Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 15th International Scientific and Practical Conference. Volume II, 212-219

Integrated Intelligent System for Scientific and Educational Information Retrieval

Mukhammadjon Musaev
Artificial Intelligence
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
mm.musaev@rambler.ru

Marat Rakhmatullaev
Library Information Systems
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
marat56@mail.ru

Sherbek Normatov
Library Information Systems
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
shb.normatov@gmail.com

Kamoliddin Shukurov
Artificial Intelligence
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
keshukurov@gmail.com

Malika Abdullaeva
Artificial Intelligence
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
m.abdullayeva@tuit.uz

***Abstract*. The relevance of creating information systems using artificial intelligence methods and tools is dictated by the following reasons: The volume of scientific and educational information is growing; Traditional information retrieval methods have exhausted themselves. Using only deterministic and iteration methods, rigid algorithms don't give the expected results. They require more time to process information and more memory. Significant progress in recent years in the development of artificial intelligence (AI) methods and systems gives hope that their use will significantly reduce the time needed to search for data for scientific research and educational activities. The aim of the research results presented in the article is to increase the efficiency for scientific and educational information retrieval based on the use of AI methods implemented in the integrated intelligent information system "SMART TUIT". The article presents the results of theoretical and applied research obtained by several departments of the Tashkent University of Information Technology (TUIT) in solving the following tasks: Voice recognition for subsequent processing; Pattern recognition in order to identify the users of information; Search and processing of scientific and educational resources in electronic libraries; Analysis of information needs of users depending on the level of competence and type of activity; Evaluation of scientific and educational information to identify the most important data sources; Geoinformation system to solve the problems of the location of the information source. Initially, each research area in the departments was aimed at solving a certain class of problems related to medicine, linguistics, electronic libraries, corporate networks, information security systems, etc. The TUIT creative group decided to combine efforts to apply the results obtained to solve the important problem of intellectualizing the search for sources of scientific and educational information among a large amount of data.**

Keywords: artificial intelligence, pattern recognition, voice recognition, information retrieval, database, knowledge base.

I. INTRODUCTION

The relevance of developing information systems for accessing current data through artificial intelligence methods and tools is underscored by several compelling factors:

1. Rapid Growth of Scientific and Educational Information: The volume of scientific and educational data is expanding exponentially, nearly doubling each year. This growth necessitates more efficient means of accessing and managing this wealth of information.

2. Increasing Importance of Access to Information Resources: Access to valuable information is crucial not only for advancements in science and education but also for the overall progress of the economy and society. Scientific and technical solutions drive progress across all sectors, highlighting the critical need for reliable access to pertinent information resources.

Print ISSN 1691-5402
Online ISSN 2256-070X
https://doi.org/10.17770/etr2024vol2.8028

3. Exhaustion of Traditional Retrieval Methods: Conventional data retrieval methods have reached their limits. Relying solely on classical approaches, which consume extensive time and memory resources, often fails to yield satisfactory results. This underscores the necessity for innovative approaches to information retrieval.

4. Demand for Timely Decision-Making: In today's complex environment, swift decision-making is imperative, particularly in situations where vast amounts of information must be processed. The complexity and sheer volume of information require prompt decision-making to address emerging challenges effectively.

5. Advancements in Artificial Intelligence: Significant advancements in artificial intelligence (AI) methods and systems offer promising prospects for reducing the time required to search for scientific research and educational data. Leveraging AI technologies holds the potential to streamline information retrieval processes, thereby enhancing research and educational activities.

By addressing these pressing needs, the development of information systems utilizing AI methodologies promises to revolutionize the accessibility and utilization of scientific and educational data, fostering progress across various domains.

Since the most objective scientific information remains concentrated within libraries and subscription-based databases, a critical aspect of research is to enhance the efficiency of information retrieval from these repositories. The system-functional approach serves as the methodological foundation for exploring the capabilities of AI technologies across various processes within information and library activities [1].

Information systems encompass a multitude of processes and functions that resist formalization [2], necessitating direct human intervention:

- Evaluating existing information resources and assessing the extracted information.
- Understanding the nature of information needs and identifying these needs within the system.
- Identifying relevant information resources based on information needs.
- Organizing existing information resources and structuring selected information from extracted elements.
- Managing existing information resources and overseeing the extracted information.
- Swiftly searching for and selecting information resources, utilizing extracted information.
- Analyzing information and knowledge.
- Transforming information into knowledge by establishing semantic relationships between data units (the "building blocks" of knowledge).
- Disseminating and transferring information and knowledge.
- Facilitating interaction and exchange of information and knowledge.

These functions underscore the indispensable role of human intelligence in information systems, working in tandem with AI technologies to optimize information retrieval and management processes within library environments.

Of particular significance is the study conducted by [3], which delves into the analysis of diverse intelligent agent technologies within library contexts. The author scrutinizes the application of AI in this domain from two distinct angles:

- Digital Libraries (DL): This perspective encompasses the utilization of intelligent agents for distributed searches of heterogeneous information within digital library environments. Additionally, the author explores the role of agents in supporting the information retrieval process within information library systems (DLS).
- Services in Traditional Libraries: This facet examines the integration of AI technologies into services provided by traditional libraries. It includes the development of user interfaces tailored for DLS, the implementation of automated reference services, and the architecture of library services aimed at enhancing efficiency and accessibility.

By examining these perspectives, the study sheds light on the multifaceted applications of AI within library settings, ranging from digital environments to traditional service delivery models.

Indeed, despite the substantial body of research in this field, there is a tendency to examine factors and tasks related to AI utilization in scientific information retrieval in isolation, rather than addressing the integration of individual subsystems and modules involved in the process. However, adopting a systematic approach that facilitates the integration of heterogeneous modules, encompassing both AI-driven and traditional data processing functions, holds the potential to yield a synergistic effect, thereby enhancing the efficiency of locating critical information resources.

By embracing a holistic perspective that emphasizes integration, researchers and practitioners can capitalize on the complementary strengths of various modules within the information retrieval process. This integrated approach enables seamless coordination and cooperation among disparate components, fostering a more cohesive and streamlined search experience. Furthermore, it facilitates the leveraging of AI technologies alongside conventional methods, thereby maximizing the benefits derived from each approach.

In essence, prioritizing a systematic approach to integration not only enables the efficient utilization of AI in information retrieval but also fosters innovation and optimization across the entire process. By transcending isolated considerations and embracing synergy, researchers can unlock new avenues for advancing the effectiveness and scalability of scientific information retrieval systems.

An information resource (IR) within this context denotes a repository of scientific and educational information, distinguished by its bibliographic description and full-text content. IR encompasses a diverse range of sources, including books, journals, scientific articles, reports, and other pertinent materials. It's worth noting that IR can extend beyond traditional text-based formats to encompass multimedia sources such as audio and video content. The primary objective revolves around enhancing the efficiency of IR retrieval from vast datasets and presenting it to users in an accessible and user-friendly format.

The objective of this endeavor is to enhance the effectiveness of searching for scientific and educational information, referred to as information resources, by leveraging artificial intelligence (AI) methods integrated into the comprehensive intelligent information system known as "SMART TUIT."

The article presents the outcomes of both theoretical inquiries and practical applications conducted by various departments of Tashkent University of Information Technologies (TUIT), addressing the following key challenges:

- Speech recognition for generating search queries: Research endeavors aimed at developing systems capable of recognizing speech inputs and converting them into search queries for subsequent processing.
- Pattern recognition to identify users of information resources: Investigations focused on implementing pattern recognition techniques to identify and authenticate users accessing information resources.
- Search and processing of scientific and educational resources in electronic libraries: Efforts directed towards optimizing the search and processing capabilities within electronic library environments, enhancing accessibility to scientific and educational materials.
- Analysis of information needs of users: Research initiatives aimed at analyzing the information requirements of users, taking into account their level of expertise and specific areas of activity.
- Assessment of scientific and educational information: Studies aimed at evaluating the quality and relevance of scientific and educational information to identify the most significant sources beneficial to users.
- Geographic information systems: Research activities focused on developing geographic information systems to address spatial-related challenges in locating information sources.
- Information security: Measures undertaken to ensure the security of the system, including protecting databases, especially the full-text information database, and safeguarding user databases from unauthorized access.

Through these comprehensive research efforts, the article contributes to advancing the capabilities of the integrated intelligent information system "SMART TUIT" in effectively addressing the diverse needs of users in accessing scientific and educational information.

Initially, each research area focused on addressing specific problem domains such as medicine, linguistics, electronic libraries, corporate networks, and information security systems. However, recognizing the potential synergies, the creative team at TUIT opted to consolidate their efforts and apply the accumulated results to tackle the crucial challenge of enhancing the discovery of scientific and educational information sources. Within this article, particular emphasis is placed on elucidating the capabilities of voice recognition subsystems, as well as assessing and retrieving information effectively.

The scope of this article encompasses research materials pertaining to three specific subsystems: "Speech Recognition," "Information Retrieval," and "Evaluation of Scientific and Educational Information." Notably, discussions on other subsystems such as "Pattern Recognition" and "Information Security" are deferred to subsequent articles within the conference collection. Additionally, references are made to previously published articles where more detailed information on these subsystems is available. This approach ensures a comprehensive coverage of relevant topics while facilitating a deeper exploration of specific subsystems in dedicated articles.

II. Materials and Methods

The functional structure of the integrated intelligent information system "SMART TUIT" is presented in Fig. 1.

The "Data Input" subsystem of the integrated intelligent information system "SMART TUIT" is primarily responsible for inputting all initial data necessary for creating databases, as well as generating search queries. It features a dedicated interface that facilitates the selection of the relevant section or database into which specific data is to be entered.

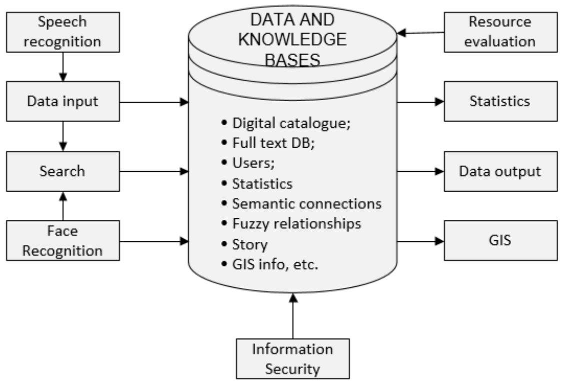

Fig.1 Functional structure of SMART TUIT

This subsystem serves as the initial entry point for populating the system's databases with essential information, streamlining the organization and accessibility of data for subsequent retrieval and analysis tasks.

III. Results and Discussion

Several databases are formed in the integrated system:

- DB1 "Electronic catalogue";
- DB2 "Full-text electronic literature";
- DB3 "User";
- DB4 "Statistics";

- DB5 “Speech Corpus”;
- DB6 “Assessing information resources”

In the DB1 database, an electronic catalog is established utilizing metadata in the internationally recognized DUBLIN CORE format. This format is widely employed in library activities worldwide [4] for the presentation of electronic resources. Utilizing international communication formats for bibliographic information facilitates swift data exchange between libraries, whether within corporate networks or on an international scale.

The record structure of an information source unit in DB1 is delineated as follows:

DB1::= < Term 1> < Term 2> < Term 3> ….< Term 16>< Term 17>< Term 18>,

Term 1 – this is the information resource ID metadata (ID IR);

Term (2-16) – this is the DUBLIN CORE metadata;

Term 17 – this is an indicator characterizing the Evaluation of an information resource;

Term 18 – indicator of the location(s) of the information resource (for example, the ID of the library where this information resource is available). This information is needed for the operation of the GIS subsystem.

DB2 “Full-text electronic literature” includes an information resource in electronic format:

DB2:: = <ID IR><FT>,

FT – full text file IR.

The DB3 User database is created based on the following metadata:

DB3:: = <ID USER><NAME><SONAME><Face ID> <LIST of keywords><OTHERS>

LIST of keywords – a list of queries submitted by the system user. This important indicator is formed while the user is working with the system. It is needed to analyze user needs.

Face ID is a photo (image) of the user. It is necessary for the functioning of the “Pattern Recognition” subsystem.

OTHERS – this section includes additional information about the user, filled out at his request (for example, phone number, email, etc.).

DB4 "Statistics" includes information about the frequency of use of the information resource, when (date) the resource was downloaded, the ID of the user who used the resource.

DB4:: <ID IR><ID USERS><DATE>

This information allows you to track the relevance of information sources and is used in their evaluation. DATE – information about the date of use of the IR.

DB 5 is a “Speech Corpus of the Uzbek Language” and includes a synchronized text-audio pair.

DB5::= <ID TEXT ><ID USER><AUDIO PATH>

ID TEXT – represents the identification number of each text that is associated with the audio file. This identifier can be used to associate an audio file with the corresponding text that was spoken in that audio file.

ID USER – field contains information about the speaker of the audio file, that is, about the person whose speech is recorded in the audio file. This numeric identifier associates an audio file with a corresponding user in the database.

AUDIO PATH - Specifies the path to the audio file of the speech corpus, which allows the database to find and access the corresponding audio file.

A. “SEARCH” Subsystem

The “Search” subsystem includes functions for searching scientific and educational information from the DB1 database. It interacts with the subsystems “Speech Recognition” (for entering a query after processing a voice command), “Pattern Recognition” (for searching data in the DB1 and DB3 database corresponding to the user image). This subsystem allows you to increase the efficiency of search through: 1) user identification; 2) reducing registration time; 3) use of search history. In this case, the system gives recommendations to the user on received “fresh” IRs, using previously received requests.

B. “SPEECH RECOGNITION” Subsystem

Numerous methods and tools for processing speech commands have been developed and extensively documented in scientific literature. Valuable results have been achieved particularly in the domain of speech processing for languages such as English, Russian, French, Spanish, Chinese, and others. However, the subsystem discussed below is specifically tailored for processing speech in the Uzbek language. Uzbek differs significantly from other languages, not only in terms of vocabulary but also in sentence structure, phonetics, and other linguistic characteristics. Therefore, specialized approaches are required to effectively process Uzbek speech, taking into account its unique linguistic attributes.

While there exist numerous methods and software tools aimed at enhancing listening, reading, and writing skills in language learning, there is often insufficient focus on methods and information technologies to improve speaking proficiency. It is crucial to emphasize the development of speaking skills as they are fundamental for effective communication in various contexts, including business and industrial relationships. Mastery of correct pronunciation of sounds, words, and sentences is essential for facilitating smooth and clear communication, underscoring the importance of dedicating attention and resources to the enhancement of speaking abilities in language education.

The primary objective of this subsystem is to transform spoken words into formats suitable for subsequent processing by the "Search" subsystem.

In accordance with the functional structure of SMART-TUIT, the speech recognition module is tasked with executing user requests directed towards literary sources. The laboratory of speech technologies has developed speaker-independent programs capable of analyzing continuous Uzbek speech in real time, without any vocabulary constraints [5], [6]. The process of constructing automatic speech recognition programs constitutes a comprehensive technology for preparing and processing information, encompassing the following key stages:

- Creation of a speech corpus: Compilation of a comprehensive collection of speech samples representing various linguistic elements and contexts.
- Selection of informative features of the speech signal: Identification and extraction of relevant features from the speech signal that are indicative of distinct linguistic components.
- Design of acoustic and speech recognition language models: Formulation of statistical models that capture the probabilistic relationships between acoustic signals and linguistic units, facilitating accurate speech recognition.
- Development of neural network architecture for speech recognition: Construction of neural network architectures tailored for speech recognition tasks, leveraging advanced machine learning techniques to enhance performance.
- Creation of automatic speech recognition modules: Implementation of software modules integrating the aforementioned components to achieve robust and efficient automatic speech recognition capabilities.

Through these concerted efforts, the speech recognition subsystem of SMART-TUIT is equipped to effectively process spoken input, enabling seamless interaction with literary sources and facilitating user queries with enhanced accuracy and efficiency.

The creation of a speech corpus involves the collective reading of texts by groups of speakers representing various demographics, including different ages, genders, and pronunciation patterns, utilizing office and web technologies. The corpus comprises texts sourced from widely accepted materials such as books, magazines, and internet sources.

Text preparation for announcers involved several steps, including the insertion of spaces between sentences, removal of ambiguous characters, conversion of numerical data into text, and segmentation of sentences into manageable lengths.

Algorithms for extracting informative features encompass a range of techniques, including filtering, segmentation, and spectral analysis of speech signals captured from microphones. Additionally, compressed cepstral analysis of selected fragments is performed [5].

For the development of acoustic models for the Uzbek language, deep neural networks have been employed, including recurrent networks, Hopfield networks, and "coder-decoder" processing modes [7-10]. Furthermore, for the implementation of N-gram language models, LSTM-LM networks (Long Short Term Memory networks – Language model) have been utilized, alongside Softmax normalization layers [6]. These advanced techniques enable the creation of robust and accurate models for speech recognition, enhancing the performance and adaptability of the speech recognition subsystem within the SMART-TUIT system.

The automatic speech recognition module allows you to combine the parameters of acoustic and speech models of speech processing. These stages make it possible to implement an automatic recognition mode for continuous input speech spoken directly by the user of the system. The general diagram of the automatic user speech recognition mode is shown in Fig. 2.

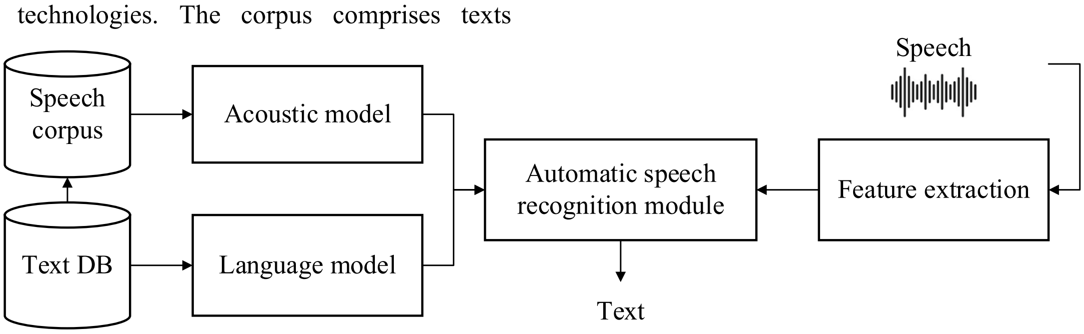

Fig.2. Diagram of speech recognition procedures

The language model of the Uzbek language is implemented on the basis of training a deep neural network Transformer, a detailed architecture of which is given in [6, 11] using a multi-hour speech corpus containing a pair of audio and its corresponding text. To competently form the necessary speech corpus of the Uzbek language, a telegram bot has been developed [11, 12]. The current volume of the generated speech corpus is 1535.3 hours of literary speech by speakers of various genders and ages, who uttered ~3.12 million sentences, of which 206 thousand are non-repeating words.

C. *"STATISTICS" Subsystem*

The "Statistics" subsystem allows you to generate a summary table of resource use for a period, who uses the database most often, what literature is in greatest demand, and how many times IR has been downloaded. The subsystem includes standard procedures for processing statistical information widely used in information and library systems and generates DB4. This information is used for library collection management as well as IR assessment.

D. *"RESOURCE EVALUATION" Subsystem*

The purpose of the information resource assessment subsystem in an integrated intelligent information library system is to extract the most valuable and relevant information resources based on user requests. The variety of purposes for assessing information sources, a large number of parameters reflecting the content and characteristics of information sources, as well as changes in information assessments depending on time complicate the issue of assessing sources of scientific and technical information.

The assessment of the source of information is carried out according to two types of criteria: objective and subjective [13], [14]. Objective criteria include the following indicators: 1) novelty of information (date of publication); 2) frequency of use of the resource (how many times users accessed the resource; 3) type of resource (book, scientific article, report, etc.); 4) ease of access (paid, free, open access, etc.). Subjective criteria (assessed by experts): 1) relevance; 2) completeness of information; 3) scientific novelty; 4) the authority of the author (indicators of the author of the publication).

In the SMART TUIT system, the "Evaluation" subsystem is associated with the "Statistics", "Full-text database" and "Data extraction" subsystems (Fig. 3).

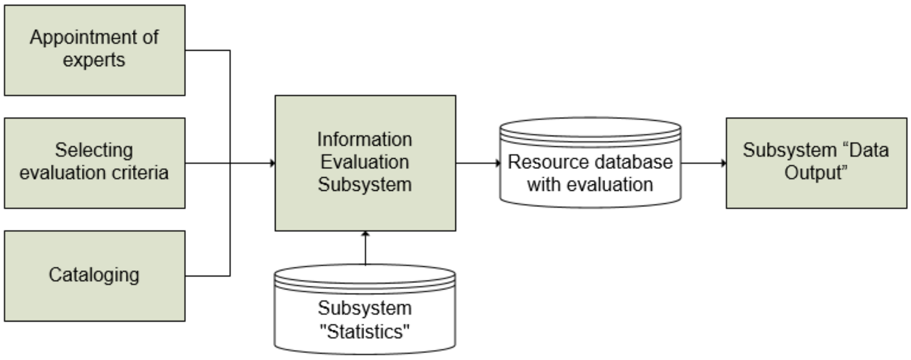

Fig. 3. Functional structure of the subsystem "Assessment of information resources"

Expert review or machine learning algorithms can be used to evaluate library resources. Highly qualified library specialists, as well as scientists, are involved as experts. The process of evaluating information sources can occur during cataloging or later.

Of course, the value of information depends on several factors, such as the purpose, interests, needs and level of knowledge of the recipient. However, you can improve your information retrieval efficiency by assessing the suitability of the information source for your specific area of study or the needs of your user group. For example, to assess the compliance of a library resource with the needs or requests of a certain group of users, a fuzzy variable Ω_R ="Compatibility of the resource with user needs" is introduced, taking fuzzy values $M = \{M_1, M_2, M_3, M_4, M_5\}$. Here M_1 = "Unsuitable", M_2 = "Partially suitable", M_3 = "Moderately suitable", M_4 = "Almost suitable", M_5 ="Completely suitable" are the meanings of the term. To determine the support of the set Ω_R, consisting of M thermal values, you can use the point method of expert assessment. This method is described in detail by the authors in [15].

In the SMART TUIT system, the information assessment subsystem works according to the following scheme (Fig. 4).

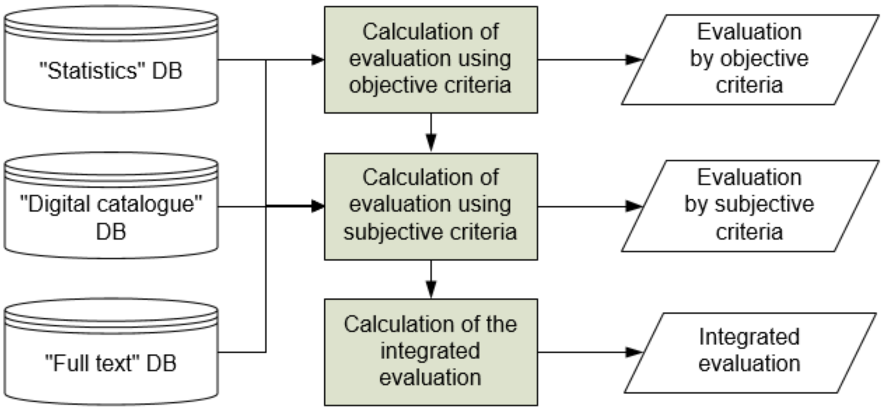

Fig.4. Integrated assessment calculation scheme

Calculation of assessment based on objective criteria. This function works directly with the Statistics subsystem. "Statistics" calculates the number of hits to the source of information and records this data in a special field. (<ID> <number of references>).

Calculation of assessment based on subjective criteria. Experts are invited to evaluate according to the above subjective criteria. Experts are librarians who specialize in cataloging and compiling library collections in a particular field of knowledge, as well as specialists (scientists, teachers, etc.) working in this field.

Calculation of the integrated assessment. At this stage, all ratings are summed up and divided by the number of evaluation criteria. So we can get an average assessment of the information resource:

$$\mathrm{EoI} = \frac{\sum_{i=0}^{i} s_i + \sum_{j=0}^{j} o_j}{i+j} \quad (1)$$

where i is the number of subjective criteria; j – number of subjective criteria; s_i – sum of subjective assessments; o_j – sum of subjective assessments; EoI is the overall assessment of the resource.

Subjective assessment of IR is the most complex process. This is because IR is difficult to evaluate unambiguously for the following reasons: 1) scientific and educational information is constantly updated, new methods, models, technologies and, accordingly, new publications appear; 2) it is difficult to regularly attract highly qualified experts to assess IR. To increase the objectivity of assessments, it is necessary to attract more experts to assess the same IR; 3) the volume of information being assessed increases, which complicates the assessment process itself. To process subjective assessment, a fuzzy compositional correspondence model is proposed [16].

In general, the price of information is dynamic and can change depending on changes in the information needs of users, the development of science and the conditions for using information. However, the subsystem makes it possible to improve the efficiency of information retrieval by providing users with valuable information that meets their needs.

IV. CONCLUSION

Research has demonstrated that integrating individual research results and subsystems can lead to a synergistic effect, resulting in overall outcomes that surpass what could be achieved by utilizing separate subsystems in isolation. At each stage of processing and generating a request and acquiring the necessary information, the system yields specific benefits:

- Reduced search time: Integration streamlines the information retrieval process, leading to quicker access to relevant data.
- Increased reliability: The integrated approach enhances the accuracy and correspondence of responses to user queries.
- Enhanced completeness: Users benefit from a wider range of options when selecting from the proposed list of information sources.

Significant progress has been made in the development of individual voice recognition subsystems specifically tailored for the Uzbek language. By leveraging intelligent algorithms for speech analysis and synthesis, computer programs have been devised to facilitate language learning within a comprehensive service delivery framework. This subsystem can be applied across all stages of the learning process, including mastering new material, reinforcement, repetition, and monitoring learning quality.

The "Information Source Evaluation" subsystem plays a pivotal role, particularly when processing large volumes of information and generating extensive results from user queries. Integration with other subsystems enables the identification of the most valuable information sources within the existing database, thereby enhancing the quality of data retrieval.

The ongoing efforts of the creative team focus on various research areas, including processing queries in textual form in addition to keywords, developing methods for semantic analysis of search queries, and enhancing geographic information systems to pinpoint the location of information sources. These endeavors aim to further enhance the capabilities and effectiveness of the integrated intelligent information system, ensuring its continued relevance and utility in meeting user needs.

REFERENCES

[1] A. I.Kapterev, Cognitive management and artificial intellect in libraries:Possibilities and highlights // Scientific and technical libraries. 2023. No. 6. P. 113–137. https://doi.org/10.33186/1027-3689-2023-6-113-137.

[2] Asefeh Asemi, Andrea Ko and Mohsen Nowkarizi, Published by Emerald Publishing Limited. Intelligent libraries: a review on expert systems, artificial intelligence,and robot. Library Hi Tech Vol. 39 No. 2, 2021 pp. 412-434 Emerald Publishing Limited 0737-8831.DOI 10.1108/LHT-02-2020-0038

[3] G. Liu, "The application of intelligent agents in libraries: a survey", 2011, Program, Vol. 45 No. 1, pp. 78-97, doi: 10.1108/00330331111107411.

[4] DCMI Metadata Terms. https://www.dublincore.org/ specifications/dublin-core/dcmi-terms/

[5] M. Musaev, I.Khujayorov, M Ochilov, The use of neural networks to improve the recognition accuracy of explosive and unvoiced phonemes in Uzbek language. 2020 Information Communication Technologies Conference (ICTC). China, 2020. -pp. 231-234.

[6] M. Musaev, S. Mussakhojayeva, I. Khujayorov, Y. Khassanov, M.Ochilov, H.A. Varol, USC: An Open-Source Uzbek Speech Corpus and Initial Speech Recognition Experiments. Speech and Computer 23rd International Conference, SPECOM 2021. St. Petersburg, Russia, September 27–30, 2021, Proceedings. – pp. 437-447.

[7] A.V. Sozykin, An Overview of Methods for Deep Learning in Neural Networks.. Bulletin of the South Ural State University. Series: Computational Mathematics and Software Engineering. 2017. vol. 6, no. 3. pp. 28–59. (in Russian) DOI: 10.14529/cmse170303.

[8] A.Graves, Jaitly, N. Towards end-to-end speech recognition with recurrent neural networks. In Proceedings of the International Conference on Machine Learning, Beijing, China, 21 June–26 June 2014; pp. 1764–1772.

[9] Yeh, C., Wang, Y., Shi, Y., Wu, C., Zhang, F., Chan, J., & Seltzer, M.L. (2021). Streaming Attention-Based Models with Augmented Memory for End-To-End Speech Recognition. 2021 IEEE Spoken Language Technology Workshop (SLT), pp. 8-14.

[10] Sak, H.; Shannon, M.; Rao, K.; Beaufays, F. Recurrent Neural Aligner: An Encoder-Decoder Neural Network Model for Sequence to Sequence Mapping. In Proceedings of the INTERSPEECH, ISCA, Stockholm, Sweden, 20–24 August 2017; pp. 1298–1302.

[11] Mukhamadiyev, A., Mukhiddinov, M. , Khujayarov, I., Ochilov, M., Cho, J., Development of Language Models for Continuous Uzbek Speech Recognition System, Sensors 2023, 23(3), 1145; https://doi.org/10.3390/s23031145

[12] Musaev M., Khujayorov I., Ochilov M., Speech Recognition Technologies Based on Artificial Intelligence Algorithms, 14th International conference intelligent human computer interaction, Tashkent, Uzbekistan, October 20-22, 2022, https://doi.org/10.1007/978-3-031-27199-1

[13] Ramasamy, Ammuthavali & Ali, Nor'ashikin. (2021). High value information for managers in organisations. electronic Journal of Computer Science and Information Technology. 7. 10.52650/ejcsit.v7i1.110.

[14] Bendechache, Malika & Limaye, Nihar & Brennan, Rob. (2020). Towards an Automatic Data Value Analysis Method for Relational Databases. 10.5220/0009575508330840.

[15] Rakhmatullaev M., Normatov Sh. Formalizing the processes of evaluating the characteristics of scientific and educational

information resources. International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan, 2022, pp. 1-4, doi: 10.1109/ICISCT55600.2022.10146831.

[16] M. Rakhmatullaev, S. Normatov, and F. Bekkamov, “FUZZY RELATIONS BASED INTELLIGENT INFORMATION RETRIEVAL FOR DIGITAL LIBRARY USERS”, ETR, vol. 2, pp. 80–83, Jun. 2023, doi: 10.17770/etr2023vol2.7218.