrycz and the Buckley FAHP methods in order to compare and to substantiate the results.

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Development of a Dynamic Modelling Tool for Agricultural Production Projections in Relation to GHG Mitigation Measures

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Abstract. The present research study outlines a methodology for assessing agricultural production forecasts in Latvia with regard to the outcome of GHG emissions. A dynamic model was developed, which allows assessment of effects of various decisions and measures on agricultural production. The model consists of several mutually connected blocks: 1) modelling of agricultural indicators with relation to macroeconomic indicators; 2) calculation of GHG emissions according to Intergovernmental Panel on Climate Change (IPCC) guidelines; 3) scenarios for analysing the impact on emissions by various mitigation measures, and 4) results for summarising the modelling outcome. The developed model may be used as a decision support tool for impact assessment of various measures to reduce emissions and for seeking solutions to GHG emission mitigation by agricultural policy decisions. The model was developed using the Powersim Studio software.

Keywords: GHG emissions, dynamic model, agriculture.

I. INTRODUCTION

After regaining its independence, a number of significant processes took place in Latvia, which influenced its agriculture: the collapse of collective farming caused a sharp decrease in the output of the livestock and crop industries (Figure 1) and Latvia's accession to the EU in 2004 contributed to the restructuring of its agriculture and the beginning of its development. The value of crop and livestock products produced by the crop and livestock sub-industries mainly determines the nature of and the trend in the development of the agricultural industry (Figure 1).

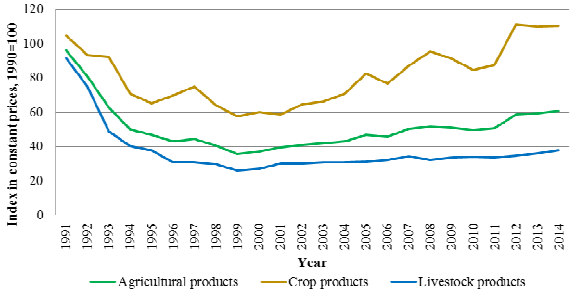

Fig.1. Changes of agricultural commodity price indexes in Latvia (constant prices) (1990=100) from 1991 to 2014 [1].

An analysis of the changes in the agricultural commodity price indexes (Figure 1) reveals that agricultural output constantly increased, particularly in crop farming. Although the crop sector grew dynamically, it still has considerable development potential because the total cropped area in 2014 accounted for only 70.7% of that in 1990.

The strong trends in agricultural development observed in Latvia will remain in future too; therefore, the system of long-term forecasting of agricultural indicators and of GHG emission modelling for the agricultural sector has to be improved. The Dynamic Model for the Long-term Forecasting of Agricultural Indicators and GHG Emission Reduction described in the paper provides such a possibility.

II. MATERIALS AND METHODS

The dynamic optimisation model for the long-term forecasting of agricultural indicators and GHG emission reduction consists of several large modules:

- Macroeconomic data module;
- Livestock indicator module;
- Crop indicator module;
- Module for calculating GHG emissions for the agricultural sector;
- Module for generating GHG emission reduction scenarios for the agricultural sector;
- Optimisation module for selecting GHG emission reduction scenarios for the agricultural sector;
- Module for summarising the modelling outcome.

The structure of the dynamic model is presented as well as the interconnections of individual modules in Figure 2.

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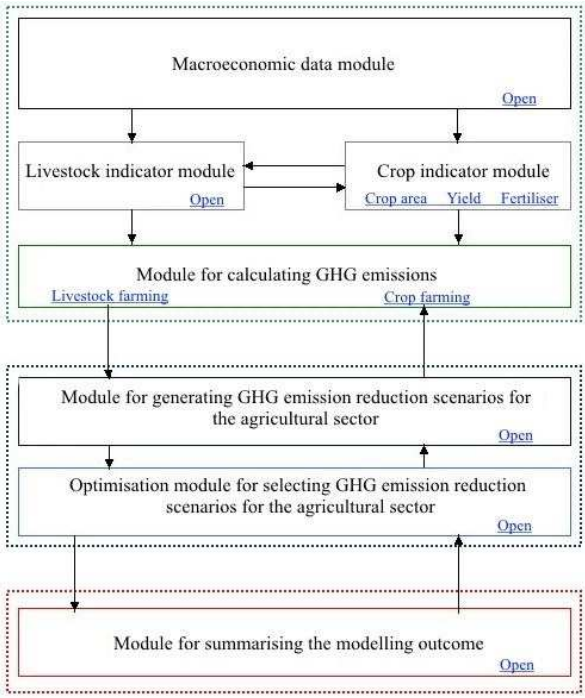

Fig.2. Structural scheme for the dynamic optimisation model for the long-term forecasting of agricultural indicators and reduction of GHG emission.

In the dynamic model, the long-term forecasting of agricultural indicators for Latvia is based on linear multifactor regression equations [2], choosing the following macroeconomic indicators as independent factors [3; 4]: GDP, share of agriculture in GDP, population and prices of agricultural commodities [5].

The generalised logistic function or Richards' curve were employed in forecasting some agricultural indicators that in the future might tend to near a level set by experts (areas cropped with wheat, maize, rapeseed and potato; numbers of fur animals and horses) [6].

The key sources of agricultural GHG emissions or active data are modelled in the modules of livestock and crop indicators. The emissions produced by the sources are estimated in the module for calculating GHG emissions. The amount of GHG emissions from livestock is determined by multiplying the simulated number of agricultural animals by the emission factor according to 2006 IPCC Guidelines for National Greenhouse Gas Inventories [7].

Methane emissions from dairy cows and cattle are calculated employing the emission factors determined according to the Tier 2 methodology, which are adjusted to the expected milk yields of dairy cows, given the fact that one of the most important variables related to methane emissions is livestock productivity. The default emission factors set by the 2006 IPCC Guidelines (Tier1) [7] or the emission factors employed in other countries are used for the other agricultural animals (goats, sheep, horses, pigs, poultry, rabbits and fur animals).

Methane emissions from fermentation in the gastrointestinal tract for every category of livestock are calculated by the following formula [7]:

$$CH_{4\,EntericFermentation} = EF_{(T)} \cdot \frac{N_{(T)}}{10^6} \quad (1)$$

where CH_4*Enteric Fermentation* – methane emissions from enteric fermentation, kt CH_4 year^{-1};
$EF_{(T)}$ – emission factor for the defined livestock population, kg CH_4 head^{-1} year^{-1};
$N_{(T)}$ – the number of heads for livestock species / category T in the country;
T – species/category of livestock.

However, the Tier 2 approach suggests calculating the emission factor by the following equation:

$$EF = \left[\frac{GE \cdot \left(\frac{Y_m}{100} \right) \cdot 365}{55.65} \right] \quad (2)$$

where EF – emission factor, kg CH_4 head^{-1} year^{-1};
GE – gross energy intake, MJ head^{-1} year^{-1};
Y_m – methane conversion factor, per cent of gross energy in feed converted to methane;
55.65 – factor of energy content of methane.

However, methane emissions from manure management are calculated by the following formula [7]:

$$CH_{4\,Manure} = \sum_{(T)} \frac{\left(EF_{(T)} \cdot N_{(T)} \right)}{10^6} \quad (3)$$

where $CH_{4\ Manure}$ = CH_4 emissions from manure management, for a defined population, kt CH_4 yr^{-1};

In addition to methane emissions from manure management, nitrous oxide N_2O emissions are also calculated [7]:

$$N_2N_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \right) \right] \cdot EF_{3(S)} \right] \cdot \frac{44}{28} \quad (4)$$

where $N_2O_{D(mm)}$ – direct N_2O emissions from Manure Management in the country, kg N_2O year^{-1};
$Nex_{(T)}$ – annual average N excretion per head of species/category T in the country, kg N animal^{-1} yr^{-1};
$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system in the country, dimensionless;
$EF_{3(S)}$ – emission factor for direct N_2O emissions from manure management system S in the country, kg N_2O-N kg^{-1} N in the manure management system;
S – manure management system.

The emissions from livestock calculated by the model are presented graphically as well (Figure 3).

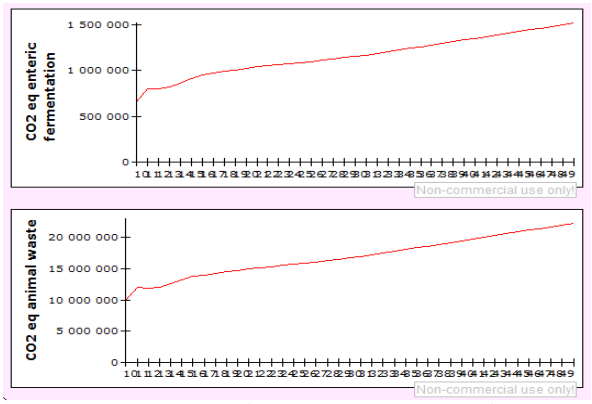

Fig.3. GHG emissions from livestock in the period from 2010 to 2050.

Based on the expected cropped area and crop yields, the crop indicator module calculates the amount of nitrogen in crop residues, the nitrogen emission factor of which, according to the 2006 IPCC Guidelines [7], is equal to 0.01 kg N_20-N(kg N)$^{-1}$. Nitrous oxide and carbon dioxide emissions due to fertilising and liming are determined according to the following emission factors set by the 2006 IPCC Guidelines [7]: 0.01 kg N_20-N(kg N)$^{-1}$ for fertilisers and manure, 0.13 t CO_2-C year^{-1} for lime fertilisers and 0.2 t CO_2-C year^{-1} for carbamide. A total amount of nitrous oxide emissions from crop farming, according to the IPCC guidelines, is calculated by the formula [7]:

$$N_2O_{Direct} - N = N_2O - N_{Ninputs} \quad (5)$$

where

$$N_2O_{Direct} - N_{inputs} = \left(F_{SN} + F_{CR}\right) \cdot EF_1 \quad (6)$$

where N_2O-N – annual direct N_2O–N emissions produced from managed soils, kg N_2O–N yr^{-1};

N_2O-$N_{N\ inputs}$ – annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O-N yr^{-1};

F_{SN} – annual amount of synthetic fertiliser N applied to soils, kg N yr^{-1};

F_{CR} – annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1};

EF_1 – emission factor for N_2O emissions from N inputs, kg N_2O–N kg^{-1} N input.

Finally, the emissions calculation is converted into CO_2 equivalent, acquiring a total emission equivalent.

The module for GHG emission reduction defines the following six GHG emission reduction scenarios:

1. ***Baseline scenario – 2015***: the baseline scenario is usually chosen if development takes place in the future in line with the historical trends. The baseline scenario uses 2015 agricultural forecasts for the period up to 2050. The baseline scenario involves all the GHG emission reduction measures introduced and to be introduced in Latvia. The factors necessary for GHG emission calculations are available in the GHG emission calculation module.
2. ***Baseline scenario – 2015+***: the baseline scenario with extra activities that involves an assessment of the impact of two GHG emission reduction measures defined according to the 2015 forecasts:
   a. Measure Precise Crop Farming involves an assumption that the largest farms (sized 100 and more ha) that farm more than 50% of the UAA in Latvia will introduce technologies that reduce the total consumption of nitrogen fertilisers by 5% as well as the loss of nitrogen due to leaching from 30% to 15% in the period from 2015 to 2050;
   b. Measure Precise Livestock Farming involves an assumption that precise feed rations will gradually result in higher digestibility of feedstuffs – from 65 to 80% for dairy cows and from 65 to 70% for other cattle.
3. ***Agricultural intensification scenario***: agricultural growth through the application of new technologies and innovations, observing the environmental and sustainable development principles.
4. ***Organic farming scenario***: considerable increases in the production of organic food.
5. ***Bioenergy scenario***: considerable increases in the production of bioenergy.
6. ***Integrated land management scenario***: optimised agricultural land management, which involves afforestation, wetland and organic soil management and other issues.

After summarising the modelling outcomes for the GHG emission scenarios, proposals can be developed for the GHG emission reduction programme for the agricultural industry at national level.

III. RESULTS AND DISCUSSION

Given the fact that it is planned to intensify agricultural production and reintegrate unutilised agricultural lands into agricultural production in Latvia, an increase in GHG emissions from the agricultural sector can reach 34% in 2020, compared with the level of 2005. In 2050, the amount of emissions could additionally increase by more than 70% (Figure 4). The main reason for the increase is the positive growth pace of agricultural production, which is based on the forecasts and an assumption that output in dairy, pig and poultry farming, grain

farming and other agricultural industries will increase.

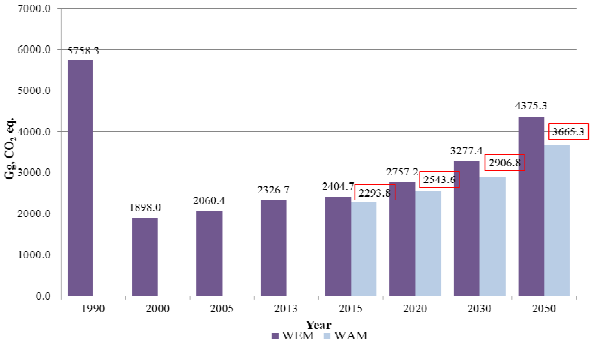

Fig. 4. Comparison of the agricultural GHG emission forecasts and the historical emissions (1990-2050).

The results of forecasting the agricultural GHG emissions are integrated in two scenarios. Scenario 1 (the baseline scenario 2015) with existing measures (WEM) includes the set emission reduction measures (Figure 4). Scenario 2 with additional measures (WAM) assesses the impact of additional measures to be introduced (the baseline scenario 2015+). The WAM scenario, which was designed in 2015, includes two extra measures: precise crop farming and precise livestock farming. It was estimated that the introduction of the extra measures would mainly reduce emissions from enteric fermentation and soil management.

If increasing the cropped area and the number of livestock, the emissions still tend to decrease compared with 1990. However, with agricultural production increasing, the total amount of GHG emissions from the agricultural sector will increase by 34% (by 23% with the extra measures) in 2020 and by up to 59% (by 41% with the extra measures) in 2030 (Figure 4).

IV. CONCLUSIONS

1. With agricultural output increasing in Latvia, reducing GHG emissions from agriculture is a serious challenge for the country.
2. Based on macroeconomic forecasts for Latvia, the dynamic model allows forecasting agricultural indicators for a long term.
3. The dynamic model estimates GHG emissions according to the 2006 IPCC methodology.
4. The GHG emission reduction scenarios allow simulating various situations and find the most appropriate one for Latvia.

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The Good, the Bad and the Unrecognized: Smart Textile Signal Clustering by Self-Organizing Map

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Abstract. The present article is a series of publications dedicated to the research of smart fabric sensors integrated into socks and is also part of the project aimed at developing the measuring system based on smart fabric supplied with sensors and intellectual data processing. The aim of the article is to perform a practical study on the application of Self-Organizing Map to smart textile signal clustering. Within the framework of the research, different approaches to the organization of network training are explored. A method for encoding an input pattern is also proposed. It has been established that the network is able to recognize the signal as a good step, a bad step, and an unrecognized step. The primary classification allows further selecting specific algorithms for a detailed analysis of good steps and bad steps. The detailed analysis of bad steps is the key to solving the problem of revealing of an athlete's special type of fatigue, leading to injuries.

Keywords: DAid® Pressure Sock System, self-organizing map, smart textile signal clustering.

I. INTRODUCTION

DAid® Pressure Sock System [1] measures and transmits a signal proportional to the pressure exerted by the foot on the sensors. In general, the system opens wide opportunities for investigating the processes of interaction of the user of smart fabric with any other objects, for example, in medicine at the stage of rehabilitation of patients or for monitoring the mobility of bedridden patients; in various sports – in equestrian sport (to control the rider's position in the saddle), dancesport, basketball (analysis of the coverage of the ball with the wrist) and in many other areas. The system transmits observations simultaneously from all sensors at predetermined intervals (for example, there are ten sensors in smart socks).

However, there is a substantial gap between the idea of signal collection (and even its physical implementation) and the operation of the system. It is due to the fact that the system must be able to recognize the signal. The signal may have noise, it is susceptible to the influence of the human body mass, tissue displacement is also not excluded, etc. Thus, one of the challenges is the analysis of the received signal. The ultimate goal of the analysis is to determine the process parameters specific to each area. For example, in case of running, as a result of analyzing the signal from the socks, it is expected to reveal such signal characteristics that would indicate the athlete's fatigue level.

As it is known, observations from clinical studies have estimated that over 60 % of running injuries could be attributed to training errors. In fact, it can be stated that all overuse running injuries are a result of training errors. An individual who has sustained an overuse running injury must have exceeded his/her limit of running distance and/or intensity in such a way that the remodeling of the injured structure predominated over the repair process due to the stresses placed on the structure [2].

On the way to the ultimate goal of identifying process parameters, there is the task of primary signal classification. Within the framework of the research, the authors investigate the use of Self-Organizing Maps (SOMs, also known as Kohonen Network) for signal clustering into the acceptable step ("the good" step that is correctly performed from the subjective point of view of the authors of the study), the unacceptable step ("the bad") and something else that cannot be called even a ugly step ("the unrecognized"). Unacceptable steps are the steps that are not executed correctly (in comparison with the "good" ones). Objective evaluation of a step is the subject of further research, once it is determined that signals of DAid® Pressure Sock System can be divided into these three classes.

The paper explores various approaches to the organization of network training. A manual way of network training is proposed. Experiments on the clustering of the signal obtained during a real run are carried out. The experiments aim at finding out whether the signal is distinguishable and determining the accuracy levels at which it is possible to classify patterns that do not participate in network training.

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The Kohonen network has been chosen owing to its simple mathematical model, which does not require significant computation and can be implemented in portable devices. The SOMs do not require a training sample. This will allow in the future, on their basis, to create systems that themselves adapt to the ordinary human step. This is a significant advantage over similar solutions.

II. OVERVIEW OF CONTEMPORARY RESEARCH IN THE FIELD

Many articles are devoted to the analysis of the signal coming from clothes, shoes, wearable equipment. The current research is close to studies [3] and [4], in which the authors discuss how to detect the gait phases and abnormalities of the phases. The source of the signal is ground contact force (GCF) sensors, which use air bladders and air pressure sensors. The authors use predefined rules to determine the appropriate gait phase. It should be noted that the integration of sensors in the shoes aligns the relief of the foot. At the same time, the use of predefined rules narrows the scope of the method.

It is worth mentioning the study [5], in which to determine the appropriate gait phase at each gait moment the authors use a threshold-based detection algorithm employing state transition theory. To obtain the signal, the smart shoe is used, combining two types of sensors: force sensitive resistors (FSRs) and a gyroscope. The data of smart shoes are used in another study of these authors [6], which recognizes gait phases. The disadvantage of using force sensitive resistors is that the FSR does not adequately reflect the actual foot pressure due to its small sensing area and limited sensing range [7]. In its turn, the study [7] uses the GCF sensors. For the analysis of the gait phases in the gait motions, the authors apply a hidden Markov model.

Summarizing the existing studies in the field of smart textile signal processing, it is possible to formulate several approaches that allow drawing conclusions about the parameters of running or walking:

- To “disassemble” the original signal into components and explore geometric shapes, its properties, etc.;
- To cluster the signal and then denote each cluster in one way or another depending on the parameters of the signals it is made up;
- On the basis of expert knowledge, to define (a) the norms of time intervals between the extremes of sensor signals, as well as (b) other indicators characterizing the steps. Then, it is necessary to divide the signal into steps, and for each step to calculate the values of the indicators;
- As in the previous approach, it is necessary to calculate the values of step indicators and then build a time series of changes in indicators in order to analyze the trend of change in indicators. The approach allows forecasting the development of various parameters of the race.

Each approach has its own advantages in determining what happens to the athlete in the running process. Solving this problem, the greatest effect can be achieved through synergistic approaches. The present research is based on the approach related to signal clustering and denoting each cluster.

III. THE EXPLOITED SYSTEM FOR PLANTAR PRESSURE ANALYSIS

In the present research, the wireless DAid® Pressure Sock System [1] (Fig. 1) has been used to measure temporal gait parameters and plantar pressure control. The proposed system consists of the array of sensors distributed over the sole part of socks, connected by conductive lines and custom designed connector with electronic devices that collect and transmit data from sensors to the data processing device [1].

Fig. 1. Allocation of left foot sensors of Daid® Pressure Sock System.

In Fig. 1 (right side), the labels ADC0, ADC1, ADC2, ADC3, ADC4 denote pressure sensors. White lines (see Fig. 1, left image) are conductive lines, which deliver the signal from sensor to sock connectors. The transmitting device connected to each sock uses Bluetooth to deliver the signal to the host computer.

The designed Daid® Pressure Sock System provides an opportunity to control relative pressure distribution, temporal gait features; it can potentially provide recognition of walk/run patterns and their long-time alterations that could help avoid possible injuries due to foot overload. The developed sensors are inexpensive, do not disturb plantar pressure distribution and may be easily customized following recommendation of physician [1]. In Fig. 2, the example of one sensor signal is depicted, where V^{-1} denotes inverted sensor output.

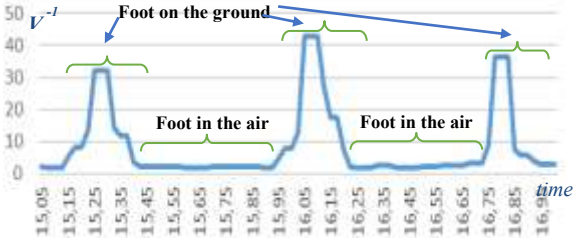

Fig. 2. A signal fragment produced by one sensor.

IV. SOM IN SIGNAL CLUSTERING TASK

SOMs are neural network based clustering methods used for the analysis and visualization of high dimensional data [8]. SOMs have an important characteristic for this study – they do not require a training sample. The only thing that is required is expert knowledge of the approximate number of classes that are expected to be received. SOMs can yield satisfactory results with a comparatively small training set and can be significantly faster than conventional MLPs for exploratory classification problems [8].

In the present research, the input vector transmits the signal of a step obtained from five sensors of smart sock (see Fig. 1). To find the start and end points of a step in the streaming signal of the race, a simple comparison of the sum signal across all sensors with a threshold value is used. If the sum is below a given threshold (see Fig. 3), the closest (right-hand) minimum of this sum will be the cut point of next step.

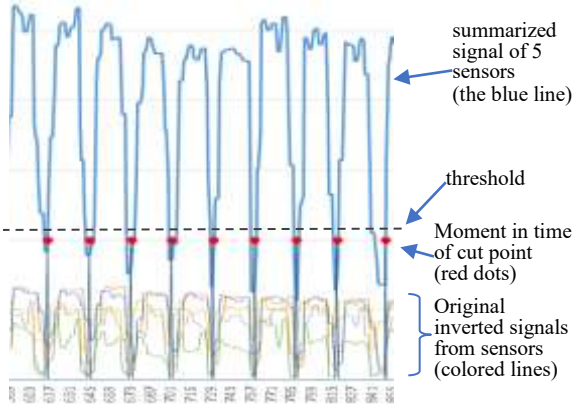

Fig. 3. Visual representation of weight vectors of the three neurons.

It is also possible to use the method of detection of the so-called reference points, based on the transformation of dynamic data into static images and the application of the multilayer perceptron (see [9] for detailed explanation). Any approach allows dividing the signal into steps. The five-channel signal of each step forms one input vector of the Kohonen network.

As the number of signal measurements of a person's step can vary, to determine the size of the input vector, the case with the largest number of measurements of the step (23 measurements) has been identified among all the steps of the two experimental races R_1 and R2. Two more formal measurements have been added to this number in order to ensure that all measurements are made. However, this is an optional activity. If the duration of any step is less than 25 measurements, for example, 18, then measurements from 19 to 25 are filled with zeros. In total, the input vector is formed by 125 measurements – 25 for each of the five sensors as shown in Fig. 4.

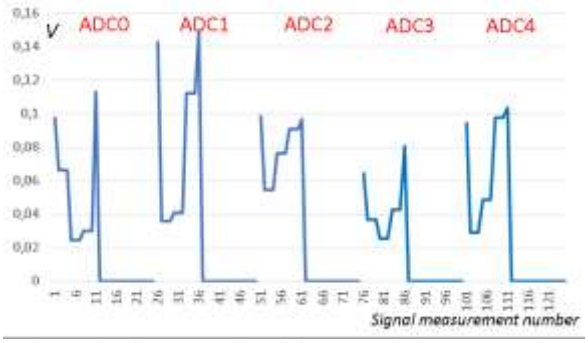

Fig. 4. Visual representation of the composite input vector of a step.

In the present paper, as a metric for determining the winning neuron of the input vector, the Euclidean metric

$$E(a,b)=\sum_{i=1}^{N}|a_i-b_i| \qquad (1)$$

and shape-based criteria are used:

$$S(a,b)=\sum_{i=1}^{N-1}|(a_i-a_{i+1})-(b_i-b_{i+1})| \qquad (2)$$

The Kohonen network consists of neurons organized into a rectangular structure. As a function of calculating the proximity of neighboring neurons, the Gaussian function is used:

$$\eta_i(d,k)=e^{\frac{d_i}{2\sigma(k)}}. \qquad (3)$$

The study uses the coefficient of learning rate η equal to 0.1 and the standard deviation of the distribution σ equal to 0.5.

Depending on the goal of the experiment, the network consists of two, three or six neurons. In fact, their number indicates the number of clusters (types of steps), into which the Self-Organizing Map divides the "cut" signals of step. Accordingly, the more neurons are used in the Kohonen network, the more details are recognized in the signal of step.

To provide full control over all parameters of the Kohonen network, use arbitrary metrics for calculating the closeness of vectors and manually set the values of the weights, the authors have created their own SOM program in the Java programming language. In future, this development can be transferred to the Android platform, which will allow for real-time monitoring of the race parameters calculated on the side of this device.

V. IMPLEMENTATION OF EXPERIMENTS

The aim of the series of experiments is to investigate how successfully Self-Organizing Maps cluster the signal received from the DAid® Pressure Sock System sensors. For simplicity, the experiments use sensor signals from only one sock (from the left foot). In total, two experimental races were made (see Table 1). The first part of the path of each race was run normally by the test persor (in the opinion of the tester), and the second half – deliberately worse, performing the so-called unacceptable steps. Under the unacceptable ("the bad") step, the following sequence of foot-to-ground contact is implied:

1) contact of the sock with the ground at a large angle (the plane of the foot at this moment is practically perpendicular to the surface);
2) contact of the heel with the ground.

The number of steps accomplished by the test person during normal and bad races is given in Table 1.

Table 1
Experimental Race

Race identifier	Total step number	Good* step count	Bad* step count
R_1	105	71	34
R_2	64	36	28

** in the test person's opinion*

It should be noted that due to the human factor, within the normal style of running, various deviations from the normal style could be tolerated (the same can be attributed to the style of bad running – some "bad" steps could be performed as quite good steps or, conversely, as "not steps" at all). The comparison of the test person's opinion with the "opinion" of the artificial neural network is also one of the important points of the present research.

Apart from races, there were also two series of jumps on the left foot: 11 jumps for the training sample and 10 jumps for the test sample. The obtained jumps are used contrary to the steps and are referred to as the "unrecognized" signals.

A. The First Experiment: Clustering Steps into Two Clusters and Choosing the Best Metric

In the first experiment, the Self-Organizing Map should cluster the R_1 race steps (see Table 1) into two clusters of steps, using two metrics: the Euclidean metric (1) and contour-based metric (2). As a result of applying the Euclidean metric, one step out of the 71 steps of the normal running style is recognized as the "bad" one by the SOM. In turn, 4 steps out of the 34 steps taken in bad running style are attributed by the SOM to the cluster of "good" ones, which makes the clustering accuracy equal to 95 %. It cannot be stated that these five steps were incorrectly clustered. It is assumed that the test person unintentionally (and not realizing) took one bad and four good steps at the wrong time. In turn, the Self-Organizing Map has its own "opinion".

Fig. 5 demonstrates the weight vectors of the SOM neurons obtained during training (clustering).

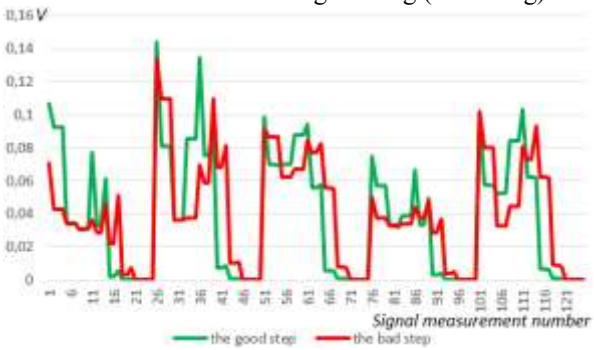

Fig. 5. Visual representation of weight vectors of two neurons.

Since the weights of the neurons contain approximately average values of all the elements of the cluster, the lines in Fig. 5 actually reflect the generalized image of a "good" step and that of a "bad" step.

In case of using the counter-based metric, the network recognizes the steps in a way similar to that of the Euclidean metric, but clusters the other seven steps in a different way. However, one cannot say that the network "made a mistake" as another metric was used, which otherwise evaluated the similarity of time series. In subsequent experiments, this trend remains unchanged – using the Euclidean metric, the clustering of steps practically coincides with the test person's opinion. Therefore, in subsequent experiments it was decided to use only the Euclidean metric. The model obtained in the first experiment is denoted as SOM^2_{R1}(two clusters, the first sample).

B. The Second Experiment: Clustering Steps Into Three Clusters: The "Good", the "Bad" and the "Unrecognized"

In the second experiment, the Kohonen network is formed by three neurons, ensuring that the signal is clustered into three classes of steps. To the selection of R_1 race signals, 11 signals of jumps were added from the toe (hereinafter, the "unrecognized" signals). As a result of training, one step (and the same as in the first experiment) out of the 71 steps of the normal running style was recognized by the Kohonen network as a bad step. Eight out of the 34 steps of the bad running style were attributed by the network to a cluster of good steps. Finally, six "unrecognized" signals out of 11 signals were recognized as bad steps. Fig. 6 shows the values of weights of all three neurons.

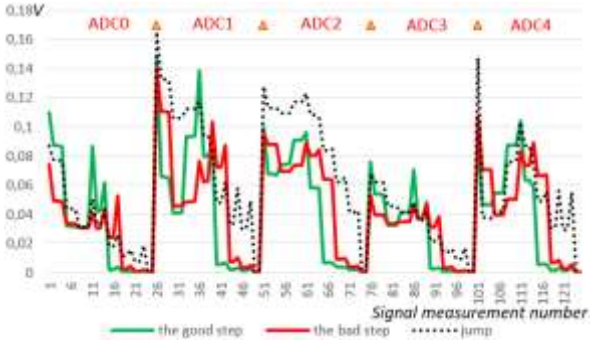

Fig. 6. The values of the weights of the neurons, the "good" step, the "bad" step and jump (unrecognized).

Fig. 6 demonstrates that the "unrecognized" signal (dotted line) significantly differs from the signal of good (green line) and bad steps, and it is also longer. This is clearly seen in the measurements 15–25 of ADC4 sensor (Fig. 6, signals 115–125): although the steps are already completed, there is still the "unrecognized" signal (dotted line). The model obtained in the second experiment is denoted as SOM^3_{R1}.

C. The Third Experiment: Classification of Test Steps on the Trained Network

In the third experiment, the steps from the R_2 race are classified on the models SOM^2_{R1} and SOM^3_{R1} obtained in the previous experiments (see Table 1). The model SOM^2_{R1} allowed classifying the signals of the race R_2 at 100 % accuracy. In turn, the model SOM^3_{R1} also classifies good and bad steps at 100 % accuracy, but the three "unrecognized" signals out of the 10 test "unrecognized" signals are attributed to bad steps. Fig. 7 compares signals of the three "unrecognized" signals with the values of weights of the neuron of bad steps and that of the "unrecognized" signal.

As seen in Fig. 7, duration of "unrecognized" signals (recognized by the SOM as bad steps) is 18 measurements, which is typical of bad steps.

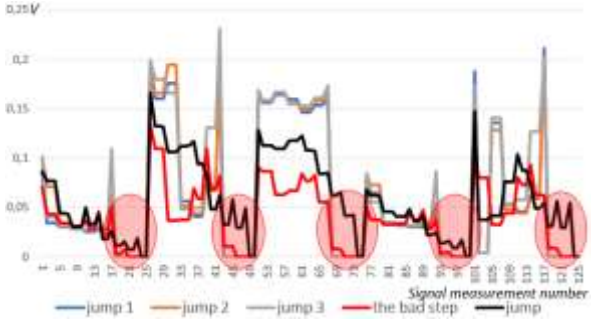

Fig. 7. Comparison of duration of the "unrecognized" signal to that of the signal of bad steps.

Indeed, repulsions from the surface when performing jumps on the left toe had similar features with landings on the toe when performing bad steps.

D. The Fourth Experiment: Clustering of the Signal of Steps by a Network with Six Neurons

Within the framework of the fourth experiment, all the steps of R1 and R2 races were used. The aim of the experiment was to investigate the clustering results of the signal of steps by a network with two neurons (the obtained model was denoted as $SOM^2_{R1,R2}$), and by a network with six neurons (the obtained model was denoted as $SOM^6_{R1,R2}$). In the case of $SOM^2_{R1,R2}$, the four steps out of the 107 steps made during the normal running style were recognized by the SOM as bad steps, and the eight steps out of the 62 steps made during the unacceptable running style were recognized by the SOM as acceptable steps.

It should be noted again that this does not indicate an error in the operation of the SOM – the test person could unconsciously take steps of the type not required of him.

Table 2
Distribution of Steps by Clusters

Type of a step	Number of steps (for two races)	$SOM^2_{R1,R2}$		$SOM^{4of6}_{R1,R2}$			
		Cluster "Good"	Cluster "Bad"	Cluster A	Cluster B	Cluster C	Cluster D
Good	107	104	3	2	18	43	44
Bad	62	8	54	54	8	0	0

It is worth noting that in the case of six neurons in the Kohonen network ($SOM^6_{R1,R2}$), two neurons turned out to be "dead" – they were not involved. The eight steps attributed by the network $SOM^2_{R1,R2}$ to good steps were classified into the cluster B. The remaining 54 steps of the unacceptable style were classified by the SOM into the cluster A. As a result, it can be concluded that this is the cluster of bad steps. Those 103 steps out of 107 steps (acceptable style), which were previously attributed to good steps, were classified into the clusters C and D, while the remaining four steps were grouped into the clusters A and B, each containing two steps. These data are provided in

Table 2.

On the basis of the weight vectors of the four neurons, the matrix of distances was created, which resulted in a dendrogram shown in Fig. 5.

Fig. 8. Dendrogram of the similarity of clusters.

As shown in the dendrogram, all the steps can be divided into three types: the "bad" cluster A, the "good" clusters B and D. The question arises: what steps were attributed by the network to the cluster C?

To answer this question, let us take a look at the matrix of cluster distances (see Fig. 9).

	a	b	c	d
a	0	2,73944	2,80785	2,92033
b		0	1,96216	0,66857
c			0	1,77845
d				0

Fig. 9. The matrix of cluster distances.

The cluster C is closer to the cluster D, which is a subset of good steps. Thus, clusters B, C and D are types of good steps with varying degrees of acceptability. In particular, the cluster C holds the steps from the sample of good steps, which were unintentionally not so well made. In fact, this group is an indication of the deviations in the test person's race from normal running style.

E. The Fifth Experiment: Comparison of Manual Clustering with SOM Clustering

The final experiment performed manual clustering (the obtained model was denoted as $Manual_{R1}^{2}$) and clustering by the Self-Organizing Map (SOM_{R1}^{2}). As the test person believed that he ran well the first half of the race and the second half – worse, then the average values of "good" and "bad" steps were taken. In Fig. 10, Fig. 11 and Fig. 12, these values are compared to the values of weights of the network SOM_{R1}^{2} of the first experiment.

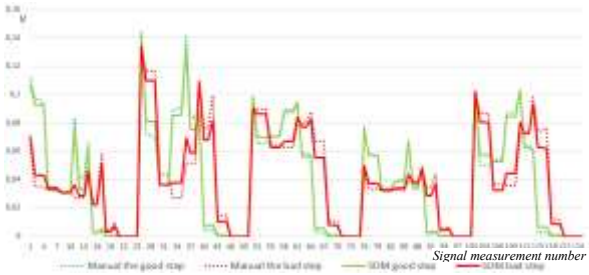

Fig. 10. The average values of steps obtained manually and by the network SOM_{R1}^{2}.

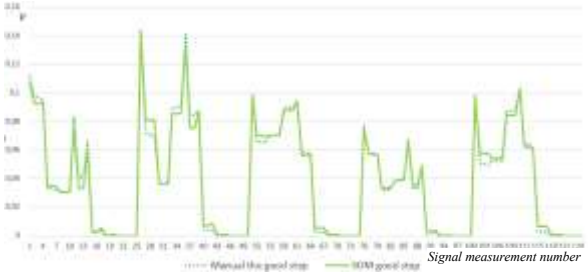

Fig. 11. The average values of "good" steps obtained manually and by the network SOM_{R1}^{2}.

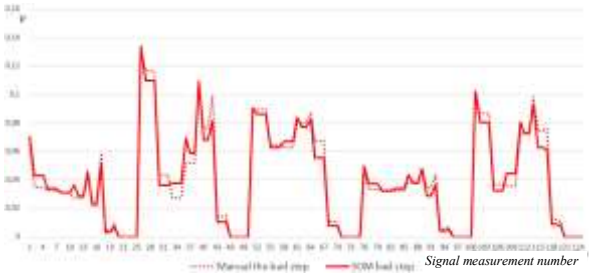

Fig. 12. The average values of "bad" steps obtained manually and by the network SOM_{R1}^{2}.

As can be seen in the figures above, manual clustering practically coincides with the clustering of the Self-Organizing Map: the graph of the average value of acceptable steps coincides with the graph of the weights of the corresponding neuron by 98.5 %, and for unacceptable steps the coincidence is 97 %. This is an important result, showing that the "opinion" of the network basically coincides with that of the test person. There are also minor "disagreements" described in the previous experiments.

VI. CONCLUSIONS

The authors of the present paper have investigated the application of the Self-Organizing Map to the clustering of the signal of steps obtained from sensors of DAid® Pressure Sock System. The experiments have been carried out with the aim to use the trained SOM in order to classify steps that do not participate in training.

As a result of the first experiment, clustering of the steps into two clusters has been achieved at 95 % accuracy. The error of five percent is explained by subjectivity when the test person attributed steps to a particular class. To increase the accuracy, expert knowledge in the field of physiology is required. It has been found that for a given signal type the Euclidean metric gives a result that is closer to the opinion of the test person than the contour-based metric does.

In the second experiment, signals of the third type (actually not being steps) have been added, and clustering into three groups has been performed. The coincidence with the opinion of the test person has been 87 %.

In the third experiment, the models obtained during the training in the first and second experiments (SOM_{R1}^{2} and SOM_{R1}^{3}) have been used. The coincidence of the classification of steps (previously not involved in training) with the opinion of the test person has been 100 % for the two types of steps, and 96 % for the steps and "unrecognized" signals.

In the fourth experiment, the authors have compared the clustering of acceptable and unacceptable steps into two and six clusters. In case of six neurons in the Kohonen network, two have not been not involved. One cluster contains unacceptable steps, three clusters – acceptable. As a result, the

gradation of good steps has been obtained. It should be noted that bad steps have not been divided into subgroups. It is also worth mentioning that even with such a small amount of data, it has been possible to demonstrate the clustering approach with further assigning of a name to each class in accordance with the steps included in it.

Finally, in the fifth experiment, the results of manual clustering and clustering by the SOM network have been compared. It has been found that the results of manual clustering and that of the SOM network practically coincide.

Within the framework of the present research, a practical study of the application of Self-Organizing Map to smart textile signal clustering has been carried out. Based on the results of the experiments, it can be concluded that the network is able to recognize the signal as the "good" step, "bad" step, and not a step at all. Such a primary (rough) classification allows further selecting specific algorithms for a detailed analysis of "good" steps and "bad" steps. The detailed analysis of bad steps is the key to solving the problem of revealing of an athlete's special type of fatigue, leading to injuries. This is also the area of the further research.

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An Algorithm of Fuzzy Inference System for ISAR Image Classification

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Abstract. This article offers an original ISAR image classification procedure based on Mamdani fuzzy inference system (FIS) dedicated to compute multiple results each from different type of analyzing criteria. The modeling and information analysis of the FIS are developed to draw a general conclusion from several results each produced by classification from neural network. Simulation experiments are carried out in MATLAB environment.

Keywords: fuzzy inference system, membership function, fuzzy rule.

I. INTRODUCTION

For all Inverse Synthetic Aperture Radar (ISAR) systems high performance and better image reconstruction technologies are vital. An opportunity for improved information analysis in that area is suggested to be the development of better algorithms for recognition of the various flying objects. To solve the classification problem after the optimization procedures of a radar image a fuzzy logic algorithm can be used to maximize the recognition rate while controling the error rate [1], [2]. Fuzzy logic can be applied also to the identification "friend-or-foe" airplanes using hybrid algorithm combining fuzzy neutral network with a probability factor. A hybrid algorithm combining fuzzy neutral network with probability factor (FNNP), multi-level fuzzy comprehensive evaluation and the Dempster-Shafer (D-S) theory can be implemented too [3].

In other fields of science the determination of the specific rules in classification system with fuzzy logic can solve problems in the classification of vessels caused by the insufficient amount of information on one SAR channel [4]. Nowadays the improved modeling and information analysis of ISAR systems are developed by implementation of detailed 3D model of observed flying object [5]. The neural network procedures can be applied to classify different features of the objects in the ISAR image as well as to compare the ISAR images with some known aircraft models in a specific database [6].

II. PRECONDITIONS AND MEANS FOR RESOLVING THE PROBLEM

Preconditions.

A specific experimental arrangement is developed for the proposed algorithm of fuzzy inference system for ISAR image classification. The arrangement consists of five neural networks each working with a specific database of models after the optimization procedures of the ISAR image. One neural network is designed to classify the object in the ISAR image by its size (small, middle or big). Another - computing the jets position (rear, wing or integrated in the fuselage), third – comparing the image with database of 16 aircraft models. Fourth comparison is made for contour of the ISAR image with a database of 16 aircraft contour models. The fifth neural network is for contour ratio comparison evaluating the number of the corresponding pixels with the contour images database. Each neural network can be developed in MATLAB environment in order to produce a result value between zero and one.

The linguistic variable is a main term in the fuzzy logic and is described a variable, witch value defines a set of verbal characteristics of a feature [7].

Building a system for making a final decision based on fuzzy logic.

The tools of fuzzy logic allows the use of two approaches to implement a system for decision. Various membership functions - functional relationships that determine the way in which each point of entrance area (input variables) form the baseline background (degree of affiliation) within the range of zero to one for the membership functions of the output variables.

In this fuzzy inference system the use of membership functions of Gaussian type are chosen, subject to the following factors: the specificity of recognition of images; universality of application of Gaussian functions; availability of similarity in model airplanes; evenness of the form; pronounced maximum; values other than zero for all points. Gaussian curves are subdivided into two types according to their form: a simple Gaussian curve and the two-way combination of two different Gaussian

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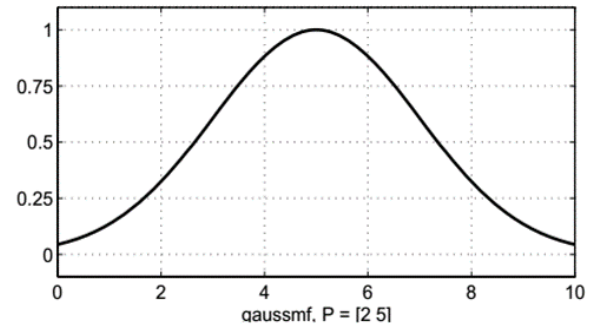
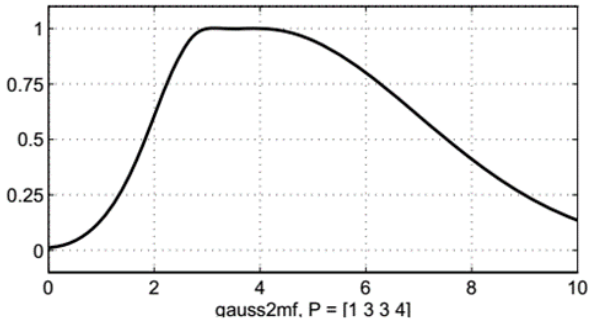
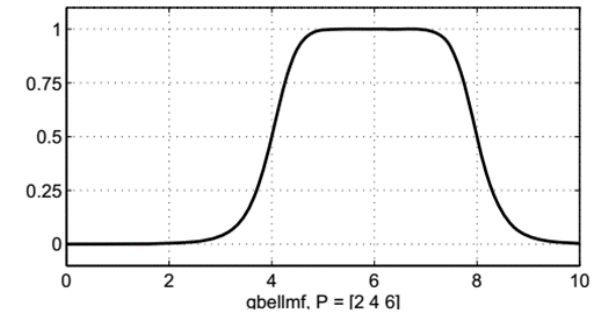
curves. Similar to them is the function of belonging of type "bell" defined by three parameters (Fig. 1).



(a)

(b)





(c)

Fig.1 Graphical description of the functions of belonging to the Gaussian distribution - plain (a) combination (b) and type "bell" (c).

The degree of membership of an object to the structure of fuzzy membership functions is determined by the value of membership ranging from zero to one. Thus the membership function associated with a fuzzy set of inputs, is used to position the output value in the corresponding area of the membership.

Mamdani's method is commonly used method for decision-making with fuzzy logic [8]. The method is based on the classic staging of Lotfi A. Zadeh [9, 10]. In Mamdani the output membership functions are expected to be fuzzy sets. After a merging of the different results is necessary fuzzy set for each output variable to be converted to a number.

To form a final decision in recognition system proposed in this thesis was chosen method of Mamdani. This method is preferable to the method of Sugeno because the demand system for decision making with fuzzy logic and the specifics of outcomes in identifying, are corresponding with the characteristics of this method.

The aggregation function for the results is selected to be one that would seek the maximum value in each membership function to the input fuzzy variables.

Given that demand maximum similarity to a reference model is characteristic for each of the built and trained neural networks function is selected to form the final result the type "largest of maximum" as a defuzzification. The Described parameters of demand system for decision making with fuzzy logic are applied in the implementation of fuzzy logic summarizing the results of the neural networks.

The system is built with the tools of Matlab and is depicted in Fig. 2.

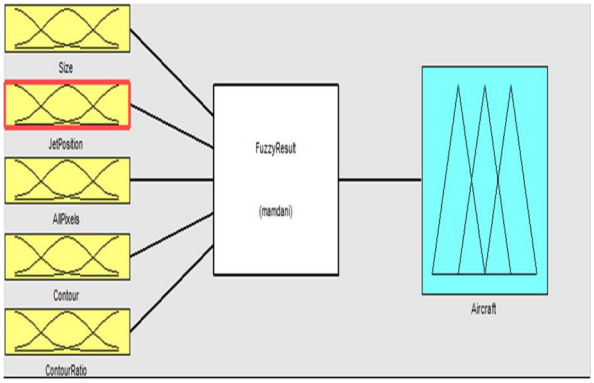


Fig. 2. Block diagram of the system for decision making by means of the Mamdani method, built in Matlab.

The input variables on the left side of the system are five corresponding to each of the five neural networks used to classify the object in the resulting image of ISAR. Each of these input variables is made of such membership functions as are the classes of the outputs of the neural network. The output variable is a synthesis of all the rules applied to the input variables and is the object of recognition that best satisfied these fuzzy rules.

The chosen shape of the curve membership function to each fuzzy set is Gaussian combination membership function. The results of the first neural network should fall within three fuzzy sets defined by the functions of belonging in the range of 0 to 3, as sectors 0-1, 1-2 and 2-3 are distributed in the same sequence as the output values of the first neural network (small, middle and big). The specific form of these functions is tailor made to take maximum space in the range 0-3 to fall into the fuzzy sets higher percentage results from the input value. The shape responds to the need with the increase of the coefficient of similarity between the subject and a reference model (object size) to increase the degree of belonging to the elements of the fuzzy set (Fig. 3).

Similar are the parameters of input variable for the results of the second neural network, analyzing the position of engine for the object of recognition, because here the neural network result is designed to have three values again. For input variable with the

result of the recognition of the object in his thick silhouette 16 fuzzy sets are created corresponding to the number of reference solid models in the third neural network.

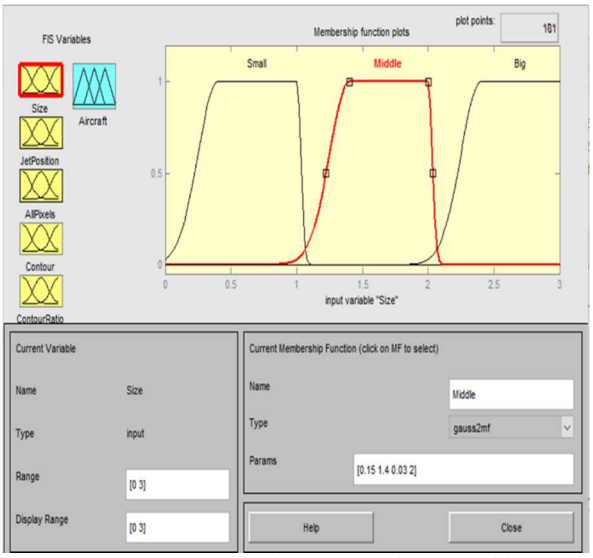


Fig. 3. Graphical expression of membership functions of fuzzy sets corresponding to the size of the object.

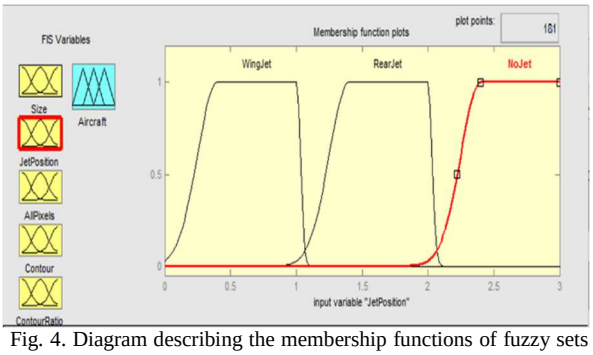


Fig. 4. Diagram describing the membership functions of fuzzy sets corresponding to the variation in position of the engine, result of neural network.

The same logic is applied with Gaussian combination membership function and spaces with a maximum surface area, respectively, membership functions results in ranges 0-1 on the outcome of the first reference model, 1-2 - the second, etc. filling the interval 0-16 (Fig. 5).

Analogous is the structure of input variables corresponding to the result for contour of the object and the result for the contour ratio comparison produced from the dedicated neural networks four and five. In this scientific work they are not described in detail.

The output fuzzy variable is made up of fuzzy sets, broken again in the range 0-16, given the objects in the database that seek similarities to object recognition. The membership functions with the Gaussian distribution of type "bell" are aimed to summarize at maximum the results of the input variables, classified by the rules. Membership functions for the fuzzy sets of the output variable are shown in Fig. 6. The particular form aims to distinguish in maximum the membership functions of each model for comparison. The shape is consistent with the selected function to summarize the results that is formed by the maximum value in each membership function of the input fuzzy variables.

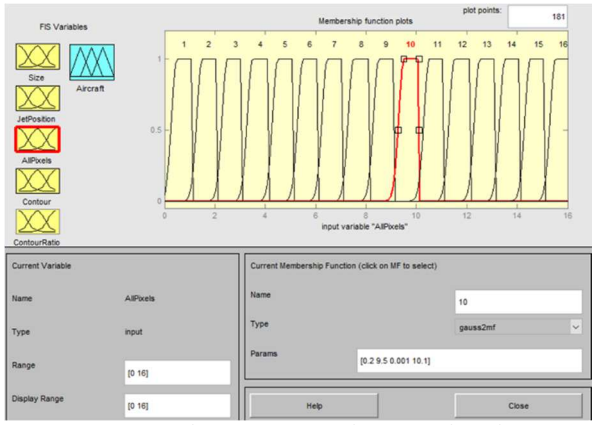


Fig. 5. Diagram of the membership functions of the fuzzy sets corresponding to each solid etalon model and the number of result values of the third neural network.

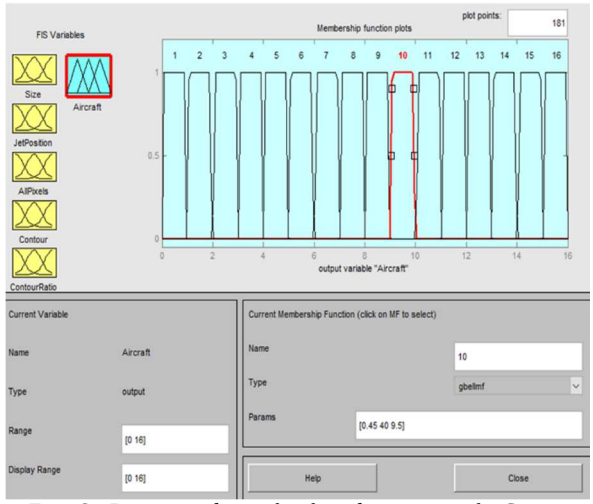


Fig. 6. Diagram of membership functions with Gaussian distribution type "bell" fuzzy sets of the output variable corresponding to the number of reference models used for object recognition in various indicators.

The set of rules necessary for the operation of the system is composed of 32 rules divided into 2 groups, the weight of every rule of the groups is equal to one.

For the first set of rules for each reference model are selected functions of fuzzy sets of input variables that describe it in its relevant characteristics (size, engine position, solid shape, contour, the number of matched pixels to the total number of pixels for the outline model) as described classes at the output of each of the neural networks. The operation used for the various fuzzy sets which are obtained for each criterion for comparison is a logical "AND" to reflect the intersection of these fuzzy sets and to comply thus with the result of each neural network. Rules are 16 in number and one of them is used for example:

(1.) *(Size==“big“) ∩ (Jet possition==“wing“) ∩ (Solid shape==“C-130 H“) ∩ (Contour==“C-130 H“) ∩ (ContourRatio==“C-130 H“) =>* ***(Object==“C-130 H“)***

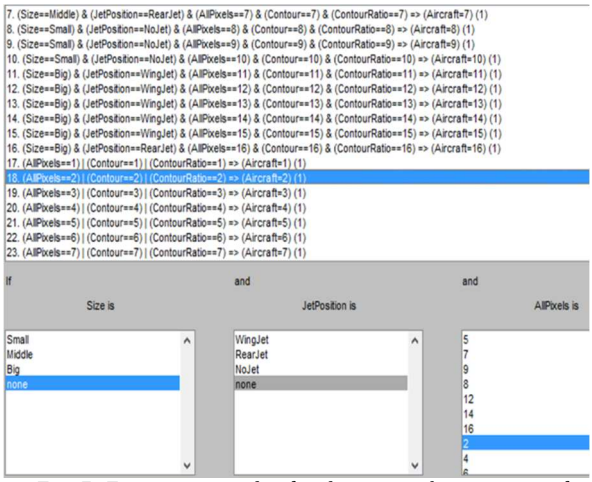


Fig. 7. Fuzzy system rules for decision making process of a system with fuzzy logic simulated in Matlab.

The second group of 16 rules are designed to treat the results of neural networks that specify the similarity of objects with specific reference model, i.e. these are three neural networks (Solid shape, Contour and ContourRatio). In the rules the logical operator "OR" is used for operation between the selected fuzzy sets, thereby to address potential similarities of objects with different reference models in various indicators of comparison (Fig.7). According the description, the set of 16 rules adopted in that group can be explained, with the example:

(2.) *(Solid shape == “Rafale“) ∪ (Contour ==“ Rafale“) ∪ (ContourRatio ==“ Rafale“) => =>****(Object ==“ Rafale“)***

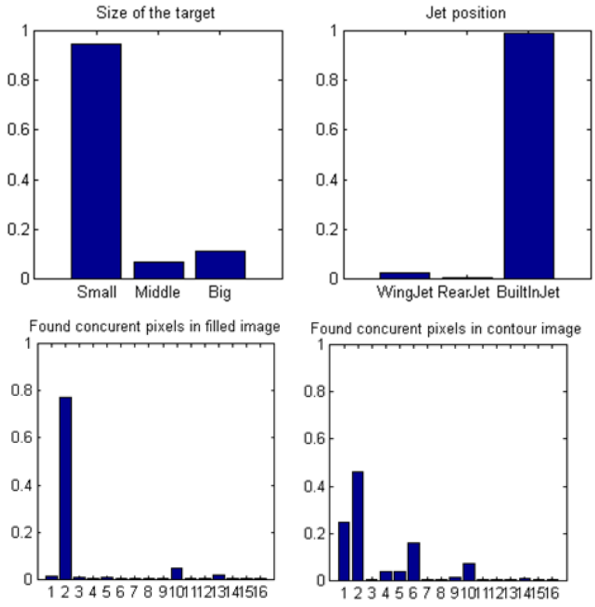
The described fuzzy inference system is aimed to summarize the results of five neural networks that have output variables of different nature, to put the fastest result as a digital value corresponding to the combination of degrees of matching the object of recognition with the different reference models.

III. RESULTS AND DISCUSSION

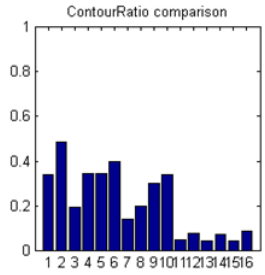
Numerical experimental results of observed object classification by neural networks and deciding upon its recognition using fuzzy logic.

The results of numerical simulation experiment of observation with reference model aircraft Rafale is described on Fig. 8 as follows:

- In section (a) is illustrated the neural networks operation;
- In section (b) is is depicted the result of decision making process with fuzzy inference system (FIS), the

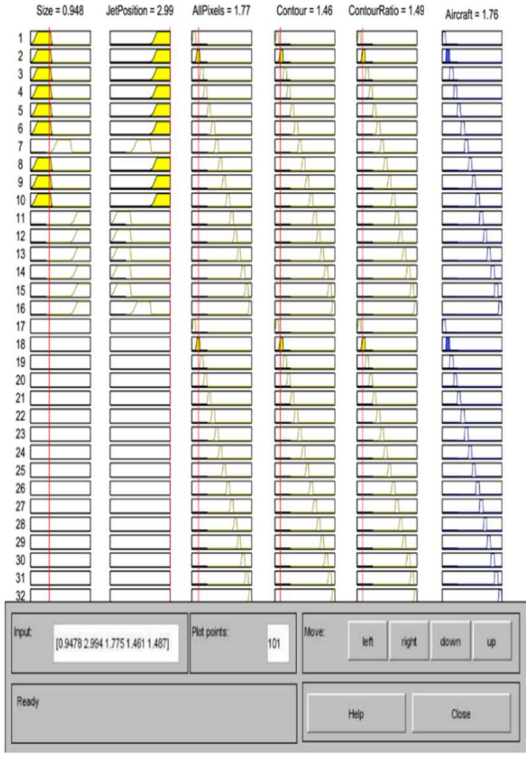


(a)



(b)

Fig.8. Graphically expressed results of the procedure for recognition. Score 1.76 (b) is connected to the output variable with the number 2. The object in that case is recognized as the plane Rafale.



entrance to it is presented with the five neural networks results as a fuzzy sets and the value of the parameter Aircraft is used to describe the number corresponding to the FIS decision - 1.76 The result is related to the output variable with this number. The object is recognized as the aircraft Rafale.

IV. CONCLUSION

A system for deciding fuzzy aimed to summarize the results of all neural networks in accordance with a system of logical rules is established. The membership sunctions of all input variables, are used to formulate a reasoned conclusion, despite the different nature of their dimensions. One of the problems inherent in the operation of neural networks is permitted, they are able to produce a satisfactory result, but not to formulate a conclusion. Flexible approach in formulating decisions is of particular importance in mind the possible application of the developed recognition system.

By the implementation of the combination of rules for the operation of the system with fuzzy logic the computational burden in making the final decision is reduced and the rapid adaptation to changes in the composition and nature of neural networks is allowed. The system can be used for image recognition obtained in the radar operating on the principle of inverse aperture synthesis.

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Land Cover Classification Based On MODIS Imagery Data Using Artificial Neural Networks

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Abstract. Remote sensing has been widely used to obtain land cover information using automated classification. Land cover is a measure of what is overlaying the surface of the earth. Accurate mapping of land cover on a regional scale is useful in such fields as precision agriculture or forest management and is one of the most important applications in remote sensing. In this study, multispectral MODIS Terra NDVI images and an artificial neural network (ANN) were used in land cover classification. Artificial neural network is a computing tool that is designed to simulate the way the human brain analyzes and process information. Artificial neural networks are one of the commonly applied machine learning algorithm, and they have become popular in the analysis of remotely sensed data, particularly in classification or feature extraction from image data more accurately than conventional method. This paper focuses on an automated classification system based on a pattern recognition neural network. Variational mode decomposition method is used as an image data pre-processing tool in this classification system. The result of this study will be land cover map.

Keywords: Artificial Neural Networks, Normalized Difference Vegetation Index, Pattern Recognition, Variational Mode Decomposition.

I. INTRODUCTION

Agricultural and forest resource mapping, in which land cover classification is an important element, is mostly performed with remote sensing data. Land cover is the physical and biological cover at the surface of the earth [1]. Examples of land cover classes include water, snow, grassland, forest, scrubland, wetland, asphalt and bare soil. Traditional methods of land cover mapping have been limited to field surveys that are time-consuming and uneconomical with data collected over long time intervals [2]. Remote sensing has been a worthwhile source of information over last three decades in mapping land cover because remotely sensed data have a large geographic coverage, short revisit periods over the same point on Earth and good image quality. It is more economical and faster technique compared to traditional methods of land cover mapping. Remote sensing can be used to obtain land cover information using manual interpretation or automated classification techniques. Usually, the pixels of the remote sensing image are grouped into meaningful and homogeneous land cover classes using digital image classification. Digital image classification is the process where each pixel is assigned the value of land cover class. The objective is to classify each pixel into only one class [2].

Temporal-related features are important for improving land cover classification accuracy using remote sensing data [3]. Vegetation indices calculated from satellite images can be used to obtain information associated with land cover. Vegetation indices is some combination of spectral bands designed to take out a particular property of vegetation [4]. The normalized difference vegetation index (NDVI) is developed for estimating vegetation cover from the red and near infrared band of satellite data. The NDVI is an indicator, which quantifies the amount of green vegetation. The NDVI index is calculated by:

$$NDVI = \frac{NIR - R}{NIR + R}, \quad (1)$$

where *NIR* represents the spectral reflectance value (i.e. digital number) in near infrared band and *R* represents the spectral reflectance value in red band. Greener and dense vegetation has low red light reflectance values and high near infrared reflectance values, and therefore high NDVI values. The NDVI values are scaled between minus one and plus one, where higher positive values are corresponding to greener vegetation, but low positive values and negative values are corresponding to non-vegetated surface features such as water, barren land, rock, ice, snow, clouds or artificial materials [5].

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This paper explores capabilities of using feature extraction method - variational mode decomposition (VMD) to decompose NDVI images. VMD is an enhanced version of the empirical mode decomposition (EMD) algorithm for analyzing non-linear and non-stationary signals, including two-dimensional signals. It adaptively decomposes the signal, e.g. image, into a set of band-limited oscillations called modes of separate spectral bands [6]. These modes or sub-signals can be used as features to make classification using some artificial intelligence or statistical classification technique. In this paper was used artificial intelligence method - pattern recognition neural network. The artificial neural network is distribution-free method that have many advantages in classification tasks including possibility to process complex, noisy, non-linear and non-stationary data [7]. Artificial neural networks are very good at pattern recognition problems and with enough neurons can classify any data with arbitrary accuracy.

II. MATERIALS AND METHODS

A. Study Area

The study site is a Ventspils Municipality that is located in the western part of Courland, Latvia. Its total area is 2472 km2 (Fig. 1). The region plays an important role in agricultural and forest management in Latvia.

Fig. 1. Ventspils Municipality in orange color.

The climate in the study site is determined by temperate climate zone with significant maritime features. Approximately half of the area of Ventspils Municipality is covered by forests, and the other half is covered by grasslands.

B. NDVI Data Set

Multi-temporal, smoothed, geometric and radiometric corrected MODIS Terra NDVI image was used with spatial resolution 250 m and temporal resolution 7 days (Fig. 2). Image was taken in July 2016.

Fig. 2. MODIS Terra NDVI image from this study.

Ground truth data were obtained from The Latvian Geospatial Information Agency. These data include land cover samples in Ventspils Municiplaity.

C. Variational Mode Decomposition

Variational mode decomposition method (VMD) non-recursively decomposes a multi-component signal *f(t)* into various band-limited monocomponent signals or intrinsic mode functions $u_k(t)$ using calculus of variation [8]. Each mode is regarded as an amplitude-modulated and frequency-modulated (AM-FM) signal and is assumed to have compact frequency support around a central frequency ω_k [9]. VMD tries to find out these central frequencies and intrinsic mode functions centered on those frequencies concurrently using an optimization methodology called alternate direction method of multipliers (ADMM). The original formulation of the optimization problem is continuous in time domain. The constrained variational problem is the following:

$$\min_{u_k,\omega_k} = \{\sum_k \left\| \partial_t \left[\left(\delta(t) + \frac{j}{\pi t} \right) * u_k(t) \right] * e^{-j\omega_k t} \right\|_2^2 \}, \quad (2)$$
$$s.t. \sum_k u_k(t) = f(t)$$

where t is a time, j is an imaginary number, e is an exponent, π is a constant (3.14159) and ∂_t is a derivative at time t.

To evaluate the bandwidth of the modes, first the associated analytic signal by means of the Hilbert transform u_k^H is calculated to obtain a unilateral frequency spectrum for each mode. The frequency spectrum of this signal is one sided (exist only for positive frequency) and assumed to be centered on ω_k. The frequency spectrum of each mode (*k-th* mode) is shifted to the baseband (origin) by multiplying with an exponential and signal now is centered at origin:

$$u_k^M(t) = (u_k(t) + j u_k^H(t)) e^{-j\omega_k t}. \quad (3)$$

The integral of the square of the time derivative (or Gaussian smoothness) of this (3) signal is a measure of bandwidth of the intrinsic mode function.

All the modes can be obtained in the frequency domain. First, Fourier transform is used to obtain original signal in frequency (spectral) domain. In frequency domain at *n+1* iteration *k-th* mode is obtained:

$$\hat{u}_k^{n+1}(\omega) = \frac{\hat{f}(\omega) - \sum_{i \neq k} \hat{u}_i(\omega) + \hat{\lambda}^n(\omega)/2}{1 + 2\alpha(\omega - \omega_k)^2}. \quad (4)$$

The term in (4):

$$\hat{f}(\omega) - \sum_{i \neq k} \hat{u}_i(\omega) \quad (5)$$

is a result of Wiener filtering, which makes VMD method robust to noise, and α is the balancing parameter of the data fidelity (bandwidth) constraint. At *n+1* iteration *k-th* mode central frequency is updated by:

$$\omega_k^{n+1} = \frac{\int_0^\infty \omega |\hat{u}_k(\omega)|^2 \, d\omega}{\int_0^\infty |\hat{u}_k(\omega)|^2 \, d\omega}. \quad (6)$$

Dual ascent for all $\omega \geq 0$ at *n+1* iteration is obtained:

$$\hat{\lambda}^{n+1}(\omega) = \hat{\lambda}^n(\omega) + \tau(\hat{f}(\omega) - \sum_k \hat{u}_k^{n+1}(\omega)). \quad (7)$$

Iterations continues until convergence:

$$\sum_k \left\| \hat{u}_k^{n+1}(\omega) - \hat{u}_k^n(\omega) \right\|_2^2 / \left\| \hat{u}_k^k(\omega) \right\|_2^2 < \varepsilon, \quad (8)$$

where ε is some small number – convergence criterion. When all modes are obtained in frequency domain, inverse Fourier transform can be used to obtain these modes in time domain.

D. Artificial Neural Networks

Artificial neural networks (ANNs) are a form of artificial intelligence, is an information-processing paradigm that inspired by biological nervous systems, such as the brain [10]. ANNs are one of accurate and widely used classification models. Structure of artificial neural networks makes them valuable for a classification task with good accuracy. Artificial neural networks are self-adaptive methods that learn from data [11]. Neural networks learn from examples and can find functional relationships between the data even if relationships are unknown or the physical meaning is not clear [10]. Therefore, ANNs are well suited for classification problems, whose solutions are difficult to obtain, but for which there are enough data or observations.

Artificial neural networks can generalize. After learning from the input data (a sample or pattern), ANNs can often correctly process the early unseen sample even if the sample data are noisy. Neural networks are less sensitive to noise better than most other methods.

Pattern recognition neural network is a feedforward neural network that is based on multilayer perceptron. It consists of three or more neuron layers: one input layer, one output layer and one or more hidden layers (Fig. 3). In most cases, a network with only one hidden layer is used to limit calculation time, especially when the results obtained are satisfactory. All the neurons of each layer (except the neurons of the output layer) are connected by an axon to each neuron of the next layer [12].

An individual neuron receives weighted inputs from previous layers, which are summed in each neuron using a combination function. The result of this combined summation is passed through a transfer function to produce the output of the neuron.

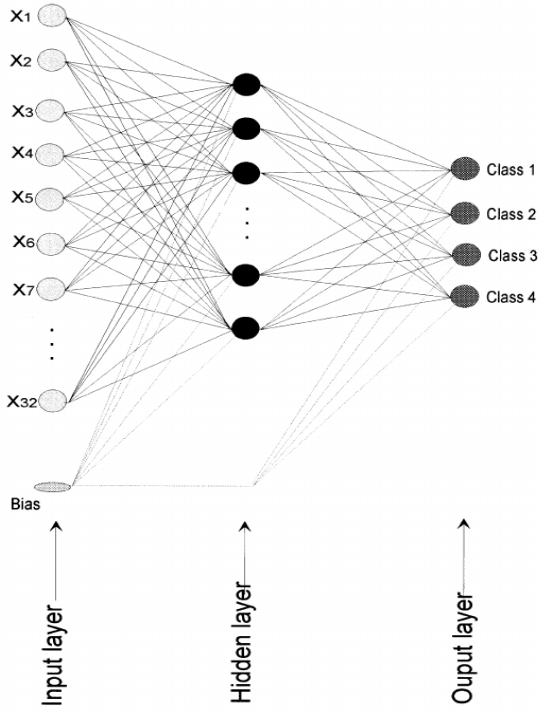


Fig. 3. Multilayer perceptron with one hidden layer.

The combination function and transfer function together constitute the activation function. The most widely used activation function for the output layer in classification task is the softmax function. The softmax function, or normalized exponential function is a generalization of the logistic function that normalize a *K*-dimensional vector *z* of arbitrary real values to a *K*-dimensional vector of real values *σ(z)* in the range (0, 1) where sum of all values (probabilities) is 1. The softmax activation function is given by**:**

$$\sigma(z)_j = \frac{e^{z_j}}{\sum_{k=1}^K e^{z_k}}, \; j = 1, ..., K, \quad (9)$$

where *K* is the number of classes.

The sigmoid (logistic) and exponential (hyperbolic) tangent functions are often used as the hidden layer transfer function. To improve the accuracy of the neural network, each data point (each feature) in the input neurons needs to be normalized – rescaled within the range of [−1, 1] or [0, 1]. The multilayer perceptron is trained with error-correction

learning, which means that the desired response (class value) for the system must be known.

To train a neuron with several input variables, $x_1,x_2,\ldots$, corresponding weights $w_1,w_2,\ldots$, and a bias, b the cross-entropy cost (performance) function in case of multi-class classification task for this neuron is defined as [12]:

$$C = -\frac{1}{n}\sum_x \left[y \ln \sigma(z)_j \right], \qquad (10)$$

where n is the number of samples in training data, x is the sum over all training samples, and y is the corresponding desired output (observed class). The function returns a result that strongly penalizes outputs that are extremely inaccurate, with very little penalty for completely correct classifications. Minimizing cross-entropy leads to good classifiers.

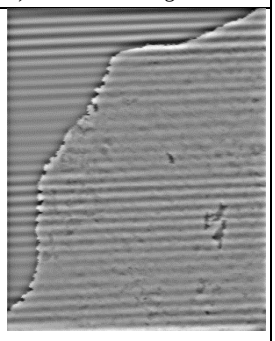
III. EXPERIMENTAL PROCEDURE

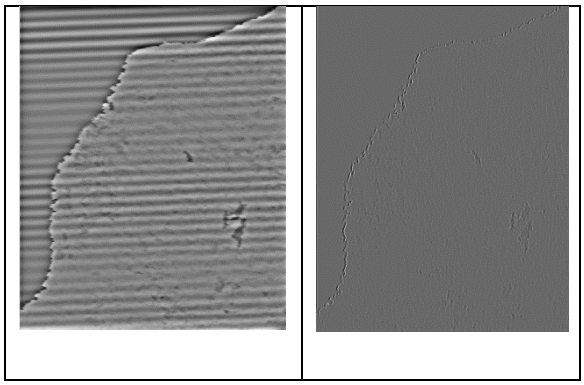
The aim of this experiment is to investigate the capability and accuracy of pattern recognition neural networks in the land cover classification task. In the first stage features were extracted from NDVI image using bi-dimensional variational mode decomposition method The second stage employed pattern recognition neural network for multi-class classification.

A. Feature Extraction

Bi-dimensional variational mode decomposition method was applied to the original NDVI image in order to obtain K sub-images. First, in order to obtain K value, non-parametric bi-dimensional empirical mode decomposition method was applied, that automatically give optimal number of modes. It give K value four. Then with known number of modes, variational mode decomposition was applied with following parameters: number of modes K was four, dual ascent time step τ was 0.1, and convergence criterion was 1e-7. Optimal bandwidth constraint α was found using error-and-trial approach, and it was 4.1. Grater or smaller α lead to modes, the sum of which do not reconstruct original image. Obtained sub-images are given in Table I.

Table I
Extracted sub-images

a) first sub-image	b) second sub-image
	
c) third sub-image	d) fourth sub-image



B. Multi-class classification

For each land cover sample in vector map that is located in Ventspils Municipality, corresponding median values calculated from pixel values of original NDVI image and four sub-images were found and input data set for pattern recognition neural network was created. This data set was divided into two sets, training and testing data set by rate 70/30. 70% of the samples (488 samples) were used as a training data set, 30% of the samples (210 samples) were used as a testing data set. Five classes were used: grassland (class 1), forest (class 2), scrubland (class 3), wetland (class 4) and water (class 5).

Pattern recognition neural network (PRNN) model used in this study was trained by scaled conjugate gradient backpropagation training function. Neural network's weights and biases were initialized with small random numbers in [-0.25, 0.25]. The number of network's hidden layers was one. The hyperbolic tangent function and the softmax function are used as activation functions for the hidden and output layers, respectively. The number of epochs that are used to train was set to 10000. As the number of hidden neurons is an important factor that determining the classification accuracy, is required to find an optimal value, but there is currently no theory to determine how many nodes in the hidden layer are optimal. The optimal complexity of PRNN model, that is, the number of hidden nodes, was determined by a trial-and-error approach. In the present study, the number of hidden nodes was progressively increased from 1 to 5. In order to improve neural network generalization ability early stopping technique was used. When the network begins to overfit the data, the global error on the validation set typically begins to rise. When the validation error increased for a 100 epochs in a row, the training was stopped, and the weights and biases at the minimum of the validation error were used. This neural network's configuration was determined experimentally as giving the best results. A program code was written in MATLAB environment. Overall accuracy and confusion matrix were used as measures of correctness in order to determine proposed PRNN model accuracy.

C. Results and Discussion

In this study was found, that optimal number of neurons in hidden layer is five. Optimal PRNN topology is shown in Fig. 4.

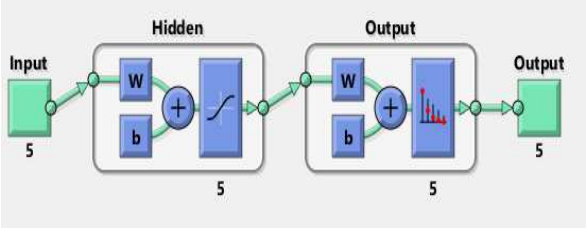


Fig. 4. Optimal PRNN topology.

Using optimal PRNN architecture, overall accuracy was 70.49% for training data. Confusion matrix for training data is given in Table II.

Table II
Confusion matrix for training data set

		Actual				
		1	**2**	**3**	**4**	**5**
Predicted	**1**	157	40	34	2	4
	2	51	187	11	0	2
	3	0	0	0	0	0
	4	0	0	0	0	0
	5	0	0	0	0	0

For testing data overall accuracy was 76.66%. Confusion matrix for testing data is given in Table III.

Table III
Confusion matrix for testing data set

		Actual				
		1	**2**	**3**	**4**	**5**
Predicted	**1**	90	18	11	0	1
	2	15	71	3	0	1
	3	0	0	0	0	0
	4	0	0	0	0	0
	5	0	0	0	0	0

Obtained overall accuracy for testing data is satisfactory, and this classification model can be used for land cover classification. Grassland and forest are well disjoined, but scrubland, wetland and water are not separated. NDVI is a good indicator to separate vegetation from non-vegetations, but it is difficult to separate different vegetation types. But pixels with water cover after NDVI image smoothing were mixed up with vegetation in this study and were not clear. If only NDVI values are used as features, then obtained overall accuracy was 66.66%. It show that the variational mode decomposition method can help improve classification accuracy. In this study, improvement in overall accuracy was from 66.66% to 76.66% for testing data.

IV. CONCLUSIONS

In this paper classification of the land cover classes over Ventspils Municipality in Courland, Latvia is obtained, using pattern recognition neural network (PRNN). NDVI is an important variable for land cover classification, but extracted features from NDVI image using bi-dimensional variational mode decomposition (VMD) method can help further improve classification accuracy. Artificial Neural Networks (ANN) are computational models with good generalization ability that are widely used for classification tasks. Using optimal PRNN architecture and VMD method as data pre-processing technique, overall accuracy was 76.66% on the test data. While without VMD method, overall accuracy was 66.66%. Therefore, the study concludes that the classification abilities of PRNN in combination with VMD provides a potentially very useful scheme for land cover classification.

V. ACCKNOWLEDGEMENTS

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Fault Trees and Belief Networks in Risk Modelling: A Comparative Analysis

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Abstract. Nowadays, an ever-growing complexity of technical systems can be observed worldwide, problems of rational use of nature resources and diminution in negative impact on the environment are not completely settled yet, and international competition in different areas is strengthening. All the above tendencies cause an increase of different risks: technical, ecological, political, military and financial. Due to their nature, most of the risks are caused by a set of factors with commonly unknown relationships. Therefore, the need to use risk modelling methods that enable visual representation of the sets of cause-risk relationships becomes evident. This paper briefly examines two widely used techniques of modelling risky situations: fault trees and belief networks, and provides their comparative analysis.

Keywords: fault tree, logic OR gate, logic AND gate, belief network, fault tree transformation, hybrid risk assessment.

I. INTRODUCTION

Humans have always appreciated having the possibility of representing, evaluating and analysing risky situations. Probability theory, for example, has appeared to meet the needs of evaluating players chances in risky situations. Nowadays, probability theory is a developed field of science that is widely and successfully used in diverse areas of human activity including risk assessment and analysis.

Any risk can be assessed using two components: probability of occurrence of a risky situation and the losses it might cause. When analysing this kind of situations, one has to account for many interrelated random factors (events) that might result in the occurrence of the top event related to unfavourable consequences.

To clearly represent numerous risk factors and correlations among them, visual approaches to modelling risky situations are necessary. In this paper, two widely used techniques of this kind are considered: fault trees and belief networks.

II. FAULT TREES

The idea of fault trees was first proposed by the Bell Telephone Company for the purposes of US Air Force. In [1], the following description of the technique is provided: "Fault trees are a graphic "model" of the pathways in a system that might lead to a predictable undesirable event related to losses. Numerical probabilities of occurrence can be included and propagated through the model so as to evaluate the probability of the predictable undesirable event".

Risk analysis using fault trees comprises [1]:

- graphical representation of chains of events/conditions leading to the unfavourable event;
- identification of potential fault contributors that are critical;
- better understanding of system characteristics;
- qualitative/quantitative understanding of the probability of the unfavourable event selected for analysis;
- identification of resources aimed at failure prevention;
- manual for redeploying resources to optimise control of risk;
- documentation of the results of analysis.

Let us consider some common principles of fault tree construction using an example. Fig. 1 shows a sample fault tree.

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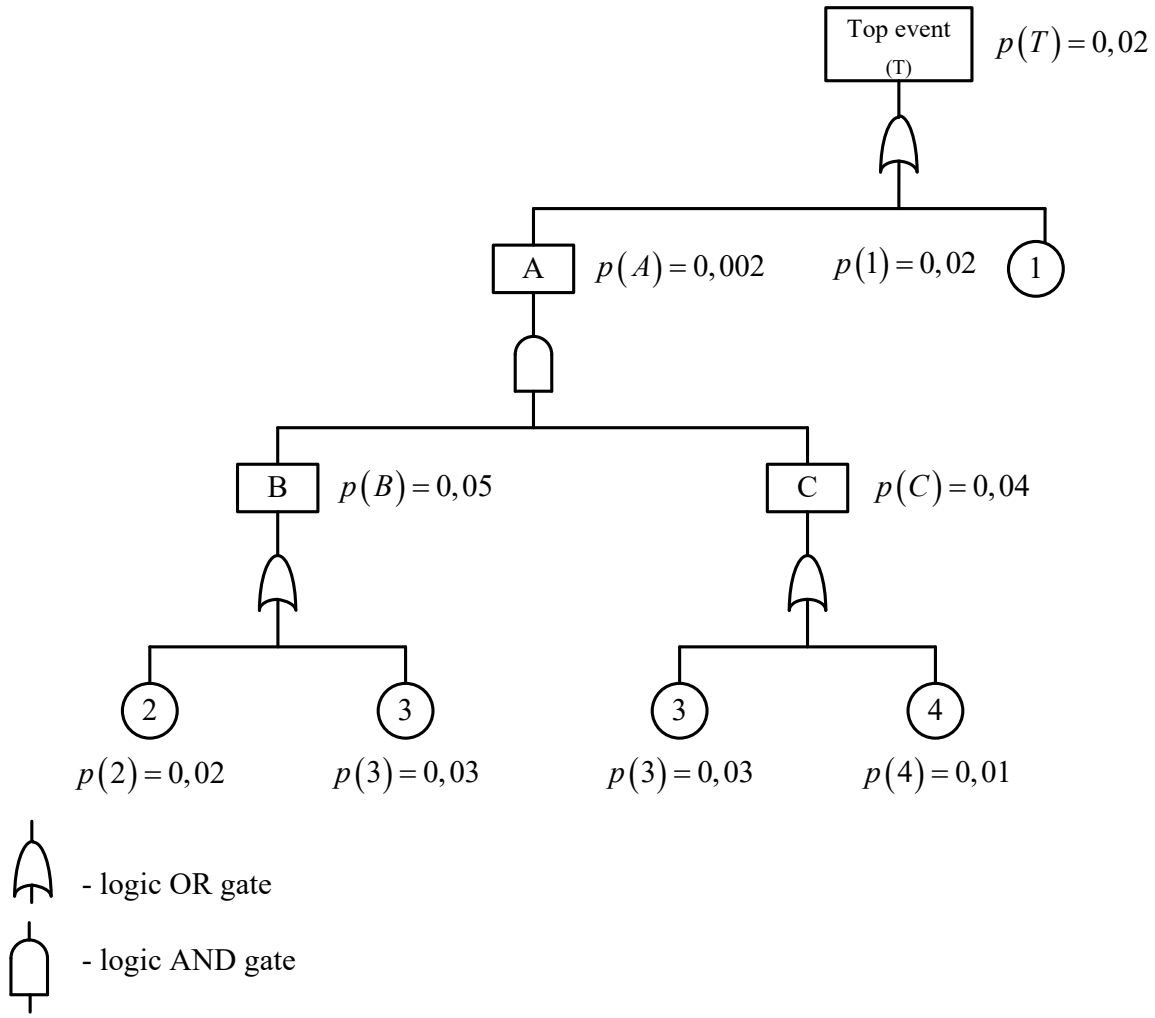

Fig. 1. Sample fault tree

In Fig. 1, nodes 1, 2, 3 and 4 represent basic events – failures of real elements of the system. Logic OR and AND gates between the nodes of events represent conditions of event occurrence in the intermediate nodes at the outputs of those logic gates. For example, an event in the intermediate node B will occur if basic event 2 *or* basic event 3 occurs; an event in the intermediate node A will occur if an event in the intermediate node B *and* in the intermediate node C occurs. To construct fault trees, other logic gates can also be used, but gates OR and AND are basic.

If an intermediate node A has got n predecessors connected with by logic gate AND, then the probability of event occurrence in that node is calculated as follows:

$$p(A)=\prod_{i=1}^{n} p(i) \tag{1}$$

where $p(i)$ - probability of event occurrence in the i-th predecessor node.

In its turn, if some intermediate node A has got n predecessors connected with it by logic gate OR, then the probability of event occurrence in that node is calculated as

$$p(A)=\prod_{i=1}^{n}\left(1-\left(1-p(i)\right)\right) \tag{2}$$

where $p(i)$ - probability of event occurrence in the i-th predecessor node

The fault tree shown in Fig. 1 depicts initial probabilities of basic events and the calculated values of the intermediate events and of the top event T.

III. BELIEF NETWORKS

Belief networks are a singly-connected graph whose each node represents the complete group of random events. Quite frequently, alternative names for the belief networks are also used, e.g. bayesian networks, bayesian belief networks, causal networks etc. A fragment of a sample belief network is given in Fig. 2.

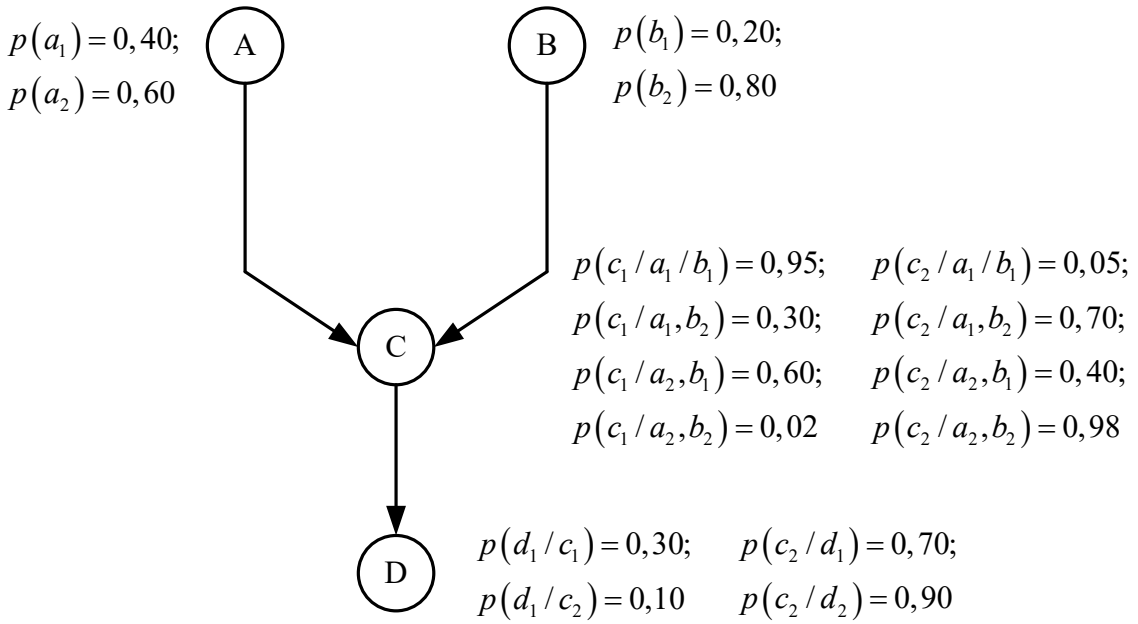

Fig. 2. A fragment of a sample belief network

Here each node represents two random events. Nodes A and B do not have any predecessors. In Fig. 2, these nodes are supplemented with matrices of unconditional probabilities of occurrence of the events connected with them.

Node C has two direct predecessors, namely, nodes A and B. In Fig. 2 that node is supplemented with matrices of unconditional probabilities of occurrence of events c_1 and c_2 for all possible combinations of events in nodes A and B.

Node D has a single direct predecessor, node C. In Fig. 2 the node is supplemented with matrices of unconditional probabilities of occurrence of events d_1 and d_2 provided that events c_1 and c_2 have occurred.

The task of probabilistic inference in belief network is formulated as determination of occurrence probabilities for the events that are of interest to us using all the information accumulated in the network. For example, for the fragment of belief network in Fig. 2, the task can be to calculate the prior probabilities of occurrence of events d_1 and d_2 based on the information about event occurrence probabilities in nodes A, B and C. Provided that an event has occurred in some node of the network, one can calculate the posterior probabilities of events in all nodes of the network.

A great deal of both accurate and approximate algorithms for probabilistic inference in belief networks have been proposed. The most common algorithm is described in [2]. More details about the algorithm can be found in [3] - [5]. The essence of the method is as follows. Special λ - and π -evaluations are propagated through the nodes of the network. After these nodes have received evaluations from other nodes, the prior values of event probabilities of the nodes are calculated in sequence. If an event has occurred in a certain node of the network, the initial evaluations are recalculated. Special λ - and π - evaluations are then forwarded in sequence to the nodes of the network and the posterior probabilities of events in all nodes of the network are calculated in sequence.

Belief networks are widely used to model risks in complex multi-aspect situations. Some examples of their use are provided in [6]- [11].

IV. POSSIBILITIES OF TRANSFORMING FAULT TREES INTO BELIEF NETWORKS

Fault tree technique has several important points:

(a) Events in all nodes of the tree are binary events;
(b) The events are statistically independent of each other;
(c) The trees represent logic relationships between the events.

A characteristic feature of belief network is that the probabilities of event occurrence in network nodes are either unconditional or stipulated by the events in the predecessor nodes of relevant nodes.

From that simple analysis it directly follows that different aspects of the knowledge necessary for successful risk modelling and analysis are encoded by means of fault trees and belief networks. So it seems attractive to combine the advantages of both techniques. One possible way to realise that idea is to transform fault trees into equivalent belief networks and then, using the obtained network representation, to apply the procedures that are in principle impossible for fault trees.

This paper employs the algorithm for fault trees transformation into belief networks presented in [12]. Simplistically, the algorithm consists in the execution of these procedures:

1. For each terminate node in the fault tree, a root node is created in the belief network.
2. For the output of every logic gate in the fault tree, a corresponding node in the belief network is created.
3. For each node in the belief network corresponding to the logic gate in the fault tree, a table of conditional probabilities is made where the probabilities characterize the states in successor node depending on the states in predecessor nodes.

Fig. 3 shows a belief network obtained through the transformation of the fault tree depicted in Fig. 1. The nodes of that network corresponding to the outputs of logic gates in the fault tree, are supplemented with matrices of conditional probabilities. However, these matrices are not equivalent to the matrices of conditional probabilities in the standard belief network. In those new matrices there are presented probabilities of states t (failures of the respective elements) depending on the states of elements mapped by predecessor nodes. These probabilities can only have two values: 0 and 1. To explicitly show the difference of these conditional probabilities from common conditional probabilities, we denote the first probabilities by symbol q.

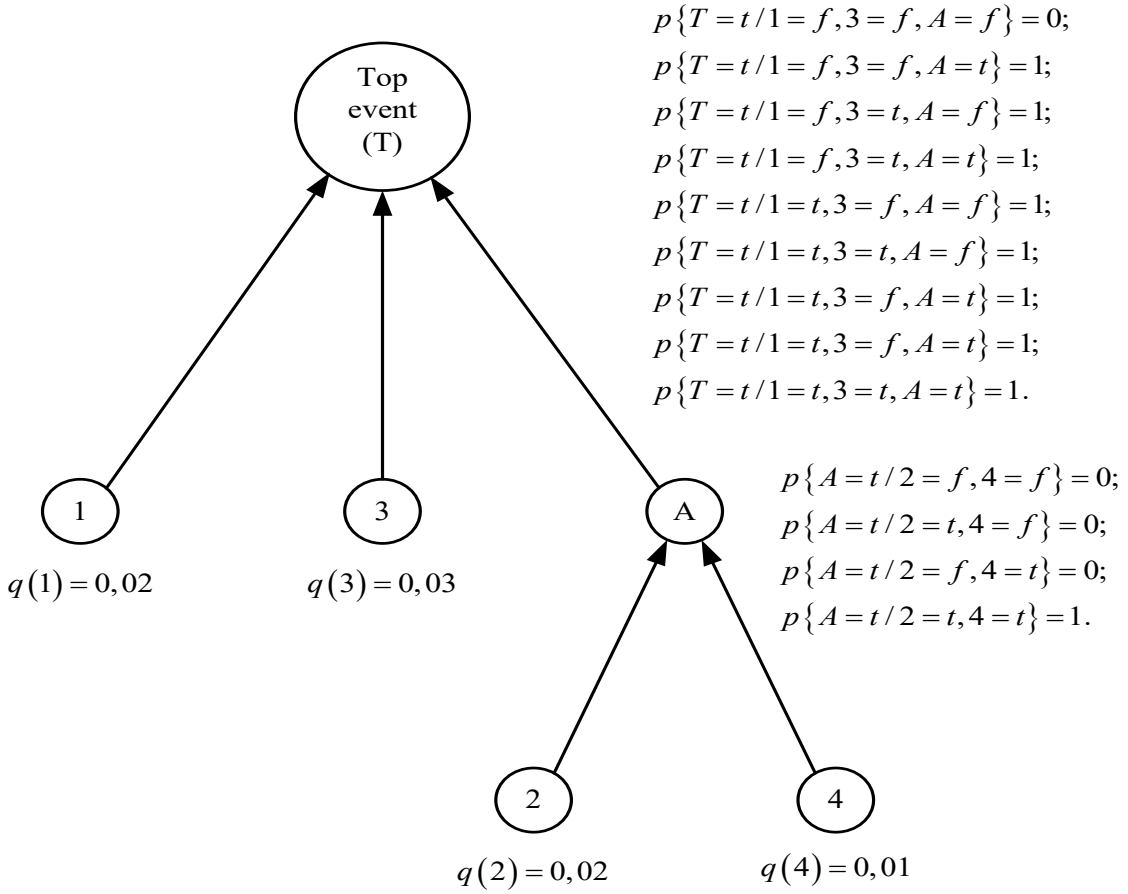

Fig.3. Belief network obtained through the transformation of the fault tree shown in Fig.1

Unfortunately, standard algorithms of probability distribution cannot be applied in the belief networks obtained through the transformation of the corresponding fault trees. For that purpose, algorithms for probability distribution in fault trees can be used taking into account the specifics of the transformed logic relations.

At a glance, it seems that fault tree transformation into equivalent belief network does not ensure any advantages. That statement can only be true for the transformation of standard fault trees. Some situations of that kind are discussed in [12]. Belief networks enable modelling the situations that cannot in principle be modelled by fault trees. Suppose that an intermediate node A in

the belief network is connected with its predecessors by a logic AND gate (Fig. 4). Let us also assume that the element corresponding to that node can be damaged due to some exterior reason (not known a priori) when other elements represented by nodes 1 and 2 are functioning properly. A situation like that cannot in principle be modelled with the help

of the fault tree; though it can be fairly simply modelled by means of the belief network. In Fig. 4, specifically, in the matrix of conditional probabilities of node A, instead of zero values of probabilities corresponding to the proper functioning of elements in nodes 1 and 2, there is written the value of probability q of element A damage due to some implicit external reason.

Another example is the so-called noisy-OR gate. Let us have a look at Fig. 5. Let us assume that elements 1 and 2 can be damaged as a result of improper actions of the service staff. Here, the nature of the damage is such that the corresponding element continues keeping some extent of work capacity while element in node A continues to work properly.

Such chances of maintaining work capacity of element A at the time when work capacity of element 1 or element 2 is partly damaged, can sufficiently easily be modelled with the help of a belief network: in the matrix of conditional probabilities of node A there are written corresponding values of probabilities q_1 and q_2 instead of 1.

Different points of fault trees transformation into belief networks are also considered in [13]-[16].

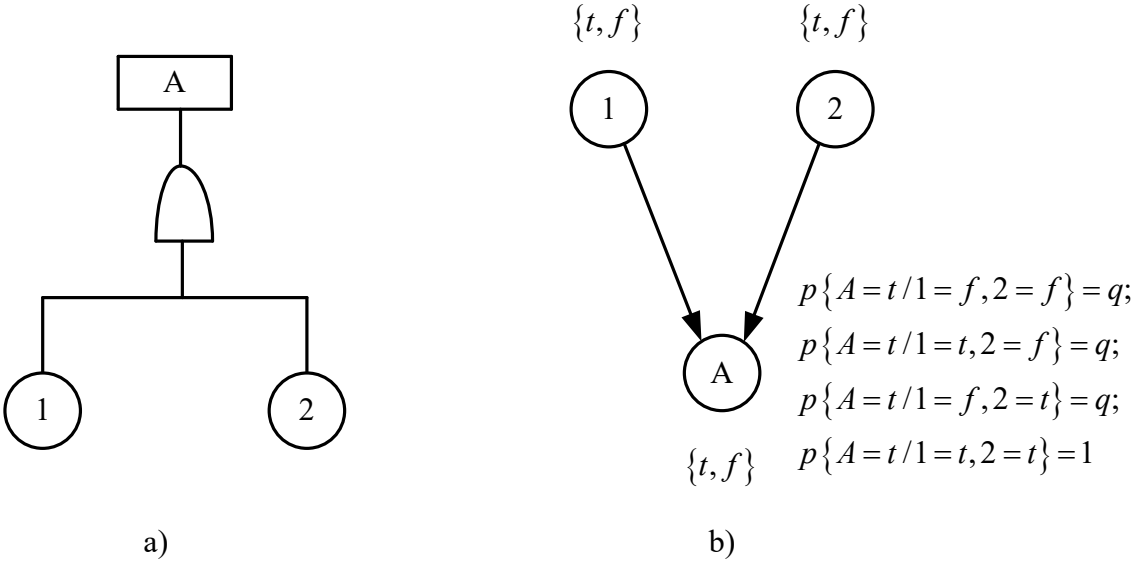

Fig. 4. Graphical representation of the phenomenon of common reason of failure with the help of a fragment of belief network

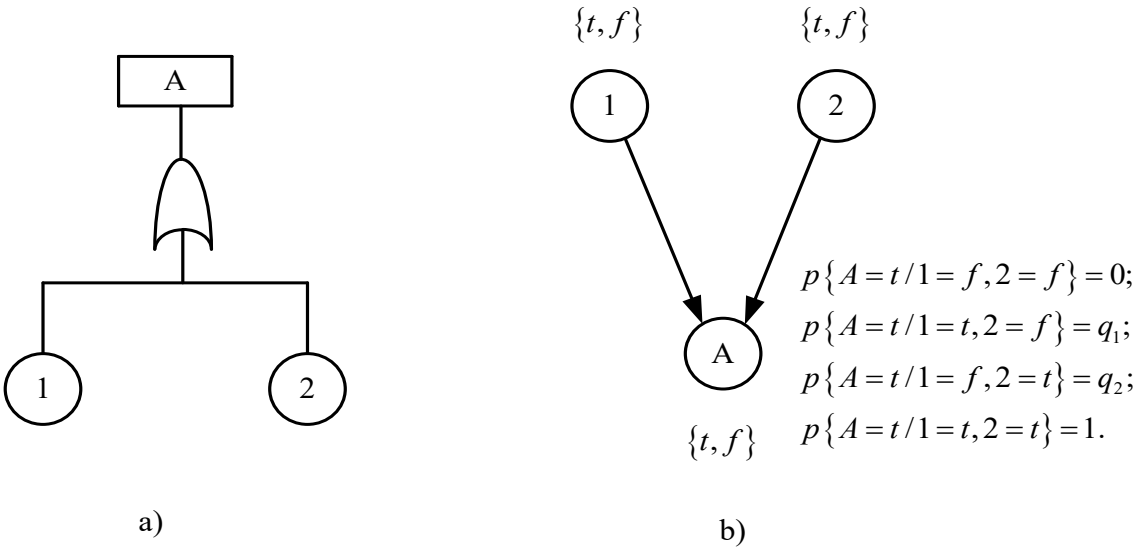

Fig. 5. Graphical representation of the noisy-OR gate by means of a fragment of belief network

Good results have been shown by joint modelling of risks with the help of belief networks and fault trees. In [8], [9] a hybrid approach to modelling risks in socio-technical systems is proposed. Socio-technical system is a system that comprises a technical part (say, manufacturing) and management and organisational parts. Besides that, the system has to take into account both the impact of the

surrounding environment on the system and the impact of the system on the environment. The authors propose to model all possible factors of risk and their correlations at the management and organisational levels using belief networks and to model risk factors and their correlations in the technical part of the system by means of fault trees. This kind of modelling enables successful incorporation of the advantages of both approaches.

V.CONCLUSIONS

Fault trees and belief networks are widely used to model and analyse different kind of risks. Fault trees enable a visual representation of all events leading to the occurrence of an unfavourable basic event and of logic connections between them. They however fail in modelling non-standard risky situations.

Belief networks are the most appropriate tool for modelling qualitative relations among the factors (events). The edges in the graph of belief network explicitly represent probabilistic relationships among the events. Provided that a certain event (events) has occurred in the network, probabilities of other events can be recalculated using a formal algorithm.

Belief networks perfectly suit modelling risks in complicated situations [6], [7] and in complex socio-technical systems [8], [9]. Good results have also been produced by the joint use of fault trees and belief networks.

Both fault trees and belief networks require a large amount of initial information. That does not cause any problem if sufficient statistical data are available. However, when expert evaluation of relevant probabilities is performed, it is more preferable to employ fuzzy probabilistic evaluations and use fuzzy versions of the algorithms for probability propagation through fault trees and belief networks.

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Intelligent Methods for Attestation of Scientific and Teaching Staff. Rasch Model

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Abstract. Introduced in many universities quality management systems suggest the development of appropriate technologies for the assessment of learning results. Unfortunately, some of the real tasks remain outside the scope of the systems due to complexity, non-formalization, unawareness or lack of adequate mathematical models, software and more. Such is the task of attestation of the research and teaching staff, which is being periodically solved in universities. The work proposed model for the formalization of the problem of attestation of scientific and pedagogical staff, based on an adapted version of the one-parameter Rasch model for dichotomic data. The model allows software implementation and help to reduce the subjectivism in evaluating the performance of teachers in universities.

Keywords: attestation of personnel, attestation of scientific-pedagogical staff, one-parameter Rasch model.

I. INTRODUCTION

The world is witnessing the modernization in the field of education related to implementation of information technologies at all stages of the educational process. Implementation of quality management systems education in higher education implies the development of adequate technologies for the modelling and assessment of learning results.

Unfortunately, some of the real tasks remain outside the scope of the systems due to complexity, nonformalization, multicriteria, unawareness or lack of adequate mathematical models, software and more. Attestation is essential and controllable parameter of the educational process. Developing procedures for objective evaluation of the teaching work and ranking of scientific and teaching staff allows for the development of personnel potential, improvement of quality control and compliance with European standards.

Because of these reasons, the development of methods of formalization and models for decision making with objective measurement and evaluation of results of scientific and teaching activity is an important task that after the development of the model and the experiment can be embedded in the quality management system.

II. OBJECTIVES, AND RESEARCH METHODOLOGY DESIGN

Attestation is performed in order to determine compliance of research workers to their positions on the basis of an assessment of their professional activity.

Attestation of personnel is a "systematic procedure to be formally assessed according to the criteria of conformity of the employee's standards of performance in the workplace in this position for a certain period of time" [1].

Attestation is intended to promote the rational use of educational and creative potential of researchers; to improve their professional level; optimization of preparation, selection and appointment of personnel, the possibility of choice in the changes of conditions of remuneration of researchers; strengthening the role of the moral and material interest.

The purpose of attestation is to define the individual ratings and ranking teachers in the structural units of the organization in accordance with their rating.

The rating of a teacher is an individual numeric indicator of the results of scientific and teaching activity of the teacher, obtained by summing ratings on individual criteria. Intuitively it is clear that the criteria are not of the same weight, so it is advisable to introduce weight coefficients of criteria based on expert opinion.

The rating system of evaluation of teachers has clear advantages, some of which are:

- Allows for a quantitative characteristic of the creative and educational potential of the teacher;
- Reduces subjectivity and the role of random factors in the final evaluation;
- Gives you the opportunity to create standards for evaluation;
- Promotes adherence to the same for all conditions to assess;
- Promotes competition in departments;
- Allows differentiation of teachers in accordance with their achievements;

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- Gives the opportunity to diagnose features of the teaching process;
- Allows for the development of software systems monitoring of the scientific and teaching work;
- Allows the accumulation of statistical data and statistical results;
- Promotes adherence to the ethical requirements.

The purpose of this paper is the formalization of the problem and the development of a method of decision making when attestation of scientific and pedagogical workers is performed, to reduce subjectivity and to automate the process.

A.Analysis of the decision-making process for the assessment of scientific and pedagogical staff

Attestation of scientific-teaching staff is carried out periodically in accordance with predetermined criteria. Universities develop specific Regulations for attestation, which are available on their websites [2], [3]. Because research-teaching activities have common characteristics, Regulations of various universities differ insignificantly [4]. Criteria for assessing and ranking personnel are similar.

Attestation of the teaching staff for research units is carried out by a special Commission, head of Department, and sometimes from teachers themselves on the basis of specific criteria.

Analyzing the thought process of the expert in the decision-making process for the evaluation of the teaching staff, can draw some conclusions related to the nature of this process.

Analysis of the decision-making process for the assessment of scientific and pedagogical staff shows that:

- The selection of criteria is carried out by experts and is highly dependent on their experience, professionalism and competence;
- In real problems the criteria are set linguistically. The process of interpretation is accompanied by inaccuracies, ambiguity, due to the subjective interpretation of the experts;
- Examination and ranking of scientific-pedagogical personnel produced by the fuzzy relations between evaluations by fuzzy criteria specified in the linguistic scales;
- In the process of ranking resources it is necessary to substitute the vector assessment by a scalar one by means of convolution of quantitative or qualitative assessment on the basis of preset criteria.

From this it follows that the task of evaluation of the teaching staff belongs to the class of multi-criteria, non-formalized tasks. The decision-making process is characterized by subjectivity, which does not allow to apply the well-known classical methods and theory model of decision making and management. Therefore, to formalize and to solve this problem, it is appropriate to use the Rasch model, which allows modelling the process of decision making and convolution of multi-criteria evaluation in the numerical rating.

B.Formalization of the problem of evaluation of the scientific and teaching staff

Assume that the latent variable <teacher's efficiency> is evaluated. For its assessment we use criteria that represent the latent variables of the lower rank, which are easier to evaluate.

Let's:

D = discrete (for example: {bad, good, excellent}, {meets the criteria, does not meet the criteria}, {0, 1} etc.) or continuous (in intervals, e.g. [0, 1], [1, 10] etc.) set of diagnosis;

$P = \{p_1, p_2, ... p_k\}$ is the discrete set of teachers subject to attestation;

$C = \{C_1, C_2, ...C_m\}$ is the discrete set of expert-defined evaluation criteria;

$A = \|a_{ij}\|$, i=1,2, ... n, j=1,2,...m is the matrix containing the assessment results; $a_{ij} \in L_j$ - assessment of teacher by i expert in accordance with the criterion C_j;

L_j – discrete or continuous scale of assessments according to the C_j- criterion, j = 1, 2, … m;

In practice, for estimating, the easiest method is to use the same scale for assessment according to different criteria, i.e. $L_1 = L_2 = ... = L_n = L$, for example in a dichotomic scale L = {Yes, No} ≡ {0,1}.

For best adequacy to the linguistic model of the decision-making process for the evaluation of the teaching staff it is possible to consider it as a problem of diagnostics of the form <P, C, L, A, D> with the following formulation: for each teacher $p_i \in P$, to determine the diagnosis $d \in D$ on the basis of results A by criteria C defined in the scale L.

Formally, this means to find an injective map

$\Omega: P \rightarrow D$

of a set of personnel, subject to certification to the diagnosis set D in which each element $pi \in P$ is matched to exactly one element $d \in D$.

To obtain Ω we will apply the Rasch model for dichotomous data.

C.Modification of one-parameter Rasch model for calculating the teachers rating

The Rasch model is designed to assess test results. It establishes the correspondence between monitored test results and two sets of latent (hidden, immeasurable directly) properties associated with the difficulty of test and the preparation of students [5].

For the application of the Rasch model, we assume that the professional activity of the teacher and complexity of criteria are evaluation parameters, which allow for an objective assessment. This assumption is not contrary to actual practice, which is confirmed by the following considerations:

- One criterion is more complex than another if the probability of meeting it is smaller, regardless of the teacher, which is estimated;

- A more effective teacher will meet more fully the criteria with arbitrary complexity, compared to the more ineffective one;
- The more effective the teacher is, the higher he will be evaluated, regardless of the Commission
- The same teacher will be evaluated in roughly equal measure from different (but equal in competence) Commissions;
- One and the same Attestation Commission will evaluate higher the highly effective teacher and lower the less effective one;
- Repeated evaluation of different teachers from different commissions may differ because of unavoidable measurement errors, but not due to the differences in competences of the Commissions.

Paraphrasing the Rasch model, we can assume that the probability P that a tutor with the efficiency of S to satisfy the criterion of complexity T gives the formula:

$$P(S,T) = \frac{S}{S+T} \qquad (1)$$

The function P(S, T) is called the success function, and the variables S and T are latent variables. If we introduce the following notation:

A = LN(S), S = EXP(A)

B = LN(T), T = EXP(B)

for P we get:

$$P(S,T) = \frac{EXP(A)}{EXP(A)+EXP(B)} = \frac{1}{1+EXP(B-A)} \qquad (2)$$

The resulting equation is called the basic logistic model of Rasch. Formula (2) shows that the probability of success depends only on the difference B - A, for which the Rasch model is one-parameter. The model parameters A and B characterize the effectiveness of the teacher and the complexity of the criteria and are measured in logit. If A = B = 1 logit, P = 0.5, what semantically means that the probability a standard teacher will meet the standard criteria - 0.5. If the effectiveness of a teacher is very much higher than the complexity of the criteria ($B - A \rightarrow -\infty$), the probability of satisfaction $P \rightarrow 1$. In the case that the effectiveness of a teacher is far less than the degree of difficulty of the criteria ($B - A \rightarrow \infty$), the probability of satisfaction $P \rightarrow 0$.

D. Choice of criteria

We expect to evaluate teachers' rating by pre-selected criteria (indicator variables), which are grouped into categories, with different weights. Correct use of the Rasch model requires that the criteria meet the following requirements:

- Transparency – the criteria should be clear and understandable to teachers and experts;
- Unambiguousness - reduce the possibility of subjective interpretation, the use of unitary assessment {Yes, No};
- Criteria are simple, without logical connections "and, or, not" and without complications due to the use of modifiers, qualificators and quantificators;
- Different criteria do not depend on each other;
- Expert evaluations are independent from each other;
- One-dimension of space – the criteria selected in such a way that they measure the same variable, namely the quality of the teachers work. Analysis of the results of the practical use of Rasch models in the evaluation of the results of the test exams in the United States and Russia [4], shows that this is one of the requirements which are difficult to meet;
- Different criteria must have a high discriminatory ability, which is achieved due to the location of their increasing complexity. This assumes that the teacher who met the requirement of this criterion (received a score of 1) very likely has satisfied all previous, relatively lighter criteria. And vice versa, if they have not satisfied this criterion, the probability to satisfy the next is very small. Most criteria used in practice do not satisfy this requirement, regardless of the lengthy pre-selection and experiments. Evaluation of the discrimination ability of criteria can be achieved only after their practical use.
- All criteria are divided into categories;
- Criteria from different categories affect differently the formulation of final evaluation, i.e. we are aware of the presence of weights, which can be selected by expert assessments.
-

III. RESULTS AND DISCUSSION

To demonstrate the operability of the Rasch model to calculate the rating of the teaching staff, an Excel spreadsheet (Table I) is used [6]. The rating of a particular teacher we calculate in the following order:

1. Each member of the Commission (expert) assesses a given teacher by pre-selected criteria in the dichotomic scale L = {0, 1}. As a result of expert evaluation, we obtain A matrix with the dimensions n x m (n is the number of experts, m is the number of criteria) and the elements a_{ij} equal to 1 if the teacher satisfied the requirements of the j-th criterion, and zero otherwise.
2. We calculate the primary ball b_i, i = 1, 2, ... n of the tutor, obtained from the estimation of the i-th expert. Primary ball we call the sum of the matrix elements in the rows modified by the weight of the criteria.
3. Calculate the parameters p_i , i=1, 2, ...n by the formula:

$$p_i = \frac{b_i}{maximalball} \quad (3)$$

4. Ignore the extreme ball in the following way:
   - if $b_i = 0$, set $p_i = \varepsilon$;
   - if b_i is equal to the max ball, set $p_i = 1 - \varepsilon$,

where ε is a small enough number, for example ε = 0,001.

5. The initial approximation of the effectiveness of the teacher according to the assessment of the i-th expert we determine by the formula:

$$A_i = LN\left(\frac{p_i}{1-p_i}\right), i = 1,2,...n \quad (4)$$

6. We calculate the primary ball c_j, j = 1, 2, ... m of the criteria, obtained by adding the grades in the columns modified by the weight of the criteria.

Table I
Attestation of scientific and pedagogical staff. Rasch model

Criteria / Attestation Commission	A set of criteria 1 weight=1						A set of criteria 2 weight=2				A set of criteria 3 weight=2						A set of criteria 4 weight=3							A set of criteria 5 weight=3			Primary ball bi	p_i	Ai = LN(pi/(1-pi)) in logits	Criteria complexity
Criteria (Rating indicator)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26				
Expert 1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	0	0	1	1	0	0	1	0	0	1	0	0	29	0,408	-0,37037	
Expert 2	1	1	1	1	0	1	1	1	1	0	1	1	0	0	0	1	1	0	1	1	1	0	1	0	0	0	32	0,451	-0,19783	
Expert 3	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	40	0,563	0,25489	
Expert 4	1	1	0	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	40	0,563	0,25489	
Expert 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	53	0,746	1,07992	
Primary ball cj	5	5	4	4	4	4	8	8	8	8	6	10	8	8	6	8	15	12	12	9	12	6	6	9	9	0				
p_j	0,999	0,999	0,800	0,800	0,800	0,800	0,800	0,800	0,800	0,800	0,600	0,999	0,800	0,800	0,600	0,800	0,999	0,800	0,800	0,600	0,800	0,400	0,400	0,600	0,600	0,001				
B_j=LN((1-p_j) p_j) in logits	-6,907	-6,907	-1,386	-1,386	-1,386	-1,386	-1,386	-1,386	-1,386	-1,386	-0,405	-6,907	-1,386	-1,386	-0,405	-1,386	-6,907	-1,386	-1,386	-0,405	-1,386	0,405	0,405	-0,405	-0,405	6,907				-0,582321
Teachers' rating																													0,20430	

7. Calculate p_j , j=1, 2, …m by the formula:

$$p_j = \frac{c_j}{maximal\ ball} \quad (5)$$

If $c_j = 0$, set $p_j = \varepsilon$; if c_j is equal to the max ball, set $p_j = 1 - \varepsilon$.

8. Calculate the initial values of the criteria complexity by the formula:

$$B_j = LN\left(\frac{1-p_j}{p_j}\right), j = 1,2,...m \quad (6)$$

9. Find average values:

$$\overline{A} = \frac{1}{n}\sum_{i=1}^{n} A_i \text{ (Teachers' rating)} \quad (7)$$

$$\overline{B} = \frac{1}{m}\sum_{j=1}^{m} B_j \text{ (Criteria complexity)} \quad (8)$$

This can be used as initial approximations of teachers' rating and criteria complexity.

The table above demonstrates the calculations. The data used are examples.

As the table shows, the estimates are in the range from -6.907 to 6.907 with an accuracy of five decimal places. Criteria complexity is -0.582321 and teachers' rating is 0.20430.

Thus it is possible to evaluate and rank all teachers.

IV. CONCLUSION

The one-parameter Rasch model can be used to assess the scientific and teaching staff in the universities. The results are obtained in logits. No need to be transformed to a different scale, as ranking of the teaching staff may be made on the basis of evaluation in logits.

The nonlinearity of the model encourages good teachers and punishes the inefficient ones, which corresponds to the mind-set of the University leadership.

Practical use of the Rasch model is accompanied by many difficulties arising from its probabilistic character, and can lead to misinterpretation of results. The difficulties are associated with the fulfilment of all necessary conditions for the application of the model rather than its software implementation [7].

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Gold - Section in Interactive User Interface Development

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Abstract. The days when only specialists worked with programs and the functionality was the most important have long passed. In today's competitive environment, an important marketing component is reliability in which the only tangible part of the program, the interface, plays a large role. Purely psychological, it is important for the users' visibility, correctness and can even be argued, friendliness. This is determined by the elements of visibility and components' location in intuitively expected places, design integrity, tone and choice of characteristic elements which, together, create a feeling of sympathy or antipathy from the software user. Regularities, which ultimately determine the user's subconscious reactions, are found in natural formations - from the most basic proportions of plants to more sophisticated self-arranged compositions.

The harmony of the structures of natural systems, that is, their internal organization, is subject to certain mathematical laws. Objective world stable stationary states corresponding to particular figures, called generalized Golen Ratios. These figures are all the structure of the invariant, which are embodied by the dialectic structure of the world and the different variations that can be observed at every step of nature. It is important to note that with the generalized Golden Ratio, not only is the well-known ratio of 1:1,618 understood, but a whole line of relationships, where like in music, a single major or minor note can be played, and another can stand out from the whole ensemble.

The main applications of the Goden Ratio in interface design are space division, caption-font size ratios, restrictive areas (buttons), title queue length, color tone saturation ratio, and cell location coordinates.

In this paper, we propose certain recomendations for the development of a user - friendly interface. These recommendations suggest uses in the software developer training process for non-design specialty students; target group - programmers, computer specialists, and IT project managers. The article does not address the development of graphic design tools and their functionality.

Keywords: golden ratio, design, interface, computer software.

I. INTRODUCTION

An important role in modern software development is making an easy, readable user interface. Occasionally, its attractiveness is the exact cause of a potential customer's choice in favor of one or other competing software products. As with any visual design object, the interface has parallel functional properties - input / output, the operations to be carried out and explanatory elements. It also has a purely decorative property, a design that has a unified style that generally is attractive and gives an easy readable feeling to the user.

The days when only specialists worked with programs and the functionality was the most important have long passed. In today's competitive environment, an important marketing component is reliability in which the only tangible part of the program, the interface, plays a large role. Purely psychological, it is important for the users' visibility, correctness and can even be argued, friendliness. This is determined by the elements of visibility and components' location in intuitively expected places, design integrity, tone and choice of characteristic elements which, together, create a feeling of sympathy or antipathy from the software user. Regularities, which ultimately determine the user's subconscious reactions, are found in natural formations - from the most basic proportions of plants to more sophisticated self-arranged compositions.

The main applications of the Golden Ratio in interface design are space division, caption font size ratio restrictive areas (buttons), filling the title queue length, color tone saturation ratio, and cell location coordinates.

II. MATERIALS AND METHODS

Golden Ratio– historical size/value ratio

The Golden Ratio, or "split of harmonious parts" has been known from antiquity. It has its origins in the written form associated with Euclid (around 300 BC), however, proof has been found Pythagoras (6th century BC) and even earlier authors [1], [2] used it. A real boom to find relationships began around the 15th century, when they were used in art (see. Figure 1), and architecture.

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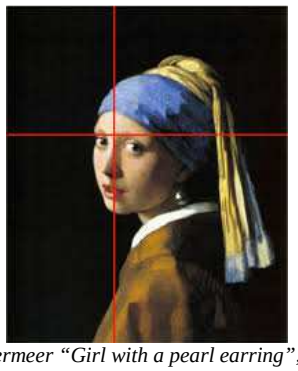

Figure 1. J. Vermeer "Girl with a pearl earring", 1665

Generalized Golden Ratio

The harmony of the structures of natural systems, that is, their internal organization, is subject to certain mathematical laws. Objective world stable stationary states corresponding to particular figures, called generalized gold sections. These figures are all the structure of the invariant, which are embodied by the dialectic structure of the world and the different variations that can be observed at every step of nature. It is important to note that with the generalized Golden Ratio, not only is the well-known ratio of 0.618 understood, but a whole line of relationships, where like in music, a single major or minor note can be played, and another can stand out from the whole ensemble.

The generalized Golden Ratio can be calculated according to the following scheme. Denote the probability of the event with p, in which case, the complement up to 1 will be $(1-p)$, describing the event default probability. To express the amount of information, we take the logarithms of the above values, and denote the relationship of this logarithms with k:

$$k = \frac{\log(1-p)}{\log p},$$

where from,

$$\log(1-p) = k \log p,$$

which in turn, we obtain [3]:

$$p^k + p - 1 = 0.$$

The set of resulting solutions of the equation is shown in Table 1.

Table 1.
Generalized Golden Ratio Examples

k	p	1-p
1	0,5000	0,5000
2	0,6180	0,3820
3	0,6823	0,3177
4	0,7245	0,2755
5	0,7549	0,2451
6	0,7781	0,2219
7	0,7965	0,2035
8	0,8117	0,1883
9	0,8243	0,1757
10	0,8351	0,1649
11	0,8444	0,1556
12	0,8525	0,1475

The following table shows the different ratios with values rising at an exponential rate.

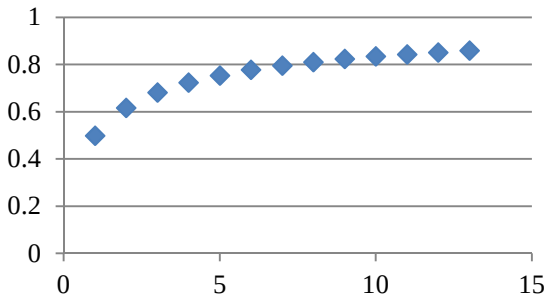

Table 2. Generalized Golden Ratio display

Other generalized Golden Ratio detection methods can be found in the literature [4], [5].

Historically, the ratio applied to $k = 2$ has been often used in architecture and art, and found in living organisms and other natural formations proportions [3], [5]. There is a widespread perception that it exactly mathematically expresses the harmony of natural formations.

Higher-level (rank) proportions, whose conformity with nature's harmony gradually decreases [3], shall be used if the number of cells, their role in the situation, or other considerations does not allow the use of commonly known ratio of 1: 1.618.

Generalized Golden Ratio applications in user interfaces

Graphic user interfaces (GUI) can include the following applications of the generalized Golden Ratio:

- size of an object relative to the total or boundary area,
- object aspect ratio,
- small object, logo, or buttons centre position coordinates,
- phrase and title length ratio (with one or more rows) in relation to the body of the text,
- font size of the different meanings (importance) in the text,
- ratios of colour saturation – both grouping objects (e.g., push-buttons or web-addresses) according to their meaning and, in particular, marking watched/attended; this same ratio can be used when the colour area should be limited on the same tone, but richer colour line.

Mainly it is used to understand the user interface for computer display (screen). But in recent years,

there has been an explosion of smartphone and tablet development. These devices are increasingly being used for games, education, and management of various processes (directly and with the help of Bluetooth technology). Here, too, object placement, size, and proportion design can apply the generalized Golden Ratio (example Fig. 2.).

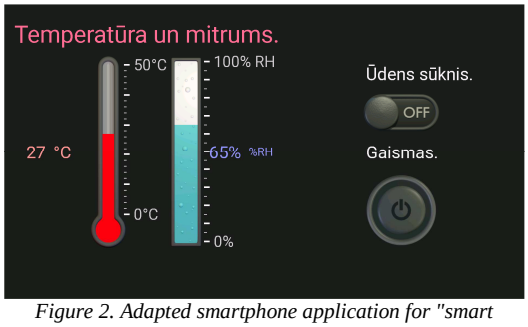

Figure 2. Adapted smartphone application for "smart greenhouses" management. Smartphone screenshot. Author A. Lastenieks.

Some possible inconveniences for the development of smartphones and tablet interfaces are many blanks and that the application does not support the free object layout, but only with fixed steps due to the limited size of the position. Because of their nature, development of smartphones and tablet interfaces require further research.

III. RESULTS AND DISCUSSION

Object position and **object size ratio** are two of the most visible user interface parameters. These can take the forms of square aspect ratio, space, object coordinates in both the vertical and horizontal directions, and distances between the centres of objects.

Modern web-pages are often designed in the form of scrollable columns; in this case, the presentation of the composition forms the column widths. Figure 3 shows a traditional column split with a ratio of 1: 1.62.

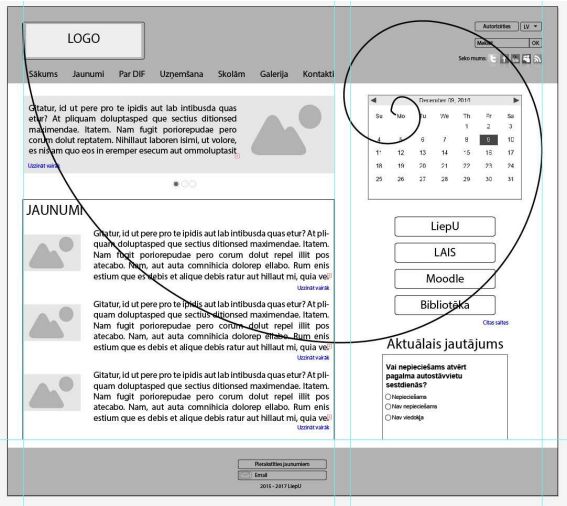

Figure 3. Column split ratio 1:1,62.

It can be seen that the separation is not optimal, because the right-hand column is relatively free with respect to the left-hand column. The page itself (prototype) with split ratio of 1: 1.32 can be seen in Figure 4.

Figure 4. Column split ratio 1:1.32

By contrast, in a multi-column page, it is possible to use mixed divisions where the size of each column down by the generalized golden ratio relationship. Of course, there must first be guided by the amount of information to display along with conceptual and textual meanings (example in Figure 5).

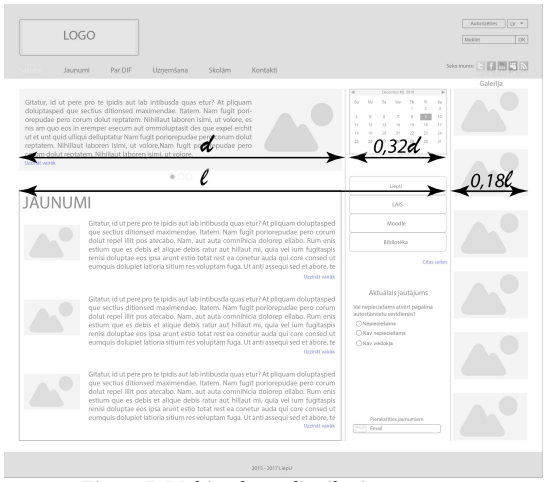

Figure 5. Multi-column distribution.

Colour saturation control is easy to use when working with graphic editors; in which case this parameter is expressed numerically and is easily calculable. The authors do not provide recommendations for keynote colour choice; they are determined by completely different considerations. But often there are cases when the base colour will be applied at different saturation levels (for example, to distinguish a once visited the website address or a pressed push-button). Unfortunately, this paper is

printed in black and white (greyscale) format and therefore, colourful examples are not provided.

The **ratio of font sizes** between the main body and heading will rarely be used in documents whose meaning are determined style or even require certain conditions are met. Generalized Golden Ratio use can rather be found in letters of a private nature or artistic works. Font size is closely related to the **title of the presentation**. Also, in cases where the title font size is limited, the author's text should have a layout of one or more rows to make it one of the generalized Golden Ratio relationships, preferably one in which the overall scene is dominated by the given object. For example, a ratio of 1: 1.22 corresponds to the title of this article.

IV. CONCLUSION

The application of the Generalized Golden Ratio in the development of user interfaces can significantly improve the readability and attractiveness of the products. Secondly, it facilitates the use of the developer's work. Since it is no longer enough that a regular object layout is formed with performance criteria and it is known that often interface developers are not professional designers, learning about the use of the Generalized Golden Ratio can serve as waypoints and assist with the finished presentation. Third, the use of the Generalized Golden Ratio in user interface development can and should be combined with other well-known aspects, such as the base colour corresponding to the product's development theme (business, education, cooking, games, etc.), sequential placement in the active field (confirmation button below or next to on the right of the previously entered information), etc. [6].

We recommend using the following steps for the development of graphical user interfaces:

- identify the functionally necessary interface objects: push buttons, titles, names, links, logos, etc.;
- develop an object grouping principle by the functionality or logical affiliation;
- work out interface areas: in the case of the absence of any other considerations (customer requirements, company documentation, unified style, regulatory provisions, etc.), select the split ratio by the generalized golden section scale, giving priority to the relationship with a lower sequence number (beginning with k = 2) while maintaining a balanced filling density; so the same principles apply different meanings in the text font size, button size and finer object positional relations;
- the changing of the title and text font sizes will necessitate returning to the preceding paragraph.

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Subject Information and Educational Environment as Means of Formation of Information and Communication Competence of Future Professionals

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Abstract. Informatization and unprecedented advances in technology make it necessary to adapt the development of skills in the information society. At present, information and communication competence becomes an urgent need and a prerequisite for the success of future specialists, so it is necessary to increase the efficiency of work, to communicate, to access information and to receive services.

Information and communicative competence of a future expert is a complex formed by the individual qualities that provide flexibility and willingness to change; efficiency of professional work in the conditions of informatization of a modern society in order to acquire information and communicative competence.

Despite numerous studies of the problem connected with the formation of information and communication competence, the actual level of knowledge and skills of graduates of Russian schools in this area is quite low. Therefore the problem of the search tools to more effectively develop the information and communication competence of a future specialist is highly relevant.

Today information educational environment becomes one of the main means of training meeting the requirements of a competence approach. These features are provided by the didactic specificity of methodological support of educational environment, by shifting the emphasis from educational activity of the teacher to the use of active and interactive teaching methods, active and independent cognitive activity of students; orientation in learning not only to the result of training, but also the process of development of new information and applying it to produce results; giving students the freedom of choice of means of implementation of the training task.

Subject information and educational environment can be defined as an open educational system formed on the basis of information of educational resources, computer training facilities, modern means of communication, educational technology which is aimed at the formation of creative, intellectual and social development of the individual.

As the theoretical research and practical experience show, the subject e-learning environment in combination with active and interactive teaching methods, individual and group creative tasks in the context of future professional activity of a specialist is one of the leading factors in the formation of its information and communication competence.

The author describes in detail the stages of the electronic textbook development, as well as web quests in the teaching of philological sciences at the university, and enumerates a number of advantages of their use.

Keywords: Information educational environment, information and communication competence, competence approach, electronic textbook, web-quest.

I. INTRODUCTION

Informatization and unprecedented advances in technology make it necessary to adapt the development of skills in the information society. At present, information and communication competence becomes an urgent need and a prerequisite for the success of future specialists, so it is necessary to increase the efficiency of work, to communicate, to access information and to receive services.

Information and communicative competence of a future expert is a complex formed by the individual qualities that provide flexibility and willingness to change; efficiency of professional work in the conditions of informatization of a modern society in order to acquire information and communicative competence.

The problem of formation of information-communication competence engaged A. Yu. Uvarov [8], E.A. Rakitina [5], A.L. Semenov [6] , E.K. Henner [2], O. Shilov [7], M.B. Lebedev[7]. Despite numerous studies of the problem connected with the formation of information and communication competence, the actual level of knowledge and skills of graduates of Russian schools in this area is quite low. As practice shows test freshmen of the Faculty of preschool and primary education Arzamas branch

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of the Nizhny Novgorod State University, about 75% of the respondents do not own even a necessary level of computer literacy, not to mention the possibility of using information and communication technologies to solve creative problems, the ability to analyze information and its critical evaluation. Therefore the problem of the search tools to more effectively develop the information and communication competence of a future specialist is highly relevant.

The structure of the information-communication competence actively studied, but remains open. As an example, a list compiled by E.A. Rakitina [5, p. 5], including: expertise in the field of cognitive activity; competence in the field of communication activity; technological competence and expertise in the field of social activities.

These competencies can be taken as a basis of information and communication competence of pedagogical high school graduate, but, in our opinion, should be expanded and supplemented by professional and creative competence.

Under the professional and creative component of the information and communication competence we mean the willingness to solve the "creative" professional work tasks with the use of modern information technologies.

Go to the competence model of education, due to the demands of the modern labor market, it requires a qualitatively new methods and means of training to obtain the necessary educational outcomes.

Today one of the main means of training which meets the requirements of competence approach becomes informational educational environment. These features are provided by the didactic specificity of methodological support of the information educational environment, by shifting the emphasis from teaching activity of the teacher on the use of active and interactive teaching methods, active and independent cognitive activity of students, orientation, learning not only the result of training, but also on the process of development of new information and its application to obtain a result of activities; Giving students the freedom of choice of means of implementation of the training task.

Subject information and educational environment can be defined as an open educational system formed on the basis of information of educational resources, computer training facilities, modern means of communication, educational technology, and aimed at the formation of creative, intellectual and social development of the individual [10].

As the theoretical research and practical experience, the subject e-learning environment in combination with active and interactive teaching methods, individual and group creative tasks in the context of future professional activity of a specialist is one of the leading factors in the formation of its information and communication competence.

II. MATERIALS AND METHODS

Experience in the use of subject information and educational system for training under the program "Information and communication technologies in primary education" in Arzamas branch of the Nizhny Novgorod State University shows that the formation of information and communication competence becomes more efficient, if the structural component of the subject information and educational environment highlight its subsystem methodical maintenance [12]:

- Competence in the field of cognitive activity corresponds to a content object environment as a methodical complex on discipline, video tutorials, presentations, training methods used, monitoring diagnostic system formation and development of competencies;
- Competence in the field of communication activity - an interactive means of communication and exchange of information (forum, study group on social networks, means of communication and management of group work, joint development projects);
- Technological competence - created by the student personal information educational environment on the basis of the site (web portfolio) containing reports on assignments, research projects, links, knowledge of monitoring, the current status of the projects, analytical reviews, glossary, etc.).
- Competence in the field of social action - the integration of the subject of the information educational environment with higher levels of educational environment (university, region, all-Russian information and educational systems), social networking;
- Professional and creative competence matches substantive content of the information educational environment of complex problem situations, individual and group creative tasks, methods of creative learning.

Organized in this way objective information and educational environment through the construction allows individual learning path most effectively organize independent learning and creative activities in the context of the student's future professional activity with the use of modern information technologies and increase the level of development of its information and communication competence.

III. RESULTS AND DISCUSSION

As a means of information-subject environment of high school multimedia and animation fragments of course can be used; sections of the self-test knowledge of students at all stages of the study course, containing different levels assignment with comments; sections of self-control, with the use of non-traditional forms of presentation of assignments (electronic crossword puzzles); structural

representation of a theoretical material - notes diagrams; problematic tasks, organized in the form of competitions; Development of sections of electronic textbooks, thematic web-quests.

The proposed method of the electronic textbook development, as well as web quests, will focus on a number of the benefits of their use. For the development of the electronic textbook, in particular its section, it is necessary to know what we're dealing with. Thus, the electronic textbook is a basic e-learning tools. This textbook contains all the basic materials needed for teacher training and conducting classes, as well as students to study educational topics [9].

When creating an electronic textbook, and in particular paragraph should be guided by the following principles: [4]

- Quantize;
- Completeness;
- Visualization;
- Inserted;
- Regulation;
- Adaptability;
- Computer support;
- Collection.

All these principles can be implemented easily using HTML language.

Language HTML - the standard markup language documents on the World Wide Web. It describes each element of the Web-document, using tags. Developed language, Timothy Berners-Lee in 1990.

Any HTML-document begins with the basic tags:

- <Html> - start tag of the document;
- <Head> - specifies where different information is placed, are not displayed in the body of the document;
- <Body> - defines the visible portion of the document.

When you create a section of the electronic textbook is primarily useful to this aspect of HTML, a text formatting.

With it, you can vary the size and font color, font, typeface, adjust the levels of headings, and more. It helps to realize the visualization of the principle of the electronic textbook.

This can be achieved using the tag <font> and the corresponding attributes to him:

- Color - sets the color of the text;
- Face - specifies the typeface;
- Size - sets the font size in units.

Do not forget about the color scheme of Web-pages. Setting colors produced in the tags <body>, <font>, <hr>, <table> [4].

HTML allows you to set a specific background color, or use a certain background image:

<Body>

- Background - sets the background image on a web page;
- Bgcolor - the background color of the web page.

The electronic textbooks is of particular importance graphical representation of data, which makes it easier to understand and remember new concepts statements.

Working with graphics in HTML is not difficult:

<Imgsrc = "name"> - add images to HTML-document.

This tag can be supplemented with:

- < "?" Imgsrc = "name" align => - aligns the image to one of the sides of the document (left, right, center; bottom, top, middle);
- < "?" Imgsrc = "name" border => - sets the thickness of the border around the image;
- <Imgsrc = "name" alt = "?"> - A tooltip when you hover over the image [4].

Implement branching Web-page by using the principle of frames.

Frames allow you to open a browser window in several documents. And if they are used, there is no tag <body>.

<Frameset>

- Cols =? - Specifies the number of vertical frames;
- Rows =? - Sets the number of horizontal frames;
- Frameborder = yes / no- presence / absence of borders between frames;

branch principle can not be implemented without the hypertext links.

The idea of hypertext technology belongs Veniveru Bush.

Hyperlink text or graphic object that contains a connection to other texts, graphics, telematics and digital information.

<a href="URL"> tags hyperlinks

- Vlink- color already visited hyperlink;
- Alink- color of active links.

Task "Create electronic textbook section using the HTML language» could serve two purposes - to study the basic principles of the electronic textbook and consolidate the basic knowledge of the language HTML.

The use of e-learning to a certain extent can make up for gaps in knowledge, and easy to use, and many well-known HTML will help to realize this kind of learning tool.

Creating computer-assisted learning will make sense only if you improve the efficiency of teaching and learning activities as a result of the opportunities of computer presentation. From this it follows, to ensure the effectiveness of the educational process automated training complex has to be radically different from the textbooks.

Thus, the use of computer technology in the formation leads to a change in the teaching process.

If we want that information was easily mastered, it should be duly represented, namely - was evident.

One such method is the web quest. And we think of a reason, after all, this way of presenting information, a lot of pluses. It allows you to save resources for the purchase of a large number of books on a given topic, to get the necessary knowledge in a shorter period of time, as well as to organize an interesting and effective work in groups.

In addition, while the students will be able to express themselves creatively. But most importantly - an effective memorization and not monotonous repetition.

Technology Web quest known enough. In 1995 she was introduced to Bernie Dodge, professor at the University of San Diego, so to say that it is new, it would be wrong. While in Russia for training it is practiced recently [10].

One of the main web-quest tasks - development of user skills working with various Internet services, and computer. To create such products as the best suited language HTML.

The language is easy to use, can be embedded in the text document image, HTML-document can be read on a computer with any browser.

The relevance of the technology is that it can introduce new services, with all this, provide training on specific topics.

Any Web quest simply arranged: it is always present administration, formulated the task, and then describes how to do the work and at the end, in some cases there is a test for self-examination, which in turn is useful for testing knowledge gained. It can be divided into groups. Conveniently divided into groups, which further contributes to a better assimilation of the material, through the exchange of ideas, each of the participants.

As to how to implement the training, development or creation via Web quest. Today it is not difficult. On the Internet a lot of services with the prepared forms, there are many online designers to create Web-quest. In their arsenal there are the required number of tools for fast and easy operation. Do not too difficult to put a picture (video) or make reference to third-party sources, and insert a table for your convenience.

Web-quests are well established for the study of the nature of the review that is not required to strictly follow a specific sequence of study material.

In the study, each group of students working with a relatively small amount of information, which is artificially restricted to allow the team to meet the tight time frame short web-kwest [11].

The quest options students are invited to explore the following topics:

1. WorldWideWeb - the World Wide Web:
- Hypertext
- Hypermedia
- HTTP
- WWW-pages
2. Electronic mail:
- Mail server
- Scheme of operation of e-mail

FTP file transfer 3.Sluzhba
- File Transfer Protocol
- Appointment of the FTP-server

4. Cistema Usenet newsgroups
- NNTP (Network News Transfer Protocol)
- Groups newsgroup

5. Complete the online service:
-On-Line translators and dictionaries
-Internet Shopping
-Systems Electronic payments

6. Remote access to computers Service:
-Telnet
- Functions of the client program
- Functions server program

To estimate does not slow down the process of listening, discussing, we are somewhat simplified evaluation system. It was decided to move away from the classical table, where painted various criteria.

Students are encouraged to take into account the quality and design of the product of the level of the report by using the integrated 10-point evaluation.

The Audit Committee is chosen by students and consists of students.

By the way, when the results of the secret ballot (scores exhibited by all participants anonymous) are ready, there is their announcement. At the same time voiced not the entire table, and called numbers of the two teams, the winners, the names of the authors of the two best projects [3].

In assessing the work and performances of his bandmates often personal likes and dislikes to the student transferred to the assessment of his work. Especially subjectivity characterized by first-year students. Participation of third-party neutral people, no doubt, adds objectivity [4].

Create Web-quest alone does not constitute a special hardship.

IV. CONCLUSION

Thus, objective information and educational environment through the construction allows individual learning path most effectively organize independent learning and creative activities in the context of the student's future professional activity with the use of modern information technologies and increase the level of development of its information and communication competence.

Education in the information-subject environment - is not only new information and the development of modern methods of learning activities. It's the intellectual development, mastery of other types of thinking, expression of ideas with new tools. In the recent past, the introduction of information and communication technologies in the training task was the development of logical and algorithmic thinking of students (for example, when teaching computer science). Now, however, the

limitations of this problem became apparent, because the computer can be a good teaching assistant in the development of figurative, verbal, intuitive thinking and other mental activity. Students using the information-educational environment better structure the information, can operate with larger blocks of information, confidently classify the content of the subject area on the identified criteria, properly set cause-effect relationships, adequate domain systematize objects specifics. When using information and educational environment in the process of learning the subject can also be successfully develop students' critical personal qualities: creativity, reflexivity, criticality, responsibility, self-reliance. The condition for this are the specially organized system of methodical and purposeful training of students to new activities in the information-educational environment [1].

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Latvian Sign Language Recognition Classification Possibilities

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Abstract. There is a lack of automated sign language recognition system in Latvia while many other countries have been already equipped with such a system. Latvian deaf society requires support of such a system which would allow people with special needs to enhance their communication in governmental and public places. The aim of this paper is to recognize Latvian sign language alphabet using classification approach with artificial neural networks, which is a first step in developing integral system of Latvian Sign Language recognition. Communication in our daily life is generally vocal, but body language has its own significance. It has many areas of application like sign languages are used for various purposes and in case of people who are deaf and dumb, sign language plays an important role. Gestures are the very first form of communication. The paper presents Sign Language Recognition possibilities with centre of gravity method. So this area influenced us very much to carry on the further work related to hand gesture classification and sign's clustering.

Keywords: artificial neural networks, centre of gravity, classification, hand gesture, sign language recognition.

I. INTRODUCTION

Gesture is one of very important people's communication components, which allows expressing emotions and gives important information in addition to spoken language. For most people the gesture is an additional method for communication, for deaf this is the main way to express themselves. Deaf people are being integrated into society through the sign language, the part of which is the representation of the national alphabet gestures. These alphabets mainly consist of static signs; however, the Latvian sign language has several signs, which are shown in motion (see Table 1).

In Latvia there is a website of Latvian Deaf People Rehabilitation, which has a Sign Language Interpreters' Department. The main goal of this organization is to "facilitate the client's social integration, availability of necessary information and services, provide sign language interpreter's services for communication with other individuals and legal entities according to the client's perception and communication abilities" [1].

There is still a lack of automated Latvian sign language recognition system in our country and there is a strong need for it from. The ultimate goal of the authors is to develop the recognition system of Latvian Sign Language based on Artificial Neural Networks to help people in social rehabilitation and integration in modern society. This is the main purpose of this paper and the starting point of the authors' research is to classify Latvian Sign Language alphabet using Artificial Neural Networks.

Nowadays there is an increasing interest in automatic SLR using video or web cameras to classify gestures correctly and transform deaf people language into a text or speech.

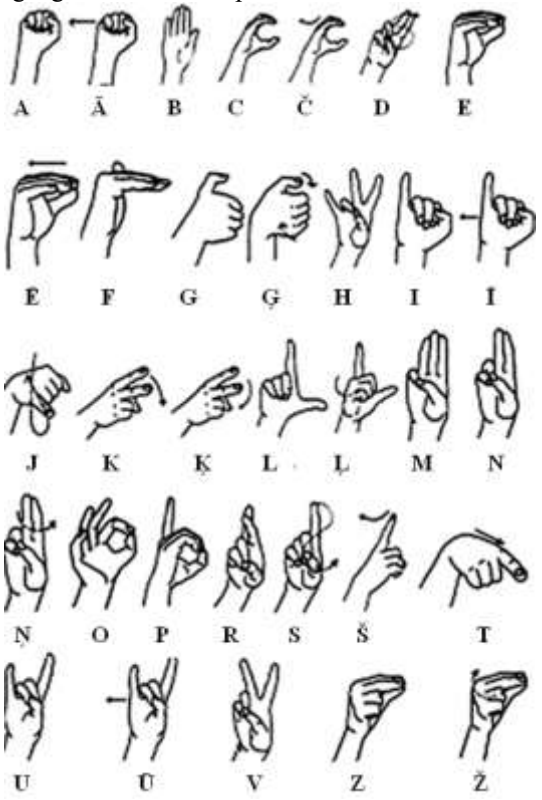

Fig. 1. The symbols of Latvian sign language [1]

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There is a wide range of SLR methods, which could be mainly described using input data and sensor technology for sign recording:

- Using different markers (on hands);
- Specially developed data gloves;
- Infra-red sensor technology (LeapMotion, Microsoft Kinect etc.);
- Sign recognition through visual (video or photo) methods.

Two last methods allow to recognize the sign language in a real time through web cameras or Leap Motion controller, which price is now really affordable (less than 70 euros) [2].

Next chapters will give a review of data pre-processing and recognition solutions with artificial neural networks

II. ARTIFICIAL NEURAL NETWORKS AND CLASSIFICATION PROBLEM

The simplified biological neuron as a model on artificial neuron has been created and implemented in many types of ANN (see Fig. 2):

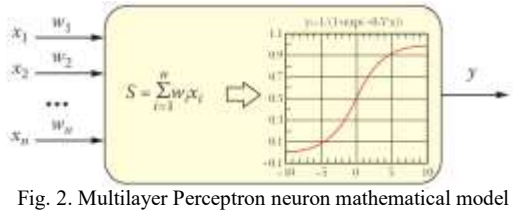

Fig. 2. Multilayer Perceptron neuron mathematical model [3]

In Figure 2 artificial neuron receives its inputs $x_1 \ldots x_n$ weighted with $w_1 \ldots w_n$. All inputs are calculated with a sum function and then propagated to activation function. After calculations neuron gives output value y, which is led to other neurons or is processed like a final output signal of the network. The artificial neural network itself is an interconnected neuron structure. These types of neurons are often used in back-propagation artificial neural networks.

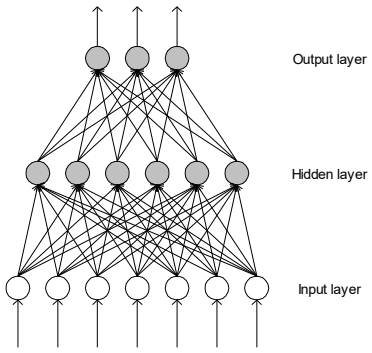

Fig. 3. The architecture of backpropagation network

A multilayer feed-forward network with an appropriate pattern of weights can be used to model some mapping between sets of input and output variables. Figure 3 shows an example of feed-forward network architecture, with three output units and one hidden layer, which can be trained using back-propagation. The shaded nodes in this figure are processing units. The arrows connecting input and hidden units and connecting hidden units and the output units represent weights.

The back-propagation learning algorithm [3], [4] is formulated as a search in the space of the pattern of weights W, in order to find an optimal configuration W*, which minimizes an error or cost function E(W). The pattern of weights will then determine how the network will respond to any arbitrary input. The error or cost function is defined by (1):

$$E = \frac{1}{2} \sum_i \sum_p (t_{ip} - o_{ip})^2 \quad (1)$$

This function compares an output value o_{ip} to a desired value tip over the set of p training vectors and i output units. The gradient descent method is used to search for the minimum of this error function through iterative updates:

$$W(k+1) = W(k) - \eta \nabla E \quad (2)$$

where η is the learning rate, and ∇E is an estimate of the gradient of E with respect to W.

The algorithm is recursive and consists of two phases: forward-propagation and backward-propagation. In the first phase, the input set of values is presented and propagated forward through the network to compute the output value for each unit. In the second phase, the total-squared error calculated in the first phase is propagated from the output units to the input units. During this process, the error signal is calculated recursively for each unit in the network and weight adjustments are determined at each level. These two phases are executed in each iteration of the back-propagation algorithm until the error function converges.

A very important step in each neural network application is data pre-processing. In Sign Language Recognition problem this task has also a big necessity. This paper will not go into details with this issue, additional information could be found in our earlier research paper [5].

There are different architectures and learning algorithms used in classification approach. One of them is Modular Neural Network presented in [5]. These networks have improved generalization due to decomposition of complex function into simpler ones. The main idea is a natural decomposition of a function of large complexity into simple functions and realization of each function by a separate neural network [6]. The modular neural network with an output decomposition is shown in Fig. 4.

In this particular case a task is divided into several subtasks, each of which can be solved individually using an independent neural network.

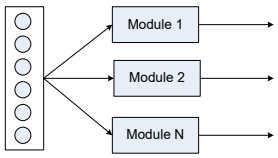

Fig. 4. Decomposition of the outputs of different modules

Another example of classification neural network is Kohonen "freezing" learning algorithm developed by author [7]. The standard Kohonen self-organizing maps are trained in unsupervised and in supervised manner. This type of network uses grid of neurons or a topological structure among the cluster units. There are m cluster units, arranged in a one- or two-dimensional array: the input signals are n-dimensional. Figure 5 shows architecture of a simple self-organizing network, which consists of input and Kohonen or clustering layer.

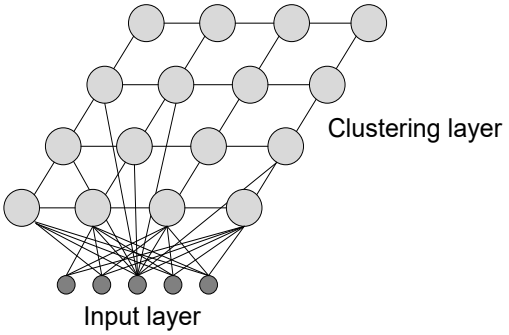

Fig. 5. The architecture of the Kohonen self-organizing map

The shadowed units are processing units. Usually one clustering unit for each class is not enough; therefore each clustering layer neuron in the Figure 4 consists of several neurons.

When a self-organizing network is used, an input vector is presented at each step. These vectors create the "environment" of the network. Each new input produces an adaptation of the parameters. If such modifications are correctly controlled, the network can build a kind of internal representation of the environment [6].

Consider the problem of charting an n-dimensional space using a one-dimensional chain of Kohonen units [3]. The units are all arranged in sequence and are numbered from 1 to m (see Fig. 6).

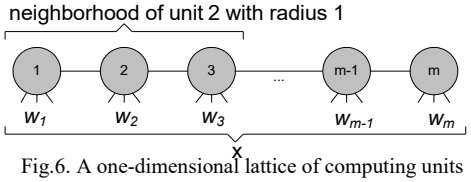

Fig.6. A one-dimensional lattice of computing units

The n-dimensional weight vectors w_1, w_2, …,w_m are used for the computation. The objective of the charting process is that each unit learns to specialize on different regions of input space. When an input from such a region is fed into the network, the corresponding unit should compute the maximum excitation. Kohonen's learning algorithm is used to guarantee that this effect is achieved.

There is a modified "freezing" algorithm developed by author allows splitting network learning process into some stages, when each part of the network is trained individually [7]. In the first learning step neural network is divided into number of clusters of neurons, where each of the clusters is associated with a definite class. In this way we obtain training with teacher. In the second stage each cluster is trained accordingly to standard Kohonen learning algorithm. Each of neuron clusters is trained individually, while others are "frozen" and do not take part in the training. After completion of individual cluster training the network is "de-frozen" and learning process ends [7].

III. PROPOSED HAND GESTURE RECOGNITION SYSTEM FOR CLASSIFICATION

There are different sign language recognition methods described in analytical research papers. One of them is recognizes hand gestures are classified as static and dynamic gestures (see Fig. 7.) [8]. Static hand gestures are those in which the hand position is unchanged during the gesturing period.

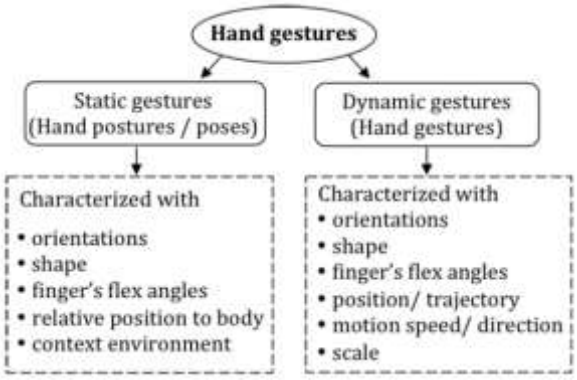

Fig. 7. Classification of hand gestures

The author's research focuses on static gestures only. Internet and other resources give us several sign language recognition applications with different methods [9], [10], [11].

Our hypothesis claims that a gesture symbol could be recognized and classified with a center of gravity method (COG). This method allows splitting alphabet symbols into several groups or clusters, thus simplifying recognition task (see Fig. 8).

Fig. 8. Center of gravity in human palm.

The COG is a common feature to check the movement route of a hand gesture - the difference between two COGs provides information about the movement speed and direction.

The hand gesture recognition procedure is divided into two stages. The first stage is preprocessing and the second stage is the classification one [11].

The first stage starts with reducing the complexity of feature extraction for hand gestures. The output image of hand portion extraction process is converted into binary image.

There are various different kinds of distinguished features that can be extracted from an image. One of the possibilities is to use an active and in-active finger which is represented by 1 and 0 respectively. As a result an image of finger portion was obtained using only singly connected pixels, the co-ordinate values for the finger tip was stored accordingly.

After the pre-processing phase is complete it is possible to calculate a centroid of hand using the following equation [11]:

$$\bar{X} = \frac{\sum_{i=0}^{k} x_i}{k} \quad \bar{Y} = \frac{\sum_{i=0}^{k} y_i}{k} \qquad (3)$$

where $(\bar{X}, \bar{Y})$ represents the centroid of the hand;

x_i and y_i are x and y coordinates of the i^{th} pixel in the hand region;

k denotes the number of pixels that represent hand area.

Then distance between the centroid and the finger tip is calculated using Euclidean distance according an equation below:

$$D = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2} \qquad (4)$$

where (x_1,x_2) and (y_1, y_2) represent two coordinate values.

In the second phase of recognition an artificial neural network with back-propagation or Kohonen algorithm could be implemented.

IV. CONCLUSIONS

Most of sign language applications focus on feature extraction of the hand gesture for performance of classification. The main goal of the preprocessing stage is hand gesture extraction from an image, removal of noise and unwanted regions, processing the extracted image to a form of a binary image and extraction of the significant features from an image for further classification.

There is a number of successful applications in sign language recognition using Artificial Neural Networks, however, no one still has been developed similar solution for Latvian sign language. The ultimate goal of the authors is to develop Latvian Sign Language recognition system based on artificial neural networks.

This analytical paper gives an insight into sign language recognition technology. The authors are doing several experiments with Latvian Sign language at the moment, and one of the possible solutions is center of gravity method and artificial neural network.

We are in the beginning of our research hoping to help people with special needs and advance in a very interesting Artificial Intelligence field.

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Creation of Innovative Approach for Study of the National Fiscal Space

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Abstract. The choice and topicality of the theme is substantiated by the fact that a sustainable development of a country is affected by the policy implemented by the government. One of its main parts is the fiscal or budget policy which means the formation of the necessary funds of the revenues and expenditures to ensure the functioning of the government. Accordingly, the concept of fiscal space has been activated which is closely connected with the implementation of the instruments of fiscal policy (taxes, government expenditures, government debt). The aim of the research is to create an innovative approach to the investigation of the creation of the state fiscal space applying the simulation method in the environment of Matlab/Simulink in order to forecast the influence of the corporate income tax on the state economic and financial indicators taking into account the changes of the corporate income tax offered by the government and the Bank of Latvia. Methodology of the research implies the following activities: the identification of the concept of fiscal space and its application in the context of the influence on economy; the creation of the assessment methodology of the components of fiscal space using technological tools (data modelling in Matlab / Simulink environment).

Keywords: economic development, fiscal policy, fiscal risk, fiscal space, taxes.

I. INTRODUCTION

The choice and topicality of the theme are substantiated by the fact that the sustainable development of any country is influenced by the government policy. One of its main constituent parts is the fiscal or budget policy. Traditionally, it is defined as the policy to form revenues and expenditures in order to ensure the activities of the government. But in the economic interpretation it means the regulatory system of economy by means of taxes and government expenditures. It should be noted that it is closely connected with the role of the government to redistribute the income of the society stating the proportion of the state budget in the gross domestic product defining the objectives for the common tax burden, expenditures of the budget, the permissible deficit, the amount and structure of the debt of the government.

For the necessity to apply the instruments of the fiscal policy it is important to understand the cyclical development of economy – economic growth, the level of high demand, supply and the general level of the well-being of inhabitants interchanging with the periods when the growth rate declines as well as the income of employees which negatively influences the total demand for goods and services. This combination of circumstances can cause economic crises, the overcome of them can be long-lasting and hard for the society as a whole. In such situations the government can purposefully intervene in the economic processes in order to restore the economic stability in a short-term period and to ensure a sustainable development in a long-term period.

The development of the financial and economic theory and practice in the world has already for a long time laid emphasis on the role of fiscal measures taken by the governments in the regulation of counter-cyclical economy although sometimes it means the adoption of unpopular decisions (the reduction of budget expenditures, the increase of taxes) [9].

At present the concept of fiscal space is topical in the financial policy-making in Latvia which is closely connected with the application of the instruments of fiscal policy (taxes, government expenditures, government debt). There are discussions about the size and preconditions of the formation of fiscal space. The government has also proposed an extensive tax reform pointing out that in such a way the economic development will be promoted and the state fiscal situation will improve. Along with the reform it is proposed to change the method of collection of the corporate income tax.

On the basis of the above mentioned explanation the authors of the research have evaluated a definite situation in Latvia analyzing the relevant trends in the area of the corporate income tax according to the legislation and the tax reform proposed by the Bank of Latvia.

The aim of the research is to investigate the formation of the state fiscal space in the context of a particular tax, i.e. the influence of the corporate income tax on the state economic and financial indicators applying the simulation methods in the environment of Matlab/Simulink and to show Matlab/

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Simulink suitability for the purpose of visualizing simulation models of various economic situations.

In the research the authors have used the monographic method, logical constructive method, the method of analysis, the comparative method of opinions and conceptions as well as the method of the simulation and modelling of the situation.

II. EVALUATION OF THE CONCEPT OF FISCAL SPACE

In the literature on economics and in the financial practice in the countries the conception ”state fiscal space” has only recently been topical in connection with the beginning of the economic crisis in the USA in 2007 and later on also in the European countries [13]. The crisis reached Latvia, too, which negatively influened the process of the formation of the state budget increasing the state budget deficit and the government debt. As we know, in the period of 2009 until 2011 there was a very painful consolidation process of budget in Latvia.

According to the definition the fiscal space is the ability of the government to be flexible (flexibility) making a choice or, expressing it figuratively, it is the financial well-being of the government. The Deputy Director of the International Monetary Fund Peter Heller defines this concept as “room in a government’s budget that allows it to provide resources for a desired purpose without jeopardizing the sustainability of its financial position or the stability of the economy”. So, the concept ”fiscal space” has a broad sense but, simply speaking, it means free or ”released” funds which can be redirected to certain activities. Traditionally, the concept ”fiscal space” is defined as additional resources for financing new state expenditures to ensure the development processes of economy [15].

At present the concept “state fiscal space” is applied in the context of the evaluation of the implemented fiscal policy in the country. At the same time there are different opinions in the economic literature how to define and calculate the fiscal space in the country:

- calculating the debt level of the government [16];
- taking into account different measures of tax receipts, that is, the structural changes of the tax policy [8], [11].

On the basis of the opinions about the investigation of the fiscal space we can emphasize the following aspects:

- sustainability – creating the resources at government’s disposal with the aim to provide a sustainable state financial policy [15];
- development – mobilization of government’s funds ensuring a favorable institutional and economic environment for certain political activities in connection with particular measures stated by the government [14];
- budgeting – the allocation of funds for specific political initiatives stated by the government in the year or medium term budget expenditure framework [14].

So, a clear understanding is needed about the influencing factors and preconditions of the fiscal policy-making of a country in the context of the consistency of the adopted decisions in connection with sustainable development (social, economic factor). Thereby, it is important to evaluate the financial influence of the state on the state socio economic development when activating such concepts as “fiscal capacity” and “fiscal incentives”.

The authors can make a conclusion that at present the fiscal policy has been positioned to the understanding of fiscal space and fiscal capacity. There is an opinion that the concept “fiscal space” is rather vague which means that there can arise different interpretations. But we can generally say that the fiscal incentives are connected with the possibility to decrease the debt of the government [16]. It all determines the need for an effective financial management in the country.

III. THE PRACTICE OF CREATING FISCAL SPACE IN LATVIA

Since joining the Eurozone in 2014 the financial management and supervision of the state has substantially improved in Latvia. According to the Law on Fiscal discipline the system of the fiscal risk management has been introduced in the country which has already been functioning for three years. It includes the identification of fiscal risks, diminishing the risks and the evaluation of the influence of the remaining fiscal risk and the prevention of the possibility of its setting in. The Law states that due to the existing risks in the country the reserve must be foreseen in the formation of the budget which could guarantee that the deficit does not violate the acceptable limit regardless of the risks and a certain fiscal space is retained [20], [21].

2016 was the first year when the security reserve of the financial risks was foreseen and this practice continued when working on the budget of 2017. In comparison with the previous years the risks have basically not changed. Nevertheless, the authors would like to point out that in the Budget of Social Security the expenditures have been revised in order to increase them against the previous forecasts and there is also a greater uncertainty about some expenditures in connection with Great Britain leaving the EU. So, the increase of regular payments to the EU budget is also possible.

In order to ensure the state financial sustainability it is necessary to improve the fiscal risk management. The authors consider that the attention should be paid to the fact that the fiscal risk in reality is symmetrical which is also according to the theory. It refers to the evaluation of the revenues and expenditures. It is

often so that the expenditures are not appropriately estimated, in reality they seem to be bigger, but the revenues are overestimated, they are lower than expected. At present the declaration of fiscal risks does not include the macroeconomic risks because theoretically the cyclical fluctuations of economy do not influence the structural balance but the experience of the past years shows that in practice it is not so. In the future the macroeconomic risks should be included in the declaration, too.

A typical feature of the fiscal policy in Latvia is the problem of ensuring the collection of revenues on the one side and the public pressure to increase the expenditures on the other side. The authors consider that the main point is to ensure the revenues which means a set of wide range of measures in order to develop entrepreneurship, the fight against the shadow economy, the improvement of tax policy, etc. The authors of the research do not intend to investigate all problems and measures but they will focus on the issues of the tax policy which is very topical nowadays. As it has been pointed out, the proposals of the tax reform have been made by the government and the Bank of Latvia, the greatest attention being paid to the personal income tax, the procedure of the capital taxation and the corporate income tax.

It has been estimated that as a result of changes next year the revenues in the budget will be 100 million less but neto wage, for example, of an employee with a minimum wage without a dependent person, would increase by 79 euros a month. There are indications that this is the right time for the changes of the tax policy because in 2018 and 2019 the Latvian economy will receive the EU funds which will absorb the fiscal influence of the new tax policy providing the indicators of the fiscal space [18].

The reform proposed by the government actually includes the points which have already long been under the discussion in the society, such as the decrease of employment tax, the takeover of the practice of the corporate income tax in Estonia, about the change of the procedure of the capital income taxation, etc.

Conceptually, providing a positive assessment of the proposed solutions in the field of taxes the authors would like to point out that at the same time there are several questions about the efficiency and the influence of this action not only referring to the budget revenues but also to the evaluation of the development of the whole society. Besides, there is no answer to the question about jeopardizing the provision of the fiscal space of the budget as a result of reforms.

In the debate on the reforms one of the opinions was that the influence of the predicted tax reform is too optimistic [17].

In order to evaluate the proposed estimations the authors made an investigation. As the main subject of the investigation in the field of tax changes the authors chose the corporate income tax (CIT) evaluating its influence on the state gross domestic product (GDP) and the state budget under the existing circumstances and the implementation of the proposals of the Bank of Latvia. It should be noted that in the empirical model of the economic growth the OECD researcher J. Arnold proves that the economic growth is mostly hindered by the corporate income tax [10].

IV. MATLAB/SIMULINK TOOL FOR ECONOMICS PROCESS MODELING

Simulation - the most powerful and versatile method for studying and evaluating the effectiveness of systems, the behavior of which depends on the influence of random factors [1].

The implementation of such opportunities in the universal programming language is a difficult task. Currently, there is quite a lot of software that allows to model processes. However, now there is a product that allows solving these problems quite effectively – the MATLAB package [2], [4], [6] containing a visual simulation tool – Simulink. Simulink - a tool that allows you to simulate the system quickly, get the indexes of expected effect and compare them with the amount of effort required to achieve them [7], [12].

Of particular interest for simulation is a Simulink tool designed specifically for modeling dynamical systems. It has a library of standard graphics units with built-in mathematical functions. It is sometimes called a tool of visual modeling [3], [5].

Although Simulink is designed mainly to solve engineering and scientific- technical problems, the possibilities of its use are almost unlimited. The input of initial parameters is made interactively by graphics assembly of elementary blocks circuit diagram, resulting in a model of the studied system. The blocks included in the model relate to each other both in information and in management. The type of connection depends on the type of the block and the logic of the model.

The Simulink program is an application to the MATLAB package. Using Simulink program the simulation implements the principle of visual programming whereby the user on the screen creates a model of a structure, process or system from standard blocks of the library, and performs calculations. In this case, unlike in classical ways of modeling, the user does not need to study the programming language and numerical mathematics methods thoroughly, there is enough to have some general knowledge required when working on the computer, and, of course, knowledge on the subject area in which he works.

Creating a model in this way, and then launching it, it is possible to see the results of modeling. In the simulation, the user can choose the method for

solving equations, as well as the way to change the model time (with a fixed or variable step). During the simulation, it is possible to monitor the processes happening in the system. To this purpose, special viewing devices that are part of the Simulink library are used. The simulation results can be presented in the form of graphs or tables.

In the research the future model was evaluated according to the existing legislation of the Republic of Latvia taking into account the tax reforms proposed by the Bank of Latvia "Taxation strategy 20/20" (see Table I).

Evaluating the potential forecast for the year 2020 according to the existing legislation the authors use official statistical data [19], [20] (see Table I).

Table I
GDP, CIT and the state consolidated budget revenues in Latvia in the years 2014-2019

Year	2014	2015	2016	2017	2018 (fore-cast)	2019 (fore-cast)
GDP	23600	24378	25072	26403	27905	29615
CIT	354,8	383,1	407,1	425,3	461,1	468,8
Budge t	4939, 2	5093, 1	5281	5760, 6	6336, 2	6256, 4

For further investigations it is needed to obtain the forecast for 2020.

Graphically depicting GDP, CIT, Budget curves, we can get trend line with equations (see Figures 1-3).

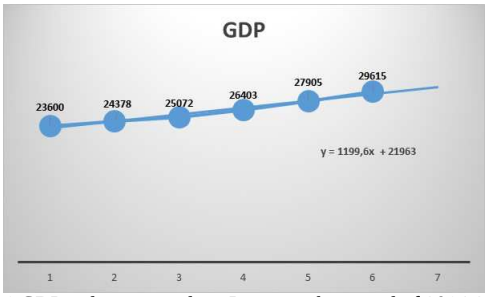

Fig.1 GDP indicator trends in Latvia in the period of 2014-2019 and the forecast for 2020

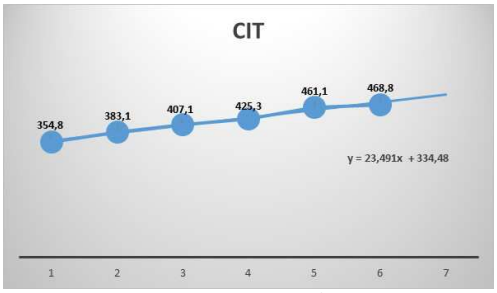

Fig.2 The revenue indicator trends of the CIT in the state consolidated budget in Latvia in the period of 2014-2019 and the forecast for 2020

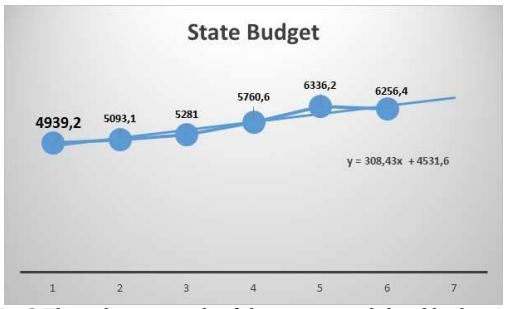

Fig.3 The indicator trends of the state consolidated budget in Latvia in the period of 2014-2019 and the forecast for 2020

Using the trend line equation the forecast for 2020 was calculated according to the legislation of Latvia [19], [20] (see Table II).

Table II
GDP, CIT, the indicators of the state consolidated budget in Latvia in the period of 2015-2019 and the forecast for 2020

Year	2015	201 6	2017	2018	2019	2020
GDP	24378	2507 2	26403	27905	29615	30360
CIT	383,1	407, 1	425,3	461,1	468,8	498,9
Bud-get	5093,1	5281	5760,6	6336,2	6256,4	6690,6

With the aim to make up the simulation of the CIT influence on the economy and fiscal situation in the country a simple Matlab/Simulink model was elaborated which calculated the proportion CIT/GDP and CIT/Budget (for the purpose of scaling all the results were multiplied by 100) (see Fig. 4).

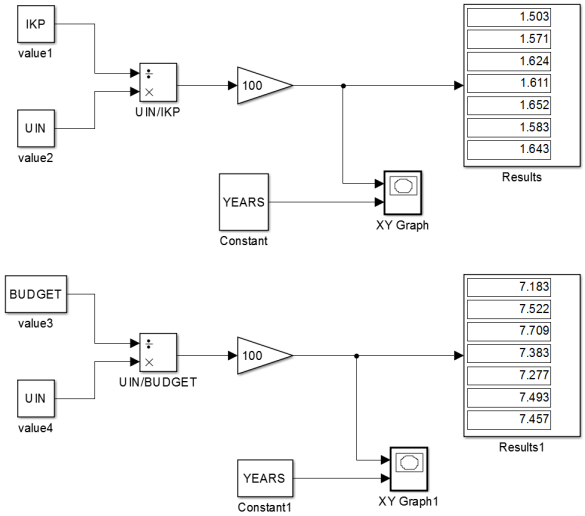

Fig.4 The evaluation model of the influence of the CIT

As a result the indicators of the CIT influence on GDP and the state consolidated budget were obtained (see Table III).

Table III
The evaluation criteria of the CIT influence on the GDP and the state budget

Year	2015	2016	2017	2018	2019	2020
CIT/ GDP	1,57	1,62	1,61	1,65	1,58	1,64
CIT/ Budget	7,52	7,71	7,38	7,28	7,49	7,46

This is a graphical depiction of indicators (see Figures 5 and 6).

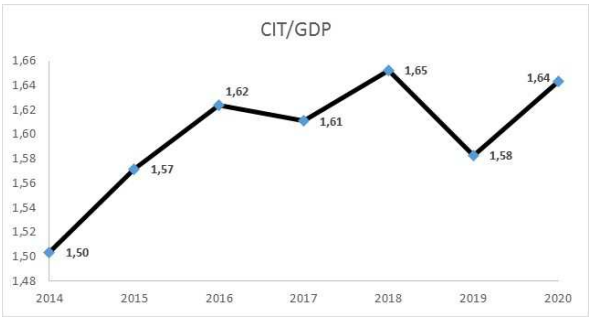

Fig.5 The influence of the CIT on the GDP according to the existing legislation of the Republic of Latvia

It can be concluded that Matlab/Simulink tool is a very suitable tool not only in the economic calculations but it can also serve as a visualization tool of a simulation model in various fields of science.

Based on the proposals of the Bank of Latvia "The tax strategies 20/20" [17] the authors have conducted an analytical research on the formation of the corporate income tax (CIT) and its influence on the economic and fiscal situation in the country.

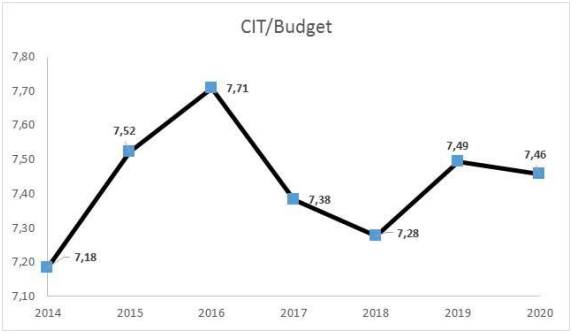

Fig.6 The influence of the CIT on the state consolidated budget GDP according to the existing legislation of the Republic of Latvia

The authors have made a simple assumption as well as made analysis of two opposite variants:

1. All enterprises invest money into the reinvested profit (i.e. 0% of the reinvested profit make a loss in the amount of 15% of the CIT income accordingly).
2. All enterprises pay 20% to the distributed profit (the CIT increase is in the amount of 5%).

In the first variant of the data modelling in the environment of the Matlab/Simulink we have obtained the following results of the first variant (see Figure 7):

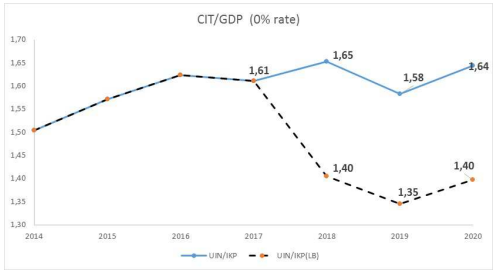

Fig.7 The CIT influence on the GDP applying 0% rate

In the second variant of the data modelling in the environment of Matlab/Simulink we have obtained the following results (see Fig. 8):

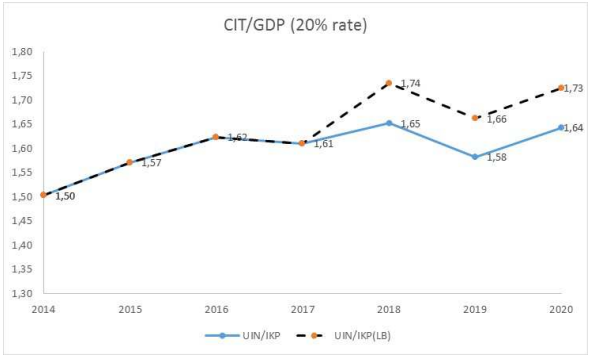

Fig.8 The CIT influence on the GDP applying 20% rate

We can make a conclusion that according to the present situation the short-term planned (2018-2019) CIT 0% rate with the assumption that it will be used by all enterprises will have a relatively negative influence on the economic activities but the future forecast is favorable in the context of the economic development.

We can make a conclusion that on the condition of 20% of the corporate income tax it could provide a greater influence on the state economic development in comparison with the present situation in the legislation of the Republic of Latvia.

As a result of the modelling of the situation the authors would like to emphasize that the cumulative influence of the CIT on the economic situation in the country will depend on certain decisions made by the entrepreneurs which will respectively influence the preconditions of the formation of the state fiscal space. The authors consider that a positive influence on the economy will be seen only in the medium term and long term because it will never be so that all the entrepreneurs will immediately decide to make investments in the development. The authors of the research are rather skeptical about the change of the attitude of the entrepreneurs referring the tax discipline in the short term. Taking into account a long time existing bad discipline of tax paying in

Latvia, shadow economy, distrust to the government reforms, the change of ”the playing rules” too often, the authors suggest the government to work with entrepreneurs, discuss issues, popularize examples of good practice and consequently keep promises.

In order to make a complete evaluation of the issue it is necessary to conduct a comprehensive analysis of all the changes of proposed taxes but it is the subject of further research.

V.CONCLUSION AND PROPOSALS

The concept ”state fiscal space” has only recently become topical in connection with the economic crisis which began in 2007 in the USA and later on also in the European countries. Both in Europe and in Latvia it has negatively influenced the process of the formation of the state budget increasing the deficit of the State Budget and government debt.

The concept ”fiscal space” has a great capacity but, simply speaking, they are free or ”released” funds in the government budgets which can be redirected to particular activities.

2016 was the first year in Latvia when in the State Budget the reserve was provided to ensure the fiscal risk and this practice continued working on the budget of 2017. In comparison with the previous years the risks are basically remained unchanged. Nevertheless, it should be noted that in the Social Security Budget the revision of expenditures has taken place against the previous forecasts and there is a greater uncertainty about particular expenditures in connection with Great Britain leaving the EU.

Of particular interest for simulation is a Simulink tool designed specifically for modeling dynamical systems. It has a library of standard graphics units with built-in mathematical functions. It is sometimes called a tool of visual modelling. The Simulink program is an application to the MATLAB package. Using the Simulink program the simulation implements the principle of visual programming whereby the user on the screen creates a model of a structure, process or system from standard blocks of the library, and performs calculations.

Evaluating the influence of a particular tax (CIT) on the GDP of Latvia and the state budget according to the existing legislation the authors can make a conclusion that the general trend is positive which provides favorable opportunities for the provision of the fiscal space.

As a result of modelling the situation of applying the proposals of ”taxation strategies 20/20” of the Bank of Latvia in the field of CIT we can say that the cumulative influence on the economic situation in the country will depend on the particular decisions made by the entrepreneurs which in its turn will also influence the preconditions of the formation of the state fiscal space.

The authors consider that the attention should be paid to the fact that the fiscal risk, which theoretically must be symmetric, in reality it is so. The question is about the estimation of the revenues and expenditures. It is often so that the expenditures are not appropriately estimated, in reality they seem to be bigger, but the revenues are overestimated, they are lower than expected. At present the declaration of fiscal risks does not include the macroeconomic risks because in economy the cyclical fluctuations do not influence the structural balance but the experience in the past years show that it is not so in practice. In the future the macroeconomic risks should also be included in the declaration of fiscal risks.

In the cooperation with entrepreneurs the government must stimulate the change of the attitude to the discipline of tax payments, to foster investments which could improve the economic development and the revenues in the State Budget.

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