Reflex Systems of Natural Language Processing in Educational Management Information Systems

Mykola Kubiavka[1], Serhii Lienkov[1], Yurii Khlaponin[2], Liubov Kubiavka[1]; Andrii Bernaz[3], and Kyrylo Pyrogov[1]

[1] *National Taras Shevchenko University of Kyiv, Volodymyrska str. 64, Kyiv, 01034, Ukraine*
[2] *Kyiv National University of Construction and Architecture 31Povitroflotskyi ave, Kyiv, 03037, Ukraine*
[3] *Command of the Ground Forces of the Armed Forces of Ukraine, Degtyarivska str. 19/7, Kyiv, 02000, Ukraine*

Abstract

This article describes the possibility of creating reflexive intellectual systems for processing natural language information based on the mathematical apparatus of the theory of non-force interaction and the prospects of building information and communication systems and technologies for managing the quality of education based on them. Tasks that can be solved by such systems are classified. It was determined that the proposed model differs from the existing ones by identifying differences in the conditional probabilities of the appearance of message addressees as the amount of informational influence of fragments of natural language text, which made it possible to automatically determine the most likely addressees of this text. The developed technology meets the requirements for simplicity, is informative and easy to understand, and is minimally expensive. The authors share the experience gained during the creation of this kind of technology and show its advantages both for computational linguistics and for information and communication systems and technologies for quality management of education.

Keywords

Information Technology, natural language text, reflexive approach, methods of information management, Information and Communication Systems and Technologies

1. Introduction

A characteristic feature of today is the intensively developing and implemented informatization processes in almost all spheres of human activity. They led to the formation of a new information infrastructure, which is associated with a new type of social relations and the use of information and communication technologies (ICT).

The modern stage of informatization of education is also associated with the wide introduction of methods and means of information and communication systems and technologies into the education system, the creation of a computer-oriented information and communication environment on this basis, and the filling of this environment with electronic scientific, educational and management information resources, with the provision of opportunities for the subjects of the educational process to access the resources of the environment, use its means and services when solving various tasks. At the same time, without the use of modern means of processing natural language information, it is impossible to count on the convenience and effectiveness of using such systems in the conditions of quality management of education. It is clear that in such a complex field as the management of the quality of education, where the activities of managers and specialists are related to the processing of a significant amount of data, it is impossible to do without the use of natural language information processing tools. But the modern

Ukrainian market of information technologies (IT) does not offer educators a wide selection of instrumental intelligent systems that could be used with the lowest costs for processing natural language texts in the management of the quality of education.

Therefore, there is a need to create problem-oriented intellectual systems capable of "selecting" information necessary for managers and education specialists from the natural language presentation of various categories of projects in education and applying it to solve the problems of planning educational activities, managing the quality of education, managing the cost of education, managing risks, etc.

It is proposed to take the theory of information (non-force) interaction as a scientific and methodological basis for solving this task. Within the framework of this theory, not only the apparatus for forecasting the development of systems based on the interaction of people was created, but also the mathematical apparatus for the formalization of the soft component, also generated by human activity, was provided.

The purpose of the work is to create, using the mathematical apparatus of the theory of non-force interaction, models, methods and means of formalizing natural language information, on the basis of which it would be possible to create economically profitable, effective, simple and competitive ICT systems for the management of the quality of education and educational management. This work is dedicated to the development of such a reflexive intellectual system.

2. Related works

Education management information systems (EMIS) enable officials to be constantly informed when developing the foundations of state education policy and to make final decisions based on reliable information. Considering this, the requirements for the formation of educational databases are very high, because poor-quality educational information can have far-reaching negative consequences, including the adoption of incorrect management decisions regarding the distribution of limited resources. In view of the above, the development of data information systems and their integration should be the basis of state management of the education system [1-3].

The effectiveness of the construction of means of automated management of the quality of education largely depends on the linguistic means of describing objects and management processes. In connection with this, there are many studies on the construction of natural language processing systems [4-25]. Modern natural language information processing systems, which arose at the intersection of computational linguistics and information retrieval systems [4], are systems that are poorly adapted to solving the problems of formalizing management information, especially in the direction of educational activities.

The modern Ukrainian market of information technologies (IT) does not offer educators a wide selection of instrumental intellectual systems that could be used with the lowest costs for processing natural language texts in the management of the quality of education.

Known domestic and foreign natural language information processing systems are, for the most part, experimental and highly specialized and do not fully satisfy the requirements of automated information processing systems in education management. And although the Ministry of Education and Science of Ukraine adopted the "Automated Information Complex of Educational Management" software and hardware complex in 2021, its main purpose remains to ensure the transition to electronic document management and access to aggregated depersonalized data for automatic reporting. In addition, the costs of creating, maintaining, and modernizing such a complex are significant [5].

But nevertheless, without such means, the productivity of information and communication systems when filling the information base of education management is significantly reduced, and the costs of performing routine actions, such as the formal presentation and input of information, searching in the information base, etc., increase [5].

The use of natural language processing systems in education management is associated with a number of specific features of this branch of activity, significant duration and complexity of the process of creating an educational product, significant changes in documentation during the implementation of such projects, incompleteness of documentation, low reliability of information sources, diversity of source documentation, which is formed at the request of various users, by the difficult formalization of most of the source documents. Accordingly, the requirements and limitations for natural language text

processing systems are determined by mobility, reliability, high productivity, ease of changing the information base, and decentralization of the data processing process.

To date, within the framework of the theory of informational (non-force) interaction, not only the apparatus for forecasting the development of systems based on human interaction has been created, but also the mathematical apparatus for the formalization of the soft component, also generated by human activity, has been provided. Today, in addition to managing the development of complex systems, the theory is also used to manage enterprises [11], programs and projects [12], to build decision-making training systems, diagnose cardiovascular diseases [13], in voice control systems for technical devices [14] and others. That is why, by applying the mathematical apparatus of the theory of non-force interaction in the management of the "soft" component, it is possible to achieve the set goal, that is, it will be possible to obtain formal (numerical) models that will make it possible to make accurate forecasts about the result of informational influence and distribute information about the management of the quality of education to its addressees.

3. Methods / Methods and Materials

The effectiveness of the construction of means of automated management of the quality of education largely depends on the linguistic means of describing objects and management processes [15]. Therefore, the adaptability and mobility of the languages of communication with the "computer", the non-procedural character of the description of objects and management processes, and the use of "contexts" and "silencing" are indispensable conditions for the rational construction of linguistic means. These requirements have a contradictory nature, due to the orientation towards non-professional users, on the one hand, and limited possibilities (both theoretical and technical) on the other.

The resolution of this contradiction is related to:

1. With the division of incoming information flows into those that are formalized (and, accordingly, require traditional dialog software tools for their processing) and those that are difficult to formalize (require significant costs for formalization);

2. Using the results obtained in the theory of non-force interaction for the construction of natural language information processing tools [15].

In order to build effective information and communication systems and technologies for the management of the quality of education, according to the authors, it is necessary to carry out the following preparatory work:

- to study the object and situation in which the processing of natural language information is carried out;
- choose a strategy, tactics, and means of processing natural language information;
- determine the most influential forms of information presentation and develop models and methods of their formation with the help of all available means of presenting (proving) information;
- to develop a system for analyzing the effectiveness of information provided and its correction in case of insufficient action.

The requirements for these tools are based on an understanding of the conditions in which educators find themselves, the sources and quality of the information received, as well as ways of forming various information representations.

Based on this, the following requirements are:

1. Simplicity.
2. Multifacetedness.
3. Algorithmic clarity.
4. The possibility of systematization of the main processes of information management.
5. Openness.

These requirements will be provided in further research:

1. By developing templates and methods for automatically determining the most influential ways of presenting information (simplicity).

2. The use of various information management tools, the choice of which will depend on the information needs regarding the required result (multifacetedness).

3. Formal methods of presenting management tools (algorithmic clarity).

4. Development of standards for information interaction, focused on transforming the presented information into awareness (the possibility of automating the main processes of information processing).

5. The possibility of access to means of providing information from many workplaces (openness).

So, let's formalize the task of applying natural language information processing systems for decision-making in education quality management. This task is formulated as follows: it is necessary to perform such actions (or to make certain decisions) in the educational project that corresponds to the semantic and pragmatic content of the natural language text.

4. Experiment

To solve this problem, and based on the informational redundancy of natural language, we will divide the input text into clusters, among which there will usually be those that determine the reaction required under the given conditions. Since it is impossible to know in advance which clusters these are, we will form a number of combinatorial regularities of the input text and, in the process of learning, select those that have the greatest impact on the decision. This is determined based on the following model:

1. The set of elements of natural language affecting decisions is divided into clusters containing parameters (1):

$$X = \{x_i\}, i = \overline{1,q},\tag{1}$$

where X is the input text; x_i – is the cluster influencing the decision; q is the number of clusters.

2. According to the frequency characteristics, it is possible to determine the approximate values of the probability of each of the decisions (each of the actions), provided that one or another cluster is encountered (2):

$$\in R, x_i \in X: p(R_j / x_i) \approx n(Rj / x_i),\tag{2}$$

where $n(R_j / x_i)$ – is the frequency of action (decision) R_j, provided that the cluster x_i was present in the input text; $p(R_j / x_i)$ – is the probability of action (decision) R_j, provided that the cluster x_i was present.

3. For each action (decision) R_j given the unconditional probability $p(R_j)$ and individual conditional probabilities $p(R_j / x_i),...,p(R_j / x_1),...,p(R_j / x_q)$, it is necessary to estimate the joint conditional probability of this solution (action) $p(R_j / x_1,…, x_i,…, x_q)$.

Since, in this interpretation, the decision-making process can be represented as the process of determining the most significant informational influences of the input text on a set of actions (decisions), we will use an approach based on the mathematical apparatus of the theory of non-force interaction to solve this problem. The measure of assessing the situation, relative to the solution in the theory of non-force interaction, is determination and awareness. The relationship between certainty and probability is given by formula (3):

$$d = \begin{cases} 0,5 \times \sqrt{\frac{p}{1-p}+\frac{1-p}{p}-2}, & when\ p \geq 0,5 \\ -0,5 \times \sqrt{\frac{p}{1-p}+\frac{1-p}{p}-2}, & when\ p < 0,5 \end{cases}\tag{3}$$

where p – decision probability; d – certainty of this decision.

The relationship between awareness and probability is given by formula (4):

$$i = \frac{0,5}{\sqrt{p \times (1-p)}}.\tag{4}$$

A measure of non-force action $b_j \in B$, $j = \overline{1,n}$ should reflect the difference in certainty and awareness of "before" and "after" changes in the subject area. And it is precisely the change in certainty and awareness that is the cause of the change in probability (5)

$$d_0 \to d_j \land i_0 \to i_j \implies p_0 \to p_j,\tag{5}$$

where p_0 – probability of decision (action) R_0; d_0 – certainty of decision (action) R_0; i_0 – awareness of the decision (action) R_0; d_j – certainty of decision (action) R_0, which is formed by a cluster of input text $b_j \in B$, i_j – awareness that corresponds to certainty d_j; p_j – probability of decision (action) R_0 given by all clusters $b_j \in B$.

At the same time, applying the mathematical apparatus of the Theory of non-force interaction, we obtain (6,7):

$$d_0 = \pm 0,5\sqrt{\frac{p}{1-p} + \frac{1-p}{p} - 2}; \; i_0 = \frac{0,5}{\sqrt{p_0 \times (1-p_0)}}, \qquad (6)$$

$$d_j = \pm 0,5\sqrt{\frac{p_j}{1-p_j} + \frac{1-p_j}{p_j} - 2}; \; i_j = \frac{0,5}{\sqrt{p_j \times (1-p_j)}}. \qquad (7)$$

It is necessary to find a transition from the difference in the certainty of the decision (action) R_0 in case there is a cluster in the text $b_j \in B$ to the certainty of decision-making R_0 given by all clusters of the input text (8)

$$\forall d_j, i_j : d_0 \to d_\Sigma \; ^\wedge i_0 \to i_\Sigma \quad \Rightarrow \quad p_\Sigma = 0,5 + \frac{d_\Sigma}{2_\Sigma}, \qquad (8)$$

where d_Σ – certainty of decision R_0, which is formed by all clusters $b_j \in B$; i_Σ - awareness corresponding to certainty d_Σ ; p_Σ – the probability of the decision R_0 under the influence of all clusters included in the input text B.

To solve this problem, we will apply the mathematical apparatus of the theory of non-force interaction. The concept of building reflex intellectual systems, which is based on the mathematical apparatus of the theory of non-force interaction, implements the principles of universal modeling of regularities in a given subject area, which are statistically manifested. The basis of the functioning of reflex intellectual systems is the method of developing an adequate reaction of the intellectual system to all external influences. This method ensures the selection of the most probable reaction of the intelligent system to a set of input influences, with known probabilities of choosing a reaction to each input influence, as well as to some combinations of input influences.

5. Results

The reflex method directly calculates the response of the intellectual system adequate to the input influences (Fig. 1). The adequacy of the reaction was confirmed in previous experimental studies conducted by authors and covered in the relevant sources [12,16].
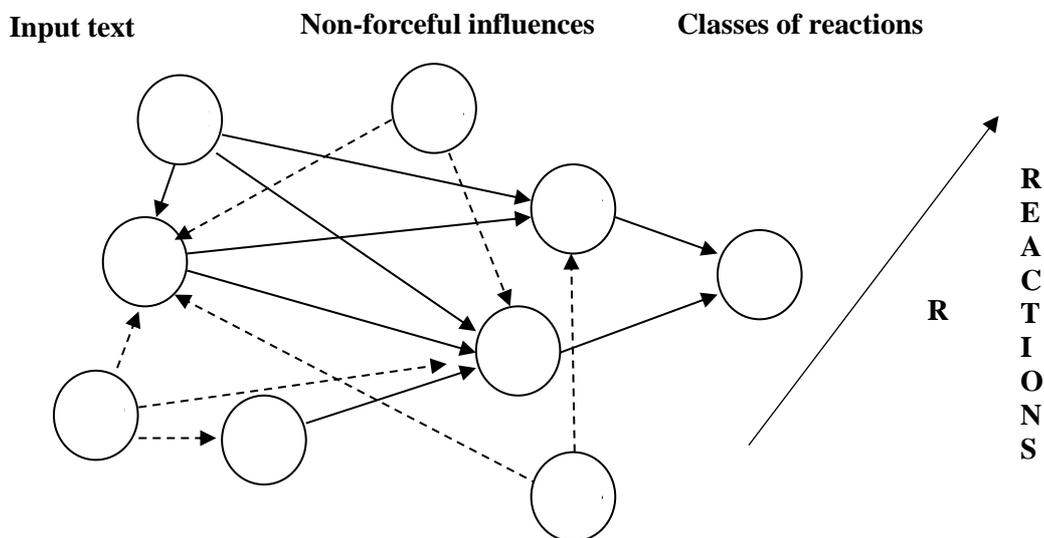
Note: those virtual objects that reflect the commonality of action (synergistic effect) are marked with a dotted line

Figure 1: Scheme for calculating the amount of influence in reflex intelligent systems

The method of calculating an adequate reaction to the meaning of the input text in the education management project has the following stages:

1. Calculation of the certainty of reactions in the project relative to the effects of text clusters. From (5)-(6):

$$d(R_i) = \pm 0,5\sqrt{\frac{p(R_i)}{1-p(R_i)} + \frac{1-p(R_i)}{p(R_i)} - 2}, \tag{9}$$

$$i(R_i) = \sqrt{d^2(R_i) + 1}, \tag{10}$$

$$d(R_i/A_j) = \pm 0,5\sqrt{\frac{p(R_i/A_j)}{1-p(R_i/A_j)} + \frac{1-p(R_i/A_j)}{p(R_i/A_j)} - 2}, \tag{11}$$

$$i(R_i/A_j) = \sqrt{d^2(R_i/A_j) + 1}, \tag{12}$$

where $p(R_i)$ – unconditional probability $p(R_i)$ choice of decision (action) R_i; $d(R_i)$ – certainty in the project regarding the decision (action) R_i; $i(R_i)$ – awareness in the project regarding the decision (action) R_i; $p(R_i/A_j)$ – the conditional probability of choosing a decision (action) R_i if present in the input text of the cluster A_j; $d(R_i / A_j)$ – certainty in the project regarding the decision (action) R_i, if present in the input text of the cluster A_j; $i(R_i/A_j)$ – awareness in the project regarding the decision (action) R_i, if there is a cluster in the input text A_j.

2. Calculation of the additional probability that input text clusters bring to the intelligent system (13):

$$\Delta d(R_i/A_j) = d(R_i/A_j) \times i(R_i) - d(R_i) \times i(R_i/A_j), \tag{13}$$

where $\Delta d(R_i/A_j)$ – changing the certainty of the decision (action) R_i if there is a cluster in the input text A_j.

3. Calculation of the total impact on decision-making managers or specialists who perform managerial actions (14):

$$\Delta d_\Sigma (R_i) = \sum_j \Delta d(R_i/A_j), \tag{14}$$

where $\Delta d_\Sigma (R_i)$ – changing the certainty of the decision (action) R_i. changing the certainty of the decision (action) R_i if there is a cluster in the input text A_j.

$$\Delta i_\Sigma (R_i) = \sqrt{\Delta d_\Sigma^2 (R_i) + 1}, \tag{15}$$

where $\Delta i_\Sigma (R_i)$ – change of awareness in the project, relative to the decision (action) R_i.

4. Calculation of the new certainty of decisions (actions) in the management of the quality of education (16):

$$\overline{d(R_i)} = \Delta d_\Sigma (R_i) \times i(R_i) + d(R_i) \times \Delta i_\Sigma (R_i), \tag{16}$$

where $\overline{d(R_i)}$ – new determination of the project management's attitude to the decision (action) R_i.

5. Selection of the most definite decision (action) R_k (17):

$$R_k : R_k \in R \wedge \overline{d(R_k)} = \max_i(\overline{d(R_i)}). \tag{17}$$

6. Discussion

During the creation of reflex systems for processing natural language information using the given method, it is necessary to solve two main tasks: to highlight in the input text and formalize the clusters that have the greatest impact, as well as the reactions of the management of the management of the quality of education with the accumulation of statistical information about the connections between them; adapt the reflexive algorithm to the features of natural language.

On the basis of the proposed model, one of the options for the application of the reflex system of natural language information processing has been developed.
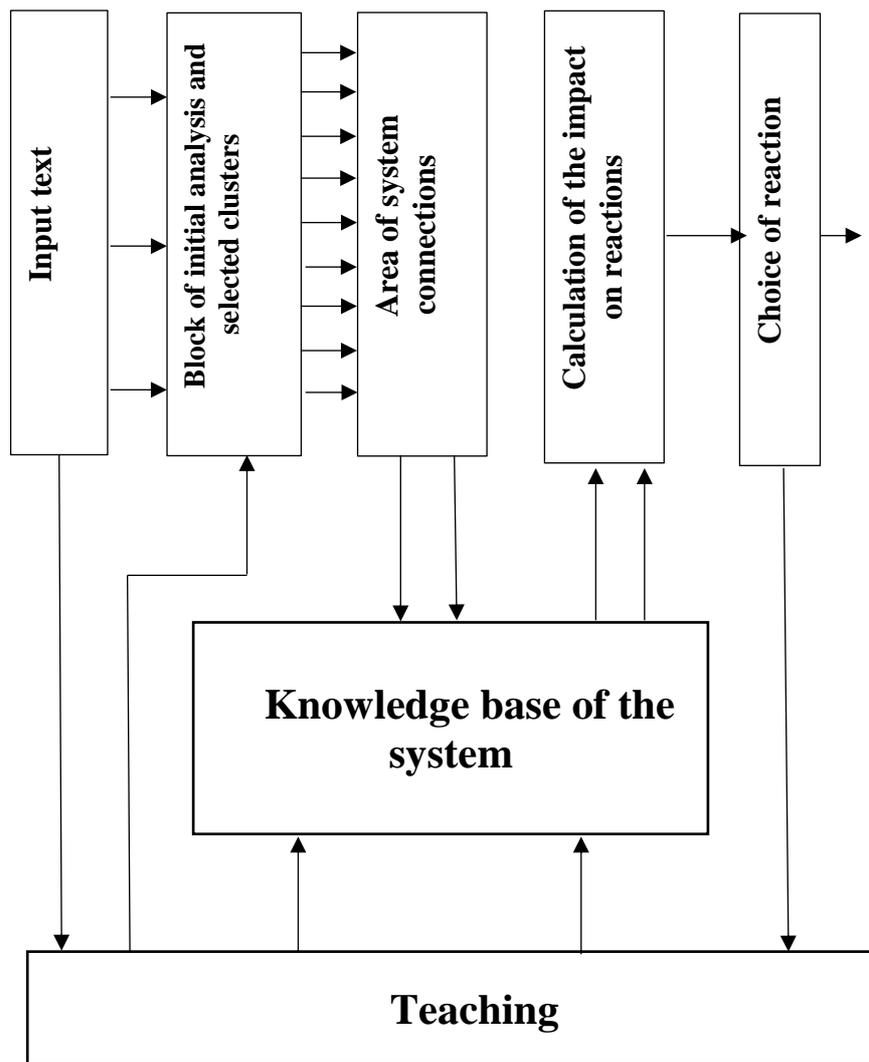
Input text

Block of initial analysis and selected clusters

Area of system connections

Calculation of the impact on reactions

Choice of reaction

Knowledge base of the system

Teaching

Figure 2: Scheme of information flows in the reflexive system of natural language information processing

On the basis of the proposed model, work on the development of a reflex system for processing natural language information was continued.

The main idea behind this system is the identification of the algorithm and the main parameters of the request for clusters of incoming natural language texts. The basis of the system is a mathematical model of non-force interaction in objects and processes that form natural language texts. This system will ensure the formation of the resulting, formal representation of the semantic component of the input text for its representation by means of natural language.

The filling of the system will be formed by a set of arbitrary clusters of input texts, description of reactions and statistical connections between clusters and reactions. Selection of the most informative clusters of input texts will be performed in the process of training the system.

During the processing of input information in the system, natural language communication tools will be used for:

- identification of the algorithm for solving the problem discussed in the natural language text;
- definition of the object and subjects of management;
- setting a time interval;
- formal representation of the parameters of the problem to be solved;
- presentation of components of education quality management in the information base.

With the help of the system, it is planned to solve a number of problems:

- formalization of the natural language text or its part;

- selection of the necessary information from the database of the information and communication system of education quality management and its presentation in a user-friendly form;
- making changes to the information representation of components (in the database). In particular, parameters of works, risks, cost, executors, responsible, etc.;

The system will implement three forms of interaction with the user, i.e. processing:

- text that is presented in the information base or obtained from external sources (for example, from the Internet);
- the user's input, which is typed on the keyboard;
- user appeal in oral language.

At the heart of the system is a reflexive model of behavior in the operating environment, which is ambiguously interpreted and will contain a set of programs that provide an interface between the user, the information base, means of filling the information base, the information retrieval system and the education quality management system.

Note that the system is not about "understanding" limited natural language, but about a system that perceives information representations in natural language without limitations.

7. Conclusion

Education is extremely important for socioeconomic development and cultural enrichment of society, providing people with relevant knowledge and skills to improve skills, and the ability to work productively in the conditions of further global development. For Ukraine, the task of effectively providing and organizing the education of pupils/students in the transforming education system, forming a new information mentality of all interested parties, is relevant. Solving this task requires constant monitoring and assessment of the state of the education system, which is based on the collection, processing of information, and analysis of educational data necessary to ensure the adoption of well-founded management decisions. Such information support makes it possible to implement modern education management information systems (Education Management Information Systems (EMIS)). The constant increase in the amount of professional knowledge and the high degree of development of information and communication technologies actualizes the problem of developing high-quality software products with elements of artificial intelligence designed to meet the information needs of users. The work of any intellectual system involves the processing of the knowledge base, which is its basis and has the property of gradually accumulating new knowledge. Intelligent systems must accumulate information, generalize it, and learn from their mistakes, using the knowledge base. Since the basis of an intellectual system, which is created as an application of the theory of non-force interaction, is the processing of various actions with the development of a reaction adequate to these actions, such systems are reflex (by analogy with the behavior of objects of living nature). The concept of building this reflex intellectual system implements the principles of universal modeling of regularities in a given subject area, which are statistically manifested. The method of developing an intelligent system response adequate to all external influences ensures the selection of the most probable response of the intelligent system to a set of input influences, with known probabilities of choosing a reaction to each input influence, as well as to some combinations of input influences.

In the process of this study, it was shown that the mathematical apparatus of the theory of non-force interaction is quite simple and convenient for building natural language text processing systems. The used mathematical apparatus will be the basis of the system of discrete processing of the semantics of texts in the management of the quality of education and educational management. In further work, it is planned to develop the structure and algorithms of the specified system and conduct its experimental verification in production conditions for the management of educational processes. The use of the developed new ICT will affect the development of the formed ICT environment, which is dynamic and open, which will allow to improve the process of management of educational institutions, improve and maximally direct their activities to increase the quality of education. The proposed model differs from the existing ones by identifying differences in the conditional probabilities of the appearance of message addressees as the amount of informational influence of fragments of natural language text, which made it possible to automatically determine the most likely addressees of this text. The developed technology meets the requirements for simplicity, is informative and easy to understand, and is minimally

expensive. Its foundation is based on the models and methods of influence process management developed by the authors [12, 16], and the obtained results bring our state closer and closer to the creation of competitive ICT for the management of the quality of education and educational management and bring us closer to the creation of full-fledged artificial intelligence. Currently, reflex intellectual systems solve various problems in the areas of human intellectual activity already today [11-14].

8. Acknowledgements

9. References

[1] S. Londar, Development of educational management information systems as a tool for the implementation of state educational policy: monograph of DNU "Institute of Educational Analytics", Kyiv, 2020, p.258.

[2] Y. Al-Mamary, A. Shamsuddin, N. Aziati, The Role of Different Types of Information Systems In Business Organizations: A Review. International Journal of Research (IJR), Vol. 1, 2019.

[3] H. Hua, J. Herstein, Education Management Information System (EMIS): integrated data and information systems and their implications in educational management. Harvard University. March, 2003. URL: http://www.infodev.org/infodev-files/resource/InfodevDocuments_188.pdf.

[4] D. Schiff, "Out of the laboratory and into the classroom: the future of artificial intelligence in education". AI and Society, 36, no.1, 2021. 331-348. URL: https://doi.org/https://doi.org/10.1007/s00146-020- 01033-8.

[5] Automated Information Complex of Educational Management, Ministry of Education and Science of Ukraine, 2021. URL: https://mon.gov.ua/ua/osvita/cifrova-osvita/avtomatizovanij-informacijnij-kompleks-osvitnogo-menedzhmentu.

[6] Dr.Gokul Shamrao Damre. Information and communication technology use in education. IJRAR January 2023, Volume 10, Issue 1, pp. 107-115.

[7] A. Ngao, G. Sang, J.E. Kihwele, Understanding Teacher Educators' Perceptions and Practices about ICT Integration in Teacher Education Program. Educ. Sci, 12, 549, 2022. URL: https://doi.org/10.3390/educsci12080549.

[8] K. Dominika, Machine Learning in Terminology Extraction from Czech and English Texts. Linguistic Frontiers, 0 (0), 2021. URL: https://doi.org/10.2478/lf-2021-0001.

[9] S. Lienkov, S. Gakhovych, I. Tolok, G. Zhyrov, V. Bakhvalov : An Option of Building the Distance Learning System with Artificial Intelligence Elements. COLINS 2021: 1194-1203.

[10] M. Pikhart, Intelligent information processing for language education: The use of artificial intelligence in language learning apps. Procedia Computer Science, 176, 1412-1419.

[11] X. Yang, A. Chen, N. PourNejatian, et al. A large language model for electronic health records. Npj Digit Med, 2022; pp. 1–9.

[12] L. Kubyavka, Management of impact projects in the informatization programs of higher educational institutions: synopsis for Ph.D. thesis in Engineering Science: 05.13.22, Kyiv National University of Building and Architecture, Kyiv, 2015.

[13] H.A. Khan, W. Jue, M. Mushtaq, & M. U. Mushtaq, Brain tumor classification in MRI image using convolutional neural network. Math. Biosci. Eng, 2020, vol. 17, no.5, pp. 6203-6216.

[14] I. Khan, V. Dagar, A. Saeed, Ch. Zhang, Environmental impact of information and communication technology: Unveiling the role of education in developing countries. Technological Forecasting and Social Change, 2022. Volume 178. URL: https://doi.org/10.1016/j.techfore.2022.121570.

[15] Yu. Teslya, Introduction to nature informatics. Maklaut, Kiev, Ukraine, 2010.

[16] M. Kubiavka, Models and methods of managing information support in the conditions of hybrid warfare: synopsis for Ph.D. thesis in Engineering Science: 05.13.06, Kyiv. Taras Shevchenko nat. uni. of Kyiv, 2017.

[17] Zha. Hong, Design of Information Teaching Management System Integrating Association Rule Mining Algorithm, BigIoT-EDU 2022: Application of Big Data, Blockchain, and Internet of Things for Education Informatization, pp. 439–445. doi: 10.1007/978-3-031-23950-2_48.

[18] S. Lenkov, M. Kubyavka, L. Kubiavka, Y. Lenkov, V. Shevchuk, Reflex Intellectual text processing systems: Natural language text addressing. CEUR Workshor Proceedings, 2019, pp. 85-95.

[19] G. Fantoni, E. Coli, F. Chiarello, R. Apreda, Dell'Orletta, F. and Pratelli, G. Text mining tool for translating terms of contract into technical specifications: Development and application in the railway sector, Computers in Industry, Volume 124, 2021, URL: https://doi.org/10.1016/j.compind.2020.103357.

[20] S. Kumar, A. Kar, and P. Ilavarasan, Applications of text mining in services management: A systematic literature review, International Journal of Information Management Data Insights, Volume 1, Issue 1, 100008, URL: https://doi.org/10.1016/j.jjimei.2021.100008.

[21] M. Köseoglu, F. Mehraliyev, M. Altin, and F. Okumus, Competitor intelligence and analysis (CIA) model and online reviews: integrating big data text mining with network analysis for strategic analysis, Tourism Review, Vol. 76 No. 3, 2021, pp. 529-552.

[22] S. Birunda, R. Devi, A Review on Word Embedding Techniques for Text Classification. In: Raj, J.S., Iliyasu, A.M., Bestak, R., Baig, Z.A. (eds) Innovative Data Communication Technologies and Application. Lecture Notes on Data Engineering and Communications Technologies, vol 59. Springer, Singapore, 2021. URL: https://doi.org/10.1007/978-981-15-9651-3_23.

[23] E. Bassignana, B. Plank, What Do You Mean by Relation Extraction? A Survey on Datasets and Study on Scientific Relation Classification. In Proceedings of the 60th Annual Meeting of the Association for Computational Linguistics: Student Research Workshop, Dublin, Ireland, 2022, pp. 67–83.

[24] T. Haddadi, Q. Haddadi, T. Mourabit, A. Allaoui, and M. Ahmed, Automatic analysis of the sustainability of public procurement based on Text Mining: The case of the Moroccan ICT markets, Cleaner and Responsible Consumption, Volume 3, 100037, 2021, URL: https://doi.org/10.1016/j.clrc.2021.100037.

[25] B. Baidena, J. Nimako-Koduab, V.K. Anyanfulc, D. Oppong, Management Information Systems and its Impact on Productivity in Higher Education: A Case of Colleges of Education in Ghana (IJC) Volume 45, No1, 2023, pp. 136-150.