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USE OF ONTOLOGY IN INFORMATION SYSTEM TO ASSIST IN THE FORMATION OF AN INDIVIDUAL EDUCATIONAL TRAJECTORY OF STUDENTS

This work examines the problem of individual educational trajectory in Ukraine. During research, it was found that this issue is considered mainly from a theoretical aspect, which results in the lack of effective and convenient tools for practical implementations to solve the problem. The analysis of existing methods and means of solving the problem has been carried out. The results of the analysis indicate that the implemented information systems partially satisfy the needs of students in the formation of an individual trajectory.

Objective. Develop an information system model to help in the formation of an individual educational trajectory for students of higher educational institutions, taking into account the needs of leading IT companies and students' inclinations. Aiding students in the formation of an IET is based on a set of recommendations formed based on student preferences.

Method. To solve the problem information system model was developed, which uses two main modules to operate. First module allows its user to pass a career guidance test and second module provide the semantic algorithm to determine disciplines best suited for user based on his professional inclinations. Levenstein's algorithm using ontology was chosen as a semantic algorithm.

Results. During research information system was developed which allows students to receive recommendation for formation of individual educational trajectory. Conducted experiments with random input data had shown the system is fully functional and performing its task. All operational aspects of the system are presented in this work using UML diagrams.

Conclusions. Forming recommendations for an individual educational trajectory is a complex process that requires a significant amount of resources. The use of information technologies allows to simplify this process, and the development of an information system - to automate it and make it accessible. The implementation of the information system model made it possible to understand all the subtleties of the process of forming recommendations and ensure their accuracy. The operation of the information system was ensured by the use of two modules to determine the user's professional orientation and search for the appropriate discipline. The process of finding a discipline that will match the professional inclination of the user is based on work with semantics, for which the ontology was used. The use of ontology in the process of determining semantic proximity using the Levenshtein algorithm made it possible to obtain semantic units that are as close as possible to the student's professional inclinations and ensure the most accurate result when formulating recommendations.

Keywords: individual educational trajectory, information system, ontology, levenshtein distance.

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ВИКОРИСТАННЯ ОНТОЛОГІЇ В ІНФОРМАЦІЙНІЙ СИСТЕМІ ДЛЯ ДОПОМОГИ У ФОРМУВАННІ ІНДИВІДУАЛЬНОЇ ОСВІТНЬОЇ ТРАЄКТОРІЇ СТУДЕНТІВ

У цій роботі розглядається проблема формування індивідуальної освітньої траєкторії в Україні. Досліджуються варіанти та засоби вирішення проблеми та розглядається власне рішення з використанням інформаційних технологій та онтології.

Ключові слова: індивідуальна освітня траєкторія, інформаційна система, онтологія, відстань левенштейна.

Problem overview

The development of education is increasingly perceived as a condition and prerequisite for the qualitative development of the economy and the social sphere. Human capital plays an increasingly important role in the modern economy. This justifies the increase in budgetary investments in the education system. The complexity of human relations is increasing, which requires a new level of socialization of the younger generation. The complexity of the education system itself is increasing, which places new demands on teaching staff, their qualifications, and even on the quality of management in this area.

At the same time, getting an education requires more and more public and private expenses. In poor and developing countries, this growth is due to an increase in children's and youth's access to education (it is becoming more accessible), in developed countries - to an increase in the quality and diversity of educational trajectories, and individualization of educational programs.

In particular, the concept of Individual Education in Ukraine did not exist as such, and the corresponding law was only recently adopted. Recognition of the right of education seekers to an individual educational trajectory (IET) is one of the progressive innovations of the Law “On Education” (2017), which provides for “a personal way of realizing the personal potential of an education seeker, which is formed taking into account his abilities, interests, needs, motivation, opportunities and experience, is based on the choice of the education seeker of types, forms and pace of education, subjects of educational activity and educational programs offered by them, educational disciplines and their level of complexity, methods and means of education" [1].

Such a law was necessary, because nowadays the priority goal is the development of competent specialists. Necessary qualities for such specialists are the ability for self-development and self-realization. Ensuring these factors is possible with an orientation to educational processes that involve taking into account the capabilities of each individual, their needs and freedom of choice. Thus, in our time, every student of education can expect to receive an education and choose an individual educational trajectory (IET).

Analysis of recent sources

Focusing on the problem of the formation of IET, we should, first of all, turn to sources that consider the process of implementing the functionality that could be used for its formation. This is due to the peculiarity of the concept of IET, which can be interpreted as follows: it's a personal path of personal development of the student's potential. This path is formed considering the abilities, interests, needs, motivation, abilities and experience of the applicant and is based on his chosen types, forms and pace of learning, educational programs, disciplines and their level of complexity, methods and teaching. An IET is also determined by an individual curriculum.

Accordingly, for the implementation of IET, a tool is needed that will take into account the personal characteristics of the applicant, his interests, needs or motivation, as well as provide further advice on choosing the appropriate educational institution.

Such a tool should be linked to the educational institution for better efficiency. The most common tools created for educational institutions are information systems, as their use in the fields of education is massive. This is due to the urgency of effective provision and organization of the education of pupils/students in the transforming education system, forming a new information mentality of all interested parties. Such rapid development 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.

Several researchers described and substantiated the use of modern information technologies in education. The conducted analysis showed that modern information technologies give students access to non-traditional sources of information, increase the efficiency of independent work, provide completely new opportunities for creativity, finding and consolidating professional skills [2].

If we return to the consideration of sources while thinking about the functional implementation, it is possible to single out works of S. Sharov, A. Bogdanov, and Sh. Danyla [3–5].

Let us check the information system (IS) described in the work [3]. The process of formation of the trajectory is described as such, which involves the analysis of the curriculum of the specialty, familiarization with the annotations of the disciplines that are included in the curriculum, as well as the analysis of competencies that are formed in the process of studying specific disciplines [3]. The complexity of the process of forming an individual trajectory justifies the use of information systems to achieve results.

When developing the IS, the authors set themselves several tasks, among which the most important are:

- Creating a project of the structure of the IS.
- Selection of tools for IS development.
- Uploading official information about educational programs, users, etc. into the IS.

The most important functions of IS include the following:

- Creation, editing and approval of the curriculum for a specific educational program.
- The student's choice of disciplines by choice from the list of courses by choice of the curriculum.
- Formation of an individual study plan by the student.

Worth mentioning that different information technologies, such as the PHP programming language and the MYSQL database were used in the development of IS. The created system was implemented in the form of an interface program with full functionality according to the described methodology.

Another example is described in the article [4]. The information support system developed in this example is designed to help people who want to get an education for employment in creating IET, with the possibility of analyzing their current knowledge and skills and comparing them with the needs of the labor market [4]. The system is implemented using web technologies such as PHP and Javascript, and the design is developed using the Bootstrap framework.

A main feature of the system is its modularity and openness, which allows for further expansion or temporary use of modules of other systems [4]. A total of seven modules were developed:

- The main module (provides representative and general management functions).
- Communication module (ensures the possibility of free expansion of the system).
- The profession space module (ensures the possibility of registration and description of professions).
- Knowledge module (allows you to accumulate and systematize a list of knowledge).
- Module of skills (contains a list of possible users' skills).
- The knowledge determinant module (determines the level of professional knowledge of those seeking a profession).
- The ability determiner module (helps in choosing professions based on the individual characteristics of a person's abilities).

The analysis of these works showed that although the ISs were developed and performed the assigned tasks (formation of individual trajectories), none of them gives any recommendations when choosing disciplines and forming trajectories. All implemented systems only optimized the process of collecting and providing information to the user. Thus, when using such a system, the user is faced with a choice among dozens or even educational programs and disciplines without any help in their formation. Also, among the reviewed recommendation systems, the use of an ontological approach was not noticeable, which would allow obtaining more accurate results.

The last IS taken for consideration from the article [5] describes a recommendation system for personalizing the learning path. During the development of the system, various web technologies were used, such as JavaScript, AngularJS, Bootstrap. NoSQL DB technology - MongoDB was used for data storage. The developed recommender system uses hybrid filtering with more active use of content filtering and less active use of collaborative filtering. The algorithm consists of analyzing the preferences and interests of students and finding appropriate educational materials. Searching for content occurs in various ways, which are separated into separate functions. These functions use the built-in logic for determining the recommended weight, which is presented in the form of a transition graph. As a result, recommendations for the user are shown with a list of twenty educational materials. The user also has the opportunity to find out why this particular discipline was recommended to him and, accordingly, decline the recommendations and receive a new one.

Although this IS uses web technologies, which gives it certain advantages over other implementations, the algorithms used to determine and provide recommendations are far from what is necessary to solve the problem of IET formation. The input data for performing the analysis are the preferences of students and their interests, which is a meager amount of information in the process of forming IET. Such a limited analysis cannot be efficient and is unlikely to provide accurate results.

The purpose of the work is: the creation of an information system model that will assist in the formation of IET with the use of ontology.

Presentation of the main material

During the literature review, it was concluded that currently there are no competent existing IS capable of assisting in the formation of IET, which would use web technologies and data analysis at the same time. The complexity of the data analysis process lies in the peculiarities of the formation of IET, namely, finding disciplines that would satisfy the student. For this, it is necessary to conduct a data analysis that would take into account the characteristics of the student and his professional inclinations and would select the appropriate disciplines from educational and professional programs. With such ideas, the IS model for formation of IET was developed with the use of ontology. Additionally, the process of assisting in IET formation in the system is ensured thanks to the following modules:

1. Career orientation tests to determine the characteristics of students;
2. Algorithm for determining the semantic proximity between student's characteristics and disciplines from educational and professional program with the use of ontology.

There is also a system module that is responsible for creating a user profile and interaction between the IS and the database. Before considering the operation of each module in detail, it is necessary to determine the general characteristics and features of the system. In particular, the general scheme of the IS is shown in Fig. 1

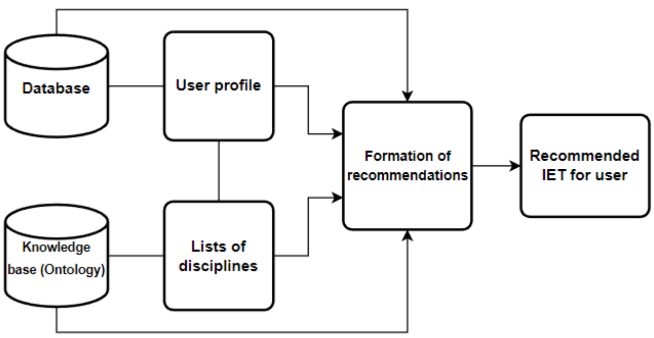

Fig. 1. General scheme of information system architecture

The corresponding model of the IS can be presented in the form of a three-element tuple:

$$S = \{A, V, R\}, \quad (1)$$

where $A = a_1, a_2, \dots, a_n$ – a set of subjects (agents) of the recommender system, where students who use the system, teachers who form the knowledge base, and teachers who form IET act as agents; $V = v_1, v_2, \dots, v_n$ – set of properties of agents, $R = r_1, r_2, \dots, r_n$ – set of relations between agents (interaction) inherent in the subjects of the information system

The logic of the behavior of such agents is presented in the form of a graph of state transitions shown in Fig. 2 and reflects the process of forming IET:

1. Information system - Determines the behavior of the agent when using the system. The result of using the system is obtaining a list of necessary disciplines for the formation of IET.
2. Ontology - Defines the behavior of the agent when forming the knowledge base, which is used to form the list of disciplines (when determining the linguistic assessment of test results).
3. Individual educational trajectory - Determines the agent's behavior when forming it. The list of disciplines which will be included further, during formation of IET is obtained from the IS.

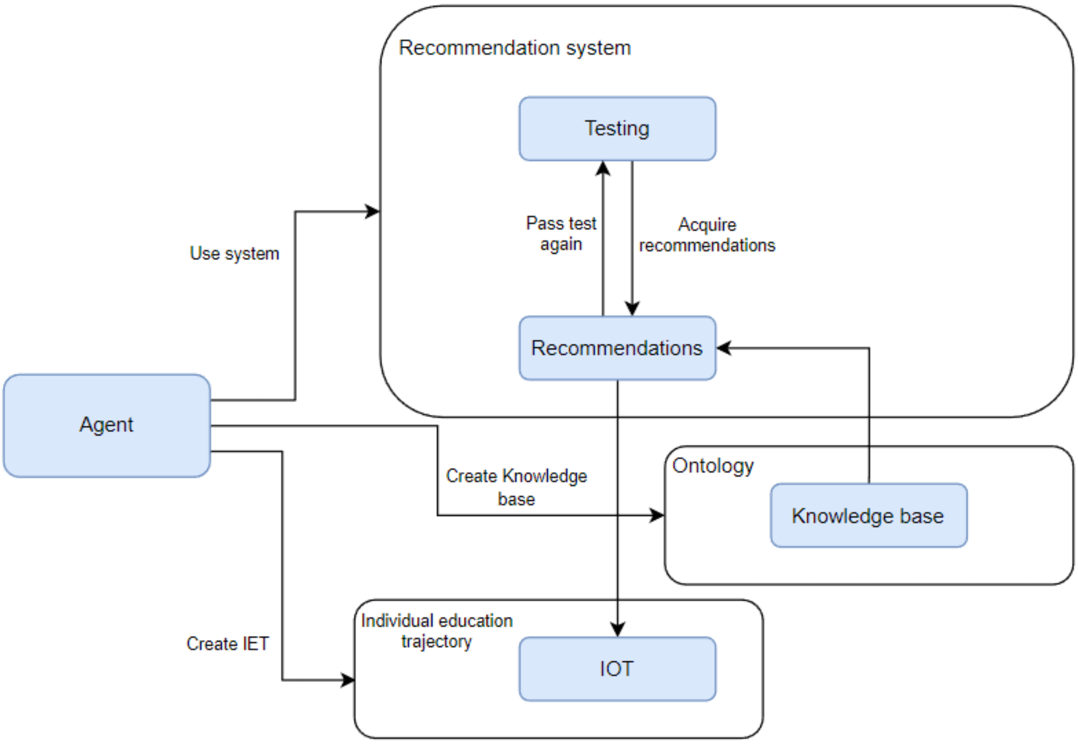

Fig. 2. State transition graph of IS agents

Accordingly, the following entities act as agents in IS: Student; the teacher who fills the database; the teacher who fills the Knowledge base.

All agents interact with each other through the processes that ensure the formation of IET. Formally, the interaction of agents can be presented in the form of a graph shown in Fig. 3.

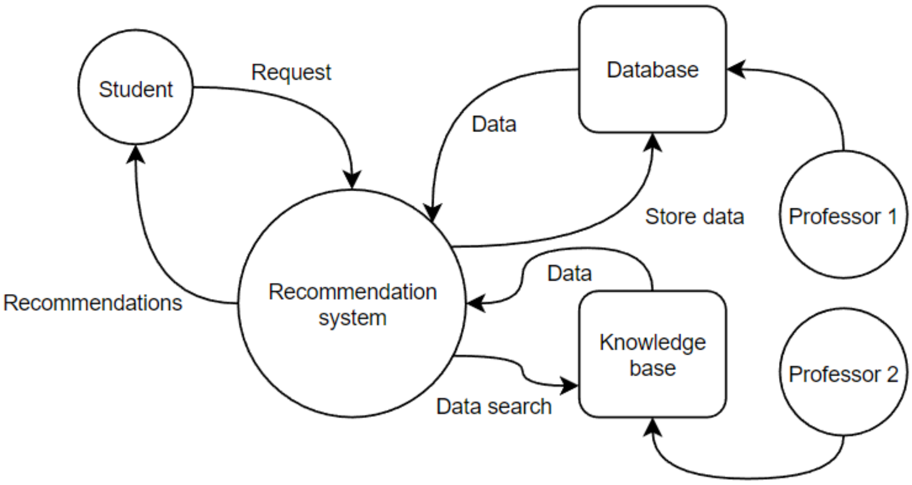

Fig. 3. Interaction of agents in the IS

With the interaction of agents in the system, we can proceed to an overview of the processes on which the system is based. For this, a diagram of the system activity was constructed, shown in Fig. 4.

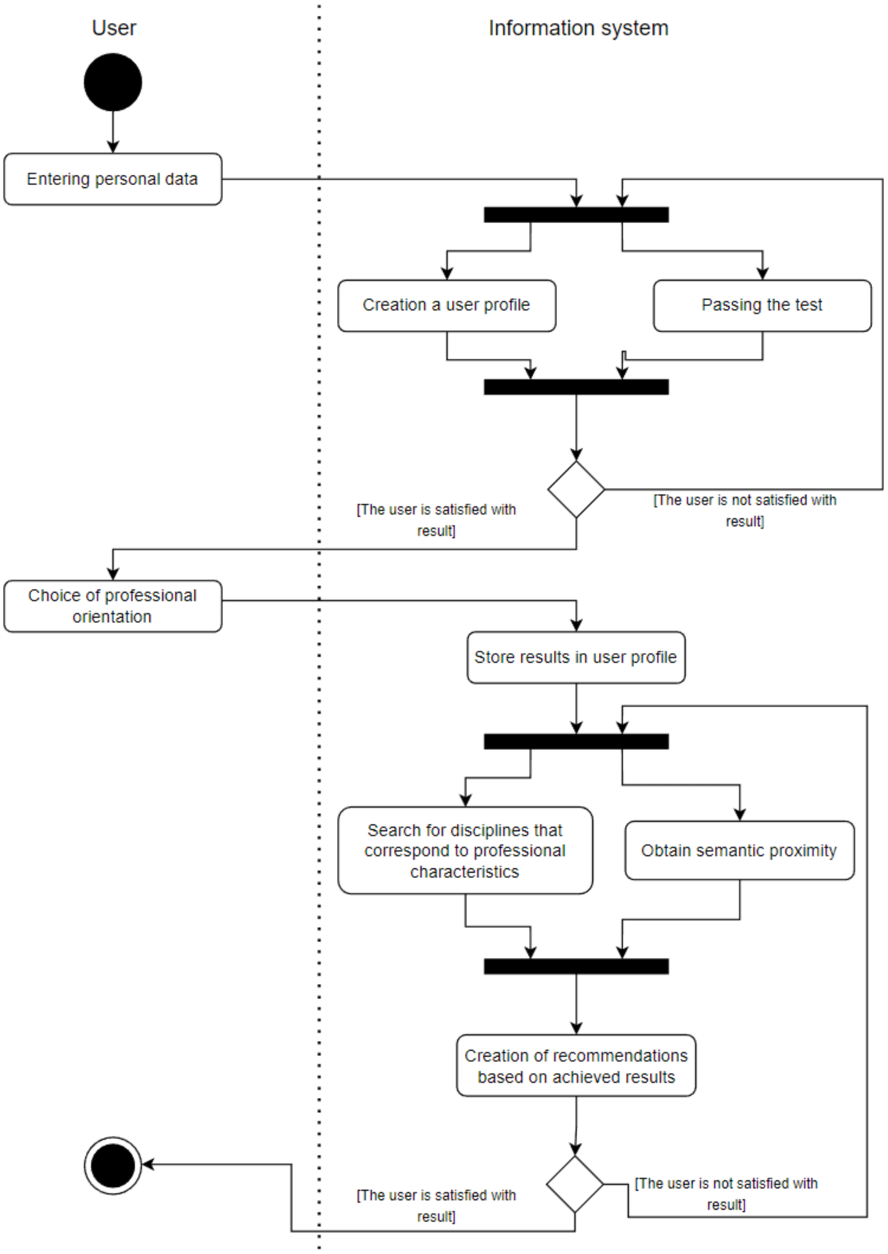

Fig. 4. Activity diagram of IS

In the process of performing its task, the IS uses three different tests to determine professional orientation. These tests offer the user (student) a number of questions to which he must provide an unambiguous answer (yes or no) or choose one of several answer options.

In general, the system uses the following tests to determine professional aptitudes:

- Questionnaire of professional orientation (QPO) of J. Holland [6, 7].
- Questionnaire of professional inclinations (QPI) of L. Yovaisha [8].
- Questionnaire for determining the type of profession (QDP) by E. Klimov [9–11].

J. Holland's method determines the degree of connection of an individual with the field of professional activity to which he has natural inclinations. There are six types of professional environment: realistic, intellectual, social, conventional, entrepreneurial, artistic [6].

L. Jovaisha's questionnaire of professional inclinations is aimed at identifying tendencies to work in various spheres, such as: sphere of art (man-artistic image); sphere of technical interests (man-technique); sphere of work with people (person-person); the sphere of mental work (inclinations to mental activity); the sphere of physical work (inclinations towards mobile, physical work); the sphere of material interests (production and consumption of material goods, planning and economic activity) [8].

The questionnaire for determining the type of future profession according to the methodology of E. Klimov is based on the theory that when choosing a profession, a person directs his thoughts first of all to what he will work with, i.e., to the subject of work, then to what he will do with it, i.e., for the purpose of work. Based on this, Klimov proposed to classify professions according to the following characteristics: subject, purpose, tools and working conditions [9–11].

Passing each test allows you to get a result in the form of a professional type of student. Next, the student is asked to choose one of the three professional types that were determined by the tests. A student can retake the test if he is not satisfied with the results. If he is satisfied, data is saved in the user profile, which is stored in the database of the recommendation system. The results of the test are professions that are available in the National Classifier of Professions. This will avoid ambiguity when receiving a result from three different sources and provide more accurate results if the user can choose what he likes best.

The professional type assigned to the student must be compared in terms of its compliance with the disciplines from DB and KB. The process of comparing these data is based on the definition of semantic proximity between words.

Semantic proximity is determined using the ontology in the developed IS. Using ontology is an option to prevent ambiguities, facilitate the implementation of sub-categories, and obtain more accurate results. Such advantages are caused by difficulties in structuring and systematizing data elements that meet the needs of the user.

Ontology is a detailed formalization of some domain of knowledge, presented with the help of a conceptual scheme. Such a scheme consists of a hierarchical structure of concepts, relationships between them, theorems and restrictions that are adopted in a certain software [12].

The ontology used in the work consists of keywords that correspond to disciplines from the work programs of courses in a higher education institution. The formal model of such ontology can be presented as follows:

$$O = \{B, C, X\}, \tag{2}$$

where B are terms of the subject area (discipline); C – the relationship between them (depends on educational and professional programs); X – interpretation functions (weight of disciplines assigned according to various criteria).

In general, ontologies are also defined as a knowledge base of a special kind, or as a “specification of conceptualization” of a subject area. The concept of a knowledge base is different from a database, as it operates on knowledge, not data. The difference between knowledge and data is that data is only a form of representation of knowledge, that is, knowledge is a much deeper and broader concept.

In this research, Levenshtein algorithm [13] was chosen to search for relevant concepts in the ontology for semantic similarity with the professional type assigned to the student. This algorithm allows to determine the minimum number of insertion, deletion and replacement operations necessary to transform one sequence of characters into another.

For the correct operation of the algorithm, it is necessary to obtain an ontological description of educational and professional programs and corresponding selective disciplines. The search and obtaining of the ontological description is carried out using the syllabus obtained from the website of the National University “Lviv Polytechnic”.

Also, it is necessary to convert the received professional inclination into appropriate professions. Dozens of different professions fall under each personality type defined in the test. Thus, there is an additional need to limit the number of professions that are given as inputs to the algorithm. To do this, you can offer the student to make a choice from those professions that he likes the most. Next, each of the professions chosen by the student must be broken down into concepts that describe the professions. The need to use such plurals for professional description is due to semantic ambiguity and limitations when directly comparing the names of professions with the elements of the ontological presentation of the content of the disciplines

After the actions described above, we calculate the measure of semantic closeness. Formally, the algorithm looks like this: let the given set be $P = p_1, p_2, \dots, p_n$, where p is a profession obtained after student passed the career guidance test. Initially, the list of professions was larger, but later it was reduced to several professions, according to the student's choice. Next, for each element of P, we create a subset, for example, such subset would look like $p = c_1, c_2, \dots, c_n$, where c is a concept that describe profession.

We conduct similar preparation with the ontology: the set $OP = op_1, op_2, \dots, op_n$, where op is a discipline from the educational and professional program. Any educational and professional program has dozens of disciplines, even if limited only to selective ones. The ontological description of such disciplines is presented in the form of keywords (concepts), so we present each discipline as a set $D = d_1, d_2, \dots, d_n$, where d is a keyword describing the discipline.

Then, with the algorithm at hands, we would perform following steps (in terms of using IS):

1. We perform calculations to determine the semantic distance between each element of P and OP using the Levenshtein algorithm;
2. Pairs of words, the numerical value of the distance between which is less than 3, are considered semantically close;
3. For the chosen educational and professional program, we proceed to the comparison of its disciplines with professions;
4. We calculate the distance between elements of P_n and D.
5. If the obtained numerical value of the distance is less than 3, we consider the discipline to which one of

the compared concepts belongs, semantically close to the profession keyword c. We repeat the process of calculating the distance until the disciplines end.

6. We record the received disciplines in the list and recommend the user to include them in an IET.

It is worth noting that the third step of the algorithm depends on the user's actions. After completing the first two steps of the algorithm, the user will be presented with a list of the most semantically relevant educational and professional programs. From this list, he should choose only one that he likes more.

We will conduct test calculations with random input data for a better understanding of the process. Suppose after user has passed the career guidance test, the system received the following set of professions: P = financier, logistician, IT specialist, economist, physicist. Relevant subsets of these professions:

- P_1 = finance, management, strategy, finance specialist.
- p_2 = logistics, management, systems, processes.
- P_3 = programming, computer engineering, software, computer systems.
- p_4 = economy, business processes, business development, economic system.
- p_5 = physics, nanomaterials, nanoelectronics, energy.

The set of educational and professional programs is unchanged and is obtained from the website of the National University "Lviv Polytechnic". The situation is similar with the disciplines, but it is worth noting that in the algorithm, as well as in the work, the main emphasis is placed on the selective components of the educational and professional program.

For test calculations, we will choose the following set of educational and professional programs (a random sample is limited to a few options for clarity and a simplified presentation of the algorithm's work). Also, for more accurate operation of the algorithm, in some cases, it is necessary to break the phrase into separate words:

OP = journalism, science of law, system programming, metallurgy, international economic relations.

Next, we calculate the distance between the descriptive words of the first profession and the first educational and professional program from the list according to the Levenshtein algorithm. The first educational program has the following keywords: text, communication, speech, dialog. Distance calculation:

- Distance between "finance" and "text" = 7.
- Distance between "management" and "text" = 8.
- Distance between "strategy" and "text" = 6.
- Distance between "specialist" and "text" = 8

According to the results of calculations, the considered pairs of concepts are not semantically close. We couldn't find a pair. Proceed with the next keyword:

- Distance between "finance" and "communication" = 11.
- Distance between "management" and "communication" = 11.
- Distance between "strategy" and "communication" = 11.
- Distance between "specialist" and "communication" = 10.

Similar results were obtained when comparing with the rest of the keywords. No semantic similarity was found. Let's move on to the comparison with the next educational and professional program "Science of law". This program is written with the following keywords: jurisprudence, legal system, legal space, humanization. Distance calculation:

- Distance between "logistics" and "jurisprudence" = 10.
- Distance between "management" and "jurisprudence" = 11.
- Distance between "systems" and "jurisprudence" = 11.
- Distance between "processes" and "jurisprudence" = 10.

The result is similar with the rest of the keywords, the semantic similarity has not been proven. We continue the comparison until we get a value that does not exceed the number of three. This value was obtained by comparing with the keywords of the educational and professional program "System Programming". Keywords are next: computer engineering, software engineering, system programming, system software, computer systems and networks, system software tools. The corresponding comparisons according to the Levenshtein algorithm:

- Distance between "programming" and "system" = 10.
- Distance between "programming" and "programming" = 1.
- Distance between "computer engineering" and "computer engineering" = 1.
- Distance between "software" and "system" = 6.
- Distance between "software" and "software" = 1.
- Distance between "computer systems" and "computer systems" = 1.
- Distance between "computer systems" and "networks" = 14.

Having received four semantically close keywords at once, the system enters this educational and professional program into the list for further recommendation to its user.

In a similar way, the semantic similarity with the educational and professional program "International Economic Relations" was determined. To continue the experiment with test data, it is necessary to simulate the user's choice between two educational programs.

Let's say, the student chooses an educational and professional program called "System Programming".

Then, consider the set of disciplines of this program with keywords:

- Designing operating systems, utilities and drivers = developing systems/utilities/drivers, designing systems/utilities/drivers, debugging systems/utilities/drivers, improving systems/utilities/drivers.
- Technologies of parallel programming = multiprocessor systems, parallel programming, parallel computing, message passing system.
- Directions of research and development of system programming = system programming, programming research, programming development.
- Research and design of network operating systems = operating systems, administration tasks, software for automated systems, analysis of operating systems, web server performance.
- Parallel programming of high-performance computer systems = parallel programming, high-performance information systems, high-performance systems architecture, high-performance software.

An example of calculating the distance between the keywords of the profession "IT specialist" and the optional disciplines of the educational program "System programming":

- Distance between "programming" and "developing" = 8.
- Distance between "programming" and "designing" = 8.
- Distance between "programming" and "debugging" = 8.
- Distance between "programming" and "systems" = 10.
- Distance between "programming" and "multiprocessor" = 13.
- Distance between "programming" and "parallel" = 8.
- Distance between "programming" and "programming" = 0.
- Distance between "programming" and "computing" = 7.
- Distance between "programming" and "research" = 9.
- Distance between "programming" and "software" = 10.
- Distance between "programming" and "automated" = 10.
- Distance between "programming" and "operating" = 6.
- Distance between "programming" and "high-performance" = 13.
- Distance between "programming" and "architecture" = 11.
- Distance between "programming" and "information" = 9.

According to the results of calculations, we get the following pairs of words, which can be considered semantically close:

- "programming" and "programming".
- "systems" and "systems".
- "software" and "software".

Key words from the obtained word pairs belong to the disciplines "Directions of research and development of system programming", "Parallel programming of high-performance computer systems" and "Technologies of parallel programming". Accordingly, we can recommend these disciplines from the educational and professional program "System programming" for inclusion in the student's IET.

If the user is not satisfied with the recommendations received, he can take the test again and start the process of generating recommendations again. If the results suit the user, they will be formed in the form of a recommendatory list of disciplines. The user can then send the results obtained to any external service for the further aid in formation of IET.

Conclusions

The article analyzed the current scientific task of forming an IET, considered existing examples of solving the problem, and proposed a way to solve it in the form of an IS model for forming IET. During the research, information system with the use of ontology was developed. It was tested with random input data, which demonstrated high accuracy of the results

The scientific novelty of obtained results is that the ontology was used in the development of information system. The peculiarities of the problem of generating recommendations for an individual trajectory require not the data filtering tool used in most recommender systems, but a powerful semantic basis for the selection and search of disciplines that satisfy the student. Such a tool can be considered an ontology of keywords belonging to selective disciplines in educational and professional programs.

The practical significance of obtained results is that the information system for the formation of recommendations was developed. The conducted test calculations demonstrated the high accuracy of the data selection and search process for the formation of recommendations, which was achieved thanks to the use of the ontology.

Prospects for further research will be directed to the modification of the algorithm for determining semantic proximity, use of additional tools to increase recommendation accuracy even more and the practical implementation of the IS. It is planned to use web technologies to ensure relevance, availability and uninterrupted operation of the system.

Література

1. Про освіту : Закон України від 05.09.2017 № 2145-VIII. URL: http:// zakon2.rada.gov.ua/laws/show/2145-19.
2. Любович А. А. Сучасні інформаційні технології в освіті / А. А. Любович, О. Г. Єсіна // Інформатика та інформаційні технології : студ. наук. конф., 20 квітня 2015 р. – Одеса : ОНЕУ. – С. 118-120.
3. Інформаційна система формування індивідуальної освітньої траєкторії студентів. URL: https://www.researchgate.net/publication/354577447_Information_System_for_the_Formation_of_Students'_Individual_Educational_Trajectory.
4. Система інформаційного забезпечення процесу формування індивідуальної освітньої траєкторії студентів. URL: https://journal.iitta.gov.ua/index.php/itlt/article/view/1390/1062.
5. Система рекомендації навчальних матеріалів для персоналізації навчального шляху. URL: https://core.ac.uk/download/pdf/323532858.pdf.
6. Holland John L. Making vocational choices: A theory of careers. Prentice Hall, 1973.
7. Holland J.L., Gottfredson G.D., Bacer H.G. Validity of vocational aspiration and interests of inventories: Extended replicated and reinterpreted. Journal of Consulting Psychology. 1990. Vol. 37. P. 337-342.
8. Йовайши Л. Опитувальник професійних нахилів. URL: http://prevolio.com/tests/.
9. Климов Е. А. Как выбирать профессию / Е. А. Климов. – Москва : Просвещение, 1990. – 159 с.
10. Климов Е. А. Образ мира в разнотипных профессиях / Е. А. Климов. – Москва : Изд-во МГУ, 1995. – 224 с.
11. Резапкина Г. В. Психология и выбор профессии: программа предпрофильной подготовки : [учеб.-метод. пособие для психологов и педагогов] / Г. В. Резапкина. – Москва: Генезис. 2005. – 208 с.
12. Gruber T. A translation approach to portable ontologies. Knowledge Acquisition. 1993. № 5 (2). P. 199–220.
13. Відстань Левенштейна. URL: https://uk.wikipedia.org/wiki/Відстань_Левенштейна

References

1. Law of Ukraine "On Education" dated 05.09.2017 No 2145-VIII. URL: http://zakon2.rada.gov.ua/laws/show/2145-19.
2. Lyubovych A. A. Modern information technologies in education / A. A. Lyubovych, O. G. Yesina // Informatics and information technologies: stud. Sc. Conf., April 20, 2015: mater. Conf. – Odesa, ONEU. – P. 118-120.
3. Information system for forming individual educational trajectory of students. Available at: https://www.researchgate.net/publication/354577447_Information_System_for_the_Formation_of_Students'_Individual_Educational_Trajectory.
4. The information support system of the process of forming the individual educational trajectory of students. Available at: https://journal.iitta.gov.ua/index.php/itlt/article/view/1390/1062.
5. System of recommendation of educational materials for personalization of educational path. Available at: https://core.ac.uk/download/pdf/323532858.pdf.
6. Holland John L. Making vocational choices: A theory of careers. Prentice Hall, 1973.
7. Holland J. L. Validity of vocational aspiration and interests of inventories: Extended replicated and reinterpreted / Holland J.L., Gottfredson G.D., Bacer H.G. // Journal of Consulting Psychology. – 1990. – Vol. 37. – P. 337-342.
8. Questionnaire of professional inclinations of L. Yovaisha. http://prevolio.com/tests/.
9. Klimov E. A. How to choose a profession. Moscow: Enlightenment, 1990. 159 p.
10. Klimov E. A. The image of the world in different types of professions. Moscow: Publishing House of Moscow State University, 1995. 224 p.
11. Rezapkina G.V. Psychology and choice of profession: pre-profile training program: [learning method. manual for psychologists and teachers]. Moscow: Genesis. 2005. 208 p.
12. Gruber T. A translation approach to portable ontologies. Knowledge Acquisition. 1993. № 5 (2). P. 199–220.
13. Wikipedia. Levenstein distance. https://uk.wikipedia.org/wiki/Відстань_Левенштейна