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THE INTRODUCTION OF INTELLECTUAL SYSTEM FOR EVALUATING PROFESSIONAL ABILITIES OF APPLICANTS INTO THE ACTIVITIES OF EDUCATIONAL INSTITUTIONS

Об'єктом дослідження є методи і засоби професійної ідентифікації абітурієнтів. Дослідження направлене на надання абітурієнтам науково-обгрунтованої підтримки прийняття рішення щодо вибору напряму навчання. Впровадження інтелектуальних систем підтримки прийняття рішень в процес самоактуалізації абітурієнтів надасть можливість значно підвищити ефективність профорієнтаційної діяльності навчальних закладів.

Однією з найбільших проблем інтелектуалізації систем оцінки здібностей та досягнень є те, що результати тестування абітурієнтів являють собою множину нечітких даних. При цьому, коректність розділення даних значно залежить від побудови нечіткої множини ознак для виведення діагностичного рішення. До того ж, найбільш розповсюджені тести не враховують вимоги до спеціалістів будівельної галузі.

В основу системи, що розробляється, покладено тести для визначення структури особистості комплексної профорієнтаційної діагностики «Абітурієнт». Ця система містить довідникову інформацію про професійні категорії навчання та тести для визначення структури особистості. Висновки базуються на методиках, що дозволяють прогнозувати успішність діяльності в різних галузях. Здатність особи до певної професійної діяльності відображає здатність до набуття спеціальних знань і навичок в процесі навчання. Саме тому в ході дослідження використовувалися тести «Абітурієнт». Для підвищення надійності оцінки професійних здібностей абітурієнта запропоновано використовувати інтелектуальну систему, в основу роботи якої покладено нечітку нейронну мережу Такаги-Сугено-Канга. Такий вибір пов'язано з тим, що мережа Такаги-Сугено-Канга має ряд особливостей, які забезпечують їй переваги при вирішенні задачі відповідності здібностей абітурієнта до можливості набуття знань і навичок за певною спеціальністю. Зокрема, здатністю нечітких нейронних мереж розділяти лінійно-нероздільні дані. Завдяки цьому забезпечується здатність системи виділяти природні здібності абітурієнтів із суміші даних.

У порівнянні з іншими засобами, мережа Такаги-Сугено-Канга надає можливість розв'язувати задачу класифікації дуже великої кількості даних мережею меншої розмірності.

Ключові слова: *ідентифікація здібностей і досягнень особистості, інтелектуальна система, організація обробки нечіткої інформації.*

1. Introduction

In modern society, there are a large number of specialties, the acquiring of which presupposes the presence of certain abilities that it is desirable to reveal even at the stage of choosing a field of study. To this end, educational institutions process a diverse flow of information about the educational success of people studying in different specialties. Analysis of this information allows to draw conclusions about the effectiveness of vocational guidance activities of educational institutions and improve its organization. The university can provide decision-making support for applicants in a specialty's choice on the basis of:

– evaluation of the results of training in preparatory courses;

– testing during open days, competitions and presentation of documents;

– additional professional tests or creative competitions.

The actual direction of improving career guidance activities is the introduction of decision support systems that are obtained when communicating with applicants. At the same time, there is a growing demand for systems that can not only summarize the findings of knowledge and skills tests acquired during the pre-university training, but also highlight the natural abilities of applicants from a mixture of data.

2. The object of research and its technological audit

The object of research is the methods and means of professional identification of applicants.

To assess the abilities and achievements of applicants for admission to educational institutions are used diverse tests of abilities and achievements of applicants. The results of ability tests and achievement tests are reflected on the continuum, on the one hand of which are tests of school achievements, and on the other hand, tests of intelligence, psychological readiness or tests of special abilities to predict success in specific industries. School achievement tests are developed by school teachers to assess knowledge, and special skills tests are developed by pre-university training specialists, taking into account the experience of university

professors, personnel requirements for a specialist profile and the requirements of potential employers.

For the selection of applicants use:
– «Scholastic Assessment Test» (SAT) [1];
– «Test Battery of American Colleges Testing Program» (ACT) [2];
– «Written Graduate Record Examinations» (GRE) [3].

The results of such testing are usually located in the middle of a continuum of abilities and achievements. This leads to the fact that test results are a lot of fuzzy data that require classification [4].

Multifactor abilities tests include [2, 3]:
– «Integrated battery of abilities»;
– «Guilford-Zimmermann abilities battery»;
– «International Battery of Primary Factors Tests»;
– «Metropolitan Readiness Tests» (MRT);
– «Boehm test of basic concepts».

There are also various tests of special abilities that reflect the requirements for specialists in a particular field and are used to predict success in specific industries. These tests include [5, 6]:
– «Law School Admission Test» (LSAT);
– «Medical College Admission Test» (MCAT);
– various tests assessing stationery and stenographic abilities, eyesight and ability to learn, hearing, mechanical abilities, musical and artistic abilities, creativity.

In the information environment of Ukraine, the Integrated Professional Orientation Diagnostics «Applicant» is functioning. This information system contains reference information about the vocational category of training and tests for determining the structure of the personality, approved by the Ministry of Education and Science of Ukraine and has no alternatives [7].

However, none of these tests take into account the requirements for specialists in the construction industry and the demand of construction educational institutions. In addition to construction, there are a sufficient number of other specialties, for which you need certain abilities that you want to detect in the process of communication at the stage of choosing the direction of study.

3. The aim and objectives of research

The aim of research is provision of applicants with scientifically sound support for making decisions on the choice of a course of study by introducing an intellectual system for assessing the professional abilities of applicants into the process of self-actualization.

To achieve this aim, the following objectives are formulated:

1. To investigate modern methods for assessing the abilities and achievements of applicants.

2. To investigate the existing means of processing fuzzy information.

3. To propose the introduction of an intellectual system for assessing the professional abilities of applicants into the activities of building educational institutions.

4. Research of existing solutions of the problem

Assessment of the natural abilities of the individual requires the use of tools, which are based, in addition to the tests of achievements and skills, intellectual and psychodiagnostic tests. Studies of modern methods and means of identifying the abilities and achievements of the individual have shown that there is no single approach to determining the content of professional identification. Modern methods and means of identifying the abilities and achievements of the individual have shown that there is no single approach to determining the content of professional identification [8, 9]. An important contribution to the study of this phenomenon was made by scientists [10, 11], who began research on the problem of identification and identity.

In [3], professional identification is considered as a mechanism for adopting leading professional roles and values that induce a specialist to effective activity. The authors of [12, 13] show that decision support is complicated by the fact that test results have a fuzzy conclusion. Especially multidimensional and fuzzy test results that reflect the personality structure at the stage of transition from one level of education to another.

To solve such problems, artificial neural networks of various architectures are used [14].

Fuzzy Takagi-Sugeno-Kang network is described in [15, 16]. This network is able to analyze and summarize fuzzy data. Theoretical issues of designing and studying learning algorithms for systems based on the Takagi-Sugeno-Kang network are described in detail in [14, 17]. However, the existing models of identification tools, which work is based on the use of artificial neural networks, are not adapted to the task of assessing the professional abilities of the individual. Thus, the problem of training systems for assessing the professional abilities of applicants remains unresolved.

Since the main goal of the research is supporting the decision on the choice of a learning direction in the process of self-actualization, the most accessible means of self-identification are the most accessible to the user.

The authors of this work carry out online research of existing information systems for identifying the abilities of applicants. At the same time, the Google search system recommends that the «professional orientation diagnostics of an applicant» request be addressed to the automated system «Integrated Professional Orientation Diagnostics «Applicant» [7]. This information system is an innovative development, which is approved by the Ministry of Education and Science of Ukraine and has no alternatives. The system contains reference information about the professional category of education, based on measured professional interests and inclinations in the entrepreneurial, social, artistic, intellectual, naturally realistic, technical-realistic, conventional branches of education. However, this system does not reflect the abilities of applicants, which are necessary for the successful acquisition of construction professions.

5. Methods of research

Deterministic and stochastic models need accurate, distributed information. However, the assessment of the professional abilities of the individual is often associated with the processing of fuzzy textual information. In such cases, for a fuzzy assessment of professional interests, fuzzy models are the most successful [11].

To solve the problems of increasing the efficiency of decision making under uncertainty, intelligent systems are being developed that are able to analyze and summarize the fuzzy conclusions of the test results. And, thus, to

increase the level of automation of the decision support process for choosing a specialty [13].

The paper assumes that the output of university testing contains information that is presented in text form and requires formalization. At this stage, the test results are evaluated by experts from 0 to 100 points. After that, in the interval [0; 100] the linguistic variable is set, which assumes the value «high level», «average level», «low level», «level above average», «level below average», with known measures of belonging. The scale of membership according to the results can be the following system:

– from 0 to 25 points – not suitable;
– from 26 to 50 points – no longer suitable than suitable;
– from 51 to 75 points – more suitable than not suitable;
– from 76 to 100 points – suitable.

The choice of the method of obtaining the belonging degree of the assessment of the applicant abilities remains for the specialists who are responsible for the assessment.

6. Research results

In the development and implementation of intelligent decision support systems for choosing a specialty, a number of problems arise. The main problems are related to:

– finishing of fuzzy test information;
– selection of natural abilities from a mixture of data, reflecting not only abilities, but also knowledge and skills that are acquired by an individual at different stages of the life cycle;
– decisions on the choice or change of specialty can occur;
– upon admission to higher education institutions;
– in the transition from one level of education to another;
– at change of a specialty during study;
– in the case of change the specialty after graduation.

In various cases, decision support involves the use of appropriate systems, whose work is based on various knowledge bases [13].

Problems arise when an applicant can't clearly define what it wants to do in the future, and career guidance centers do not give enough information. In addition, support for a decision on the choice of a specialty presupposes the presence of abilities that it is desirable to reveal at the stage of choosing a field of study. This means that graduates of general education schools need only support when choosing a profession due to lack of experience and a high level of uncertainty of intentions. Uncertainty of intentions is displayed on the test results obtained at the stage of admission to the educational institution, the vagueness of incoming information. That is why the paper considers the process of self-identification and socialization of an applicant at the stage «choice of a learning direction» when entering an educational institution.

The scheme of providing support to the applicant's decision making by the educational institution is shown in Fig. 1.

In the transition from pre-university education to training in a higher educational institution, an analysis is made of achievements based on the results of external independent testing and pre-university training. However, the results of the analysis of these results do not clearly reflect the special abilities of the applicant.
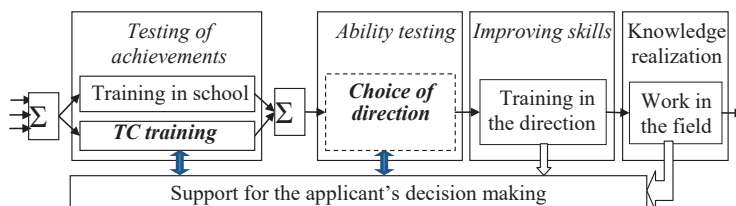

Fig. 1. The scheme of providing support for the applicant's decision making by the educational institution; TC – training courses; ↕ – the interaction of the applicant with a decision support system; ⇩ – feedback – information on the basis of which models are formed to identify the professional abilities of applicants; Σ – a symbol characterizing a mixture of indicators of abilities and achievements

To ensure the applicant's orientation in the world of professions, educational institutions of various levels generate and analyze diverse streams of information reflecting the success of students. Based on the comparison of this information with the information that was obtained upon admission, rules are built that form a fuzzy knowledge base of the system for assessing the professional abilities of applicants. The educational institution can use the acquired knowledge to assess the compliance of the abilities of the applicant during open days, competitions, interviews and additional professional tests and when submitting documents. Thus, the prediction of the consequences of the professional choice of the applicant and the possible realization of their own potential in the chosen professional activity is carried out on the basis of an analysis of the generalized learning outcomes in relevant areas.

According to the results of communication with the system, applicants receive a detailed conclusion and recommendations with explanations regarding the list of professions in which each applicant can maximize their potential [7].

The organization of assessment in the relevant industry on the basis of communication with the system is shown in Fig. 2.

The quality of the intellectual decision support system for professional identification, in the first place, depends on the reliability of its subsystems. The reliability of the subsystems, in turn, depends on the adequacy of the rules that make up the knowledge base of the system.

This work is devoted to modeling the intellectual system for assessing the professional abilities of applicants. The main purpose of the system is provision of decision support on the choice of a specialty when enrolling students in higher education institutions. Fig. 3 shows a fragment of the scheme for the formation of a fuzzy knowledge base of various subsystems of the system for assessing professional abilities to study in various specialties of some departments of the Kyiv National University of Construction and Architecture (Ukraine).

To enter different specialties of various faculties, applicants must take part in the general competition of external independent testing results. Fragment in Fig. 3 is enough to make sure that these results do not sufficiently reflect the natural abilities of applicants to acquire the knowledge and skills of each of the specialties. Only at the architectural faculty, the distribution of applicants by specialty takes place on the basis of creative competitions and at the faculty of engineering systems and ecology of enrollment in the field of «energy management» and other areas is carried out through a competition for the assessment of various disciplines.

The system, proposed for implementation, is based on Takagi-Sugeno-Kang fuzzy neural network [16], the topology of which is described in detail in [17]. The learning algorithm of the Takagi-Sugeno-Kang artificial neural network is described in general form in [15].
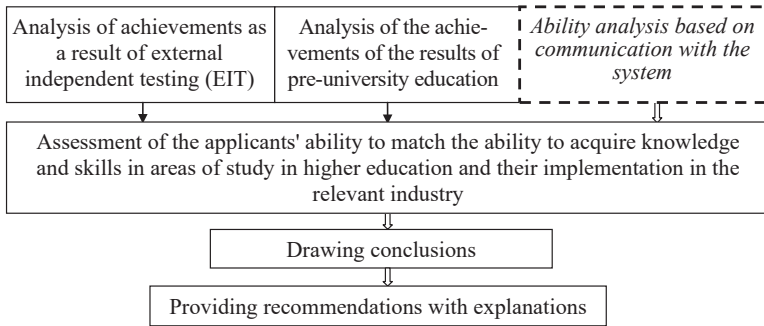
Fig. 2. Scheme of the introduction of a system for assessing the professional abilities of applicants in the work of educational institutions
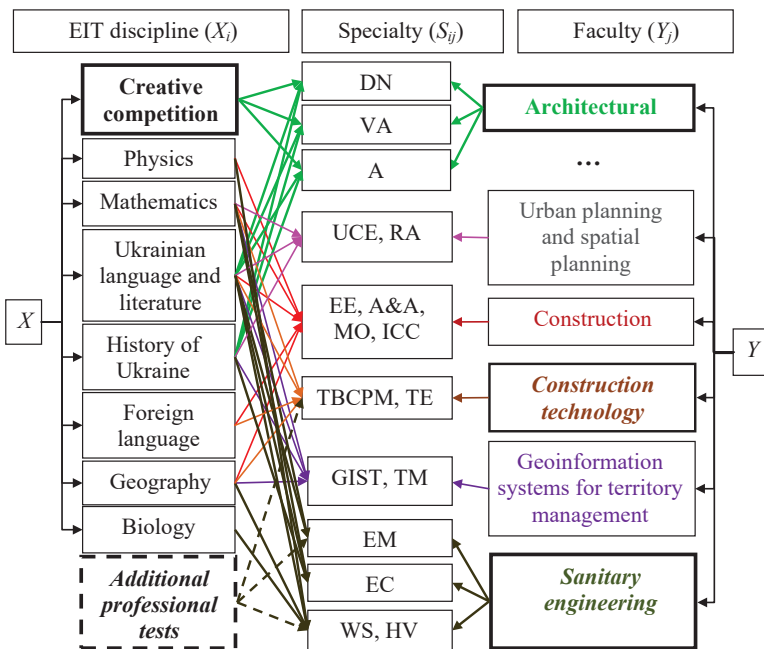

Fig. 3. Fragment of the scheme for the formation of a fuzzy knowledge base of the system for assessing the professional abilities of applicants:
DN – design; VA – visual art, decorative art, restoration; A – architecture and urban planning; UCE – urban construction and economy; RA – roads and airfields; EE – enterprise economy; A&A – accounting and auditing; MO – management of organizations and administration; ICC – industrial and civil construction; TBCPM – technology of building structures, products and materials; TE – enterprise, trade and exchange activities; GIST – geographic information systems and technologies; TM – tourism; EM – energy management; EC – ecology and environmental protection; WS – water supply and drainage; HV – heat supply and ventilation; i and j – identifiers of discipline and faculty, respectively

To adapt the Takagi-Sugeno-Kang network learning algorithm to the task of evaluating the career guidance abilities of applicants in the work, an option was chosen in which the output network parameter takes values, expresses the ability to learn in a specialty. It is assumed that the evaluation system consists of subsystems, each of which is a Takagi-Sugeno-Kang fuzzy neural network that is learned to assess the ability to learn in a particular specialty.

It is proposed to use the complex of the results of external independent assessment, diagnosis of the «Applicant» and additional professional tests as input data of the information system of decision support when entering Kyiv National University of Construction and Architecture. The output parameter takes two values: «no» or «yes».

Additional professional tests include questions and tasks, the answers to which reflect the ability to acquire special

skills. For example, various tasks in mathematics can reflect: the level of logical, associative or abstract thinking; ability to spatial imagination or «parallel thinking». Creative tasks in the Ukrainian language and literature, foreign language and history reflect such personality characteristics as social non-indifference, attitude to the environment, etc. That is why the development of additional professional tests reflecting special personnel qualification requirements for a specialist profile and customer-employers requirements to graduates are attracted to specialists working in the relevant field.

Research and analysis of the actual requirements for young professionals is carried out by specialists of the Construction Personnel Portal (Kyiv, Ukraine).

7. SWOT analysis of research results

Strengths. In this work, the choice of a specialty is proposed to be carried out on the basis of the recommendations of the information system of the «Applicant» diagnostics, taking into account the results of external independent assessment and additional professional tests or creative competitions. The recommendations are based on the study of personality structure, the degree of interest in the profession and predictions of academic achievement. Tests and tasks of additional professional tests or creative competitions of a higher educational institution are developed taking into account the special requirements of customers-employers to graduates. This significantly increases the competitiveness and quality of life of specialists who have made the right choice of the direction of their future activities. This, in turn, contributes to the expansion of the reserves of the construction industry through the realization of the intellectual potential of young people. At the same time, the efficiency of the vocational guidance work of the institution improves.

For assessing the professional abilities of the individual, improving the efficiency of decision-making based on incomplete and fuzzy data accumulated as a result of communication with applicants, fuzzy models are most successful. The main disadvantage of the «Applicant» system can be considered the inconsistency of providing clear conclusions based on fuzzy data. To overcome these shortcomings in the work an approach is proposed, which is based on the use of fuzzy models and methods of fuzzy logic. Taking into account natural abilities in mastering special knowledge and skills provides an opportunity to significantly improve the quality of education.

Weaknesses. The assessment task involves training a separate Takagi-Sugeno-Kang network for each specialty, which requires a very large number of input parameters for learning artificial neural networks.

Opportunities. The direction of further research is the formation of a training set and the Takagi-Sugeno-Kang network

for assessing the professional abilities of applicants of the Kyiv National University of Construction and Architecture. The information base of the sample is the «history» of the results of the achievements of students enrolled in different specialties of each of the faculties. Approbation of the system in the near future is planned at the Faculty of Engineering Systems and Ecology and the Faculty of Civil Engineering.

A model of an intellectual system is proposed for implementation, and the algorithm of its training is adapted to the task of assessing the professional abilities of applicants. The differences are in the base of fuzzy rules. This means that the system is able to function in any education system, provided that the rule base is designed to meet graduate requirements and the experience of specialists in a particular industry.

Threats. Additional expenses of the institution in the implementation of the system are associated with the development of appropriate software.

There are various tests of special abilities for the selection of applicants, which reflect the requirements for specialists in the industry:
– «Scholastic Assessment Test» (SAT);
– «Test Battery of American Colleges Testing Program» (ACT);
– «Law School Admission Test» (LSAT);
– «Medical College Admission Test» (MCAT).

«Integrated Professional Orientation Diagnostics «Applicant» contains background information about the professional categories of education and tests for determining the structure of the personality, gives recommendations regarding the applicant's capabilities in the existing occupational categories. And, in this way, it helps to make the choice of a training profile taking into account the personality structure. This information system is approved by the Ministry of Education and Science of Ukraine and has no alternatives. The advantages of the system include the introduction of such categories as risk and nature, as well as the possibility of analyzing the results, taking into account the age and sex of the tested person.

None of the tests takes into account the requirements for the construction industry specialists and the demand of construction educational institutions, therefore, the assessment of their advantages in this work is not formalized.

8. Conclusions

1. The study of modern methods for assessing the professional abilities of the individual has shown that the assessment of natural abilities requires the use of tools based on, apart from tests of achievements and skills, intellectual and psychodiagnostic tests. The development of such tools is associated with the processing of fuzzy test information and the selection of natural abilities from the data set, which reflect the abilities, knowledge and skills acquired during the pre-university training.

2. The study of existing means of processing fuzzy information found the feasibility of adaptation to the solution of the problem of assessing the professional abilities of Takagi-Sugeno-Kang fuzzy neural network applicants. The use of fuzzy functions at the input/output of the system allows to divide data linearly inseparable and classify a very large amount of data by a network of lower dimension.

3. Before introducing into vocational guidance activities of construction educational institutions, an intellectual

system for assessing professional skills is proposed. The system consists of intelligent subsystems, the main purpose of which is supporting the decision when choosing a field of study. The knowledge base of each subsystem is proposed to be formed on the basis of the recommendations of the «Applicant» information system, taking into account the EIT results and special (university) testing.

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