Intelligent information technologies implementation to the process of professional self-identification

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Abstract

The latest learning technologies implementation, based on new approaches to the presentation and acquisition of knowledge, requires appropriate modern methods of assessment. The search for perfect methods for assessing the abilities of entrants and students at the present stage of information technology development is extremely important, because the objectification of the assessment process, providing feedback, provides an opportunity to coordinate the development of personality. The main attention in this paper is directed on the decision of questions of professional orientation by means of testing which assumes performance of game tasks of a professional direction. The research presents a conceptual model of a specialized intelligent system, which is designed to support the decision of the applicant to choose a specialty of higher education institution of construction profile. The paper also shows fragments of the system with professional game tasks, which reflect the level of spatial imagination of the individual and the ability to perform functional duties in accordance with the personnel requirements of different professions of construction. The formation scheme of the recommendatory conclusion on results of performance of these tasks is offered the mechanism of fuzzy inference of the recommendatory conclusion is shown. Clear and fuzzy criteria are proposed that can be used to justify the recommendation conclusion. The possibility of using the fuzzy artificial neural network Takagi-Sugeno-Kang to setup the parameters of the model used to reflect certain professional abilities of the individual is shown.

Keywords

fuzzy inference system, fuzzy evaluation criteria, professionally-oriented game tasks, recommendation conclusion.

1. Introduction

Choosing a profession is an important stage of human life. However, many entrants when entering educational institutions make the wrong decision to choose their specialty due to lack of a clear idea of the future profession. The help and advices of friends, relatives and parents do not always meet the needs of the decision maker. Providing professional assistance in choosing a specialty to entrants, who can't independently determine their future profession, is a necessary condition for training qualified professionals in various sectors of the economy. However, in the theory of decision-making there are still no unified methods and techniques for solving the problem of decision-making support in fuzzy conditions.

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The use of heuristics allows experts to provide the entrant with the necessary support based on specialized knowledge and experience [1]. But the decision of a specialty choice problem in the non-automated mode does not allow organizing support of decisions in necessary scales. Automation of the decision support process requires the collection and processing of large amounts of disparate information and involves the use of computer systems that are able to solve poorly formalized selection problems [2, 3].

Implementation of the newest learning technologies, based on new approaches to the presentation and acquisition of knowledge, also requires appropriate methods of assessment. The search for perfect methods of assessing the knowledge of entrants and students at the present stage of information technology development is extremely important, because the objectification of the assessment process, providing feedback, makes it possible to coordinate this development. This means that the introduction of intelligent decision support systems in the career guidance activities of higher education institutions is an urgent and justified task.

The main attention in this work has directed on the organization of professional self-identification of entrants of higher education institutions by introduction of modern game technologies to the process of an estimation of professional abilities [4, 5].

However, the gamerization of professional abilities assessment of the individual implies the presence:

- Databases with sets of game tasks that reflect the ability to perform functional duties in accordance with personnel requirements;
- Availability of reliable criteria for assessing these abilities;
- Specialist profile etalon maps;
- The mechanism of comparison of the entrant's profile with the corresponding etalon.

The solution to these issues in this paper has proposed by gaming test tasks according to [6 – 10].

2. Analysis of recent research and publications

The tools development for professional orientation of the individual on the basis of intelligent Internet technologies requires the formation of appropriate information resources. The main requirement for such resources is a combination of data that provide an opportunity to information, advice, test, assess the individual to provide reasonable support for decision-making on the choice of future specialty.

Various aspects of the problem of computer testing of professional competence are the subject of scientists who have focused their activities on the study of testing processes and the development of test products [11, 12]. At the same time, there is a sufficient number of works in which the issues of using of fuzzy logic and fuzzy inference are investigated, which allow to create specialized intelligent systems for different purposes [11 – 14].

Concept 1. Fuzzy logic inference is the process of obtaining logical inferences from the input data according to given fuzzy rules.

Concept 2. Fuzzy inference system is a control system based on fuzzy logic. The proceeding of the fuzzy inference system have based on the integrated knowledge of experts instead of the mathematical model, which has described with the help of linguistic variables, fuzzy sets and fuzzy rules [11, 12].

Modern fuzzy inference systems on the principle of output formation has divided into [12, 13]:

- fuzzy inference system of the first type, in which the output value is as a weighted average of the results of each rule; defuzzyfication is carried out separately for each rule; the original membership functions must be monotonically non-decreasing;
- fuzzy inference systems of the second type, in which the output fuzzy value is the result of combining the fuzzy outputs of each rule; each fuzzy output is weighted by means of rules activation; the clear initial value is the result of the defuzzyfication of the combined fuzzy inference;
- fuzzy inference systems of the third type, which are based on rules of the Sugeno type; the output value in such systems is a linear combination of input values plus some constant, and the total output is the weighted average of all rules.

Concept 3. Specialized intelligent system - a system based on knowledge and programs of artificial intelligence, which solves a fixed set of problems, which is determined when designing the system.

In knowledge-based systems, the knowledge base is separating from the rest of the system to simplify the process of replenishing knowledge in conditions associated with changes [11, 15]:

1. Demand for the profession;
2. Qualification requirements;
3. Educational programs in accordance with changes in qualification requirements.

A systematic presentation of the mathematical foundations and methods of processing fuzzy knowledge is contained in [11, 12, 16]. In these works, it is noted that inference systems with fuzzy logic are a convenient tool for explaining the conclusions, but these systems are not able to automatically acquire knowledge for use in inference mechanisms. That is why the development of decision support systems based on artificial intelligence systems with integrated fuzzy logic is a promising scientific and practical direction of solving problems of professional self-identification.

The prospect of applying models and methods of fuzzy mathematics and fuzzy inference is the possibility of implementing hybrid technologies using [7, 12, 17]:

- Fuzzy artificial neural networks;
- Adaptive replenishment of fuzzy rules databases;
- Support for fuzzy database queries;
- Construction of fuzzy cognitive maps;
- Fuzzy graphs;
- Fuzzy decision-making trees;
- Fuzzy clustering.

Concept 4. Membership Function – subjective measure of fuzziness $\mu_A(x)$ which reflects the degree of correspondence of the values of the element $x \epsilon X$ to the concept formalizing by the fuzzy plural *A*. In fuzzy output systems, the functions-consequent obtained by enforcing the rules has combined into one membership function $\mu(y)$ [11].

3. Modelling Intelligent Decision Support System of Entrants

3.1 IDSSE conceptual model

Figure 1 show the conceptual model of the Intelligent Decision Support System of Entrants (IDSSE) for the choice of training specialty, which is being developed.

IDSSE cooperates with the Ministry of Education and Science of Ukraine, employers, graduates and entrants of higher education institutions [18].

At same time:

- The Ministry of Education and Science of Ukraine ensures the formation and implementation of state policy in the fields of education and science and carries out state supervision over the activities of educational institutions and enterprises, institutions and organizations that provide services in the field of education;
- Employer – the owner or authorized body of the enterprise, institution, organization, interaction with which contributes to the training of specialists taking into account the qualification requirements for graduates, by improving the professional competencies of educational programs;
- Graduate – a person communication with whom provides an opportunity to form a database of etalons that reflect the affiliation of the personal characteristics of the entrant to the specialties in which he can successfully realize his potential;
- Entrant – a person who seeks for a support on the choice of study field.

IDSSE functioning is supported by the following structural units:

- The educational and methodical department of the higher education institution is responsible for the organizational and methodological support and improvement of the educational process in the higher education institution;

- Dean's office, which are subdivisions of faculties in a higher education institution, which are responsible for organizational work and perform the function of feedback with IDSSE;
- Departments – the basic structural units of higher education institutions that conduct educational, methodological and scientific activities in a particular specialty or intersectional group of specialties;
- Experts – highly qualified specialists with relevant education, qualifications and special knowledge on issues in the relevant field, directly conducts the expertise and is personally responsible for the accuracy and completeness of the analysis, the validity of the conclusions in accordance with the task of the expertise.

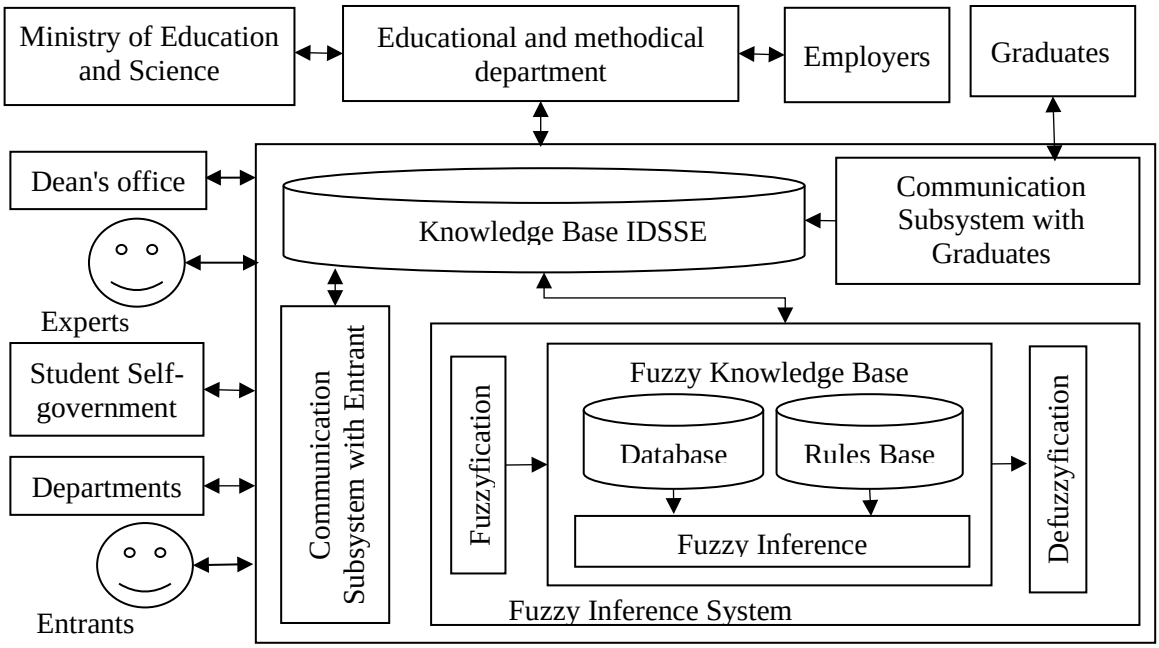


Figure 1: IDSSE model

The developing system consists of the IDSSE knowledge base, the subsystem of interaction with the entrant and graduates of the higher education institution.

The IDSSE knowledge base contains databases that are necessary for providing information, testing and assessment of professional abilities of a person in the specialties of a higher education institution. The databases store data on the specialties of the educational institution, the requirements (personal, mental, professional) that are required for the respective professions [18, 19].

The subsystem of communication with graduates performs the function of acquiring knowledge about the implementation of IDSSE recommendations on the choice of study field and job satisfaction at the stages of training and employment, respectively.

The fuzzy inference system is designed to assess the professional abilities of the entrant based on the results of communication and consists of [3, 20]:

- A fuzzy rule base that contains a system of rules *«if $x \in A$, then $y \in B$»*, where: x and y – input and output variables specified in the definition area of the fuzzy rule X and the definition area of the output Y Y; A and B – statements defined on X and Y with measures of affiliation $\mu_A(x) \in [0;1]$ and $\mu_B(y) \in [0;1]$, respectively;
- A database that stores fuzzy set membership functions used in fuzzy rules;
- Fuzzyfication unit that converts clear input values to fuzzy ones according to their membership functions;
- Fuzzy inference block, which defines the membership functions of fuzzy implications $\mu_{A \to B}(x,y)$ using operations from the rule base on fuzzy plurals from the fuzzyfication block;
- Defuzzyfication unit that implements the procedure of converting fuzzy output results into clear values according to their membership.

A feature of the developing IDSSE is the provision of the opportunity to take a test of professional abilities of the entrant by performing game tasks. To do this, the results of pre-university education of the entrant are uploaded to the IDSSE knowledge base. Based on the analysis of these results, the entrant is provided with a list of specialties of the higher education institution, for which he is competitively selected. If the entrant is not able to make a choice on their own, IDSSE offers him to pass an additional assessment of professional abilities. The rules according to which the fuzzy knowledge base of the fuzzy inference system is loaded (Fig. 1) for testing are formed by experts.

The interaction of the person undergoing testing takes place through the subsystem of inter action with the entrant [20-23].

Interaction of the entrant with IDSSE has realized by a subsystem of interaction with the entrant Fig.2.

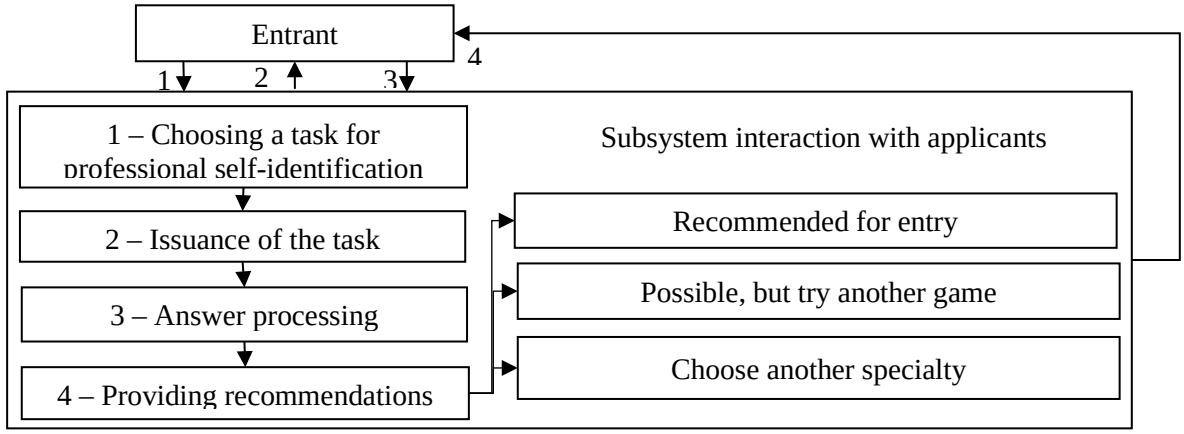


Figure 2: Scheme of the entrant's interaction with ISSDE

The interaction subsystem with the entrant performs the following functions:

- Processing the user's request for an additional professional self-identification task ("Step 1");
- Issuance of a task to assess the ability to study in current specialty ("Step 2");
- Processing of the entrant's answer ("Step 3");
- Providing a recommendation ("Step 4").

3.2 The main functions of IDSSE

The main functions of the system:

1. Informing the entrant about the specialties of the higher education institution and professional activity in these specialties;
2. Testing to identify professional competencies in the specialties of higher education;
3. Substantiation and issuance of recommendations for the choice of specialty;
4. Accumulation and storage of information about system users;
5. Formation of statistical and final data on the use of the system.

The IDSSE information resource contains the following main functional components:

- Data on types of professional activity, specialties, their content and features;
- Data on the educational institution, its characteristics and set of educational services;
- Statistical and analytical data on the labor market, employers, demand for specialists and employment opportunities;
- Test tasks to assess the professional abilities of entrants;
- Statistical data for acquiring knowledge about the entrant and the IDSSE recommendation provided to him on the choice of field of study; study results of students who accepted the recommendation and job satisfaction of graduates of higher education institutions;
- A base of etalons that reflect the affiliation of the personal characteristics of the applicant to the specialties in which he can successfully realize his potential;

- Statistical, final and reporting data on the results of the system.

3.3 IDSSE functioning processes

The process of providing support to the entrant's decision to choose a specialty consists of the formation, justification and provision of recommendations [3, 19].

The formation and justification of recommendations using IDSSE is proposed to perform based on test results that reflect (Fig.3):

- Interest to professional activity;
- Ability to perform professional tasks;;
- Level of development of spatial imagination;
- Decision making speed.

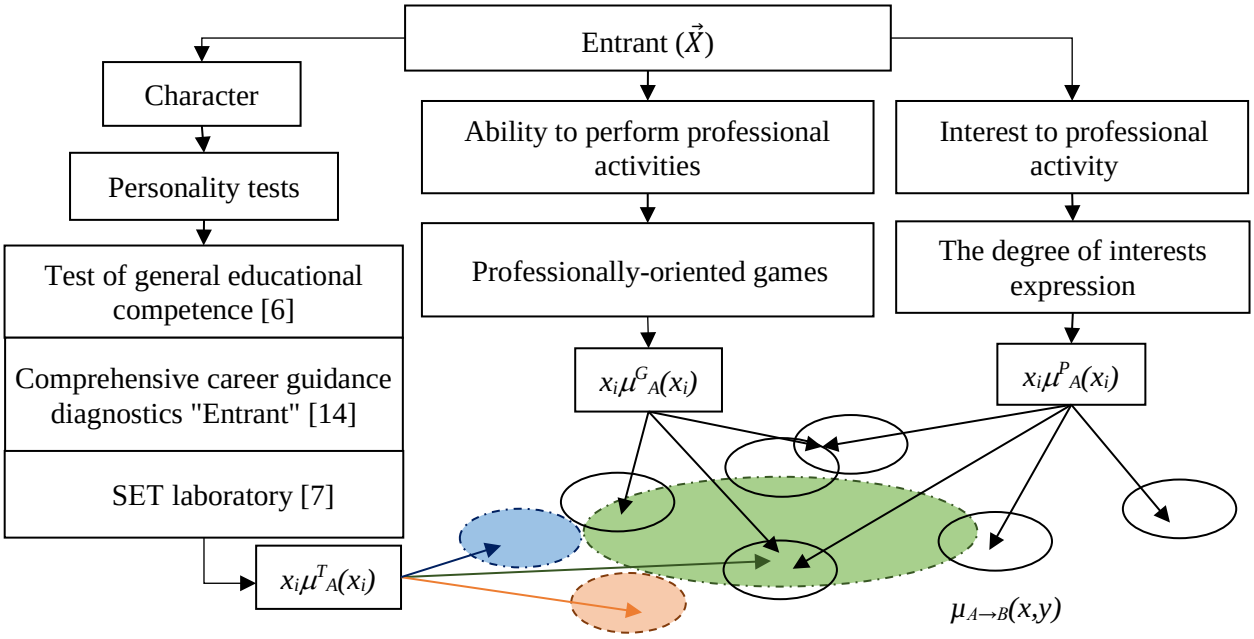


Figure 3: The formation scheme of a portrait of the entrant's personality

The degree of interest to professional activities can be characterized by the time of the game choice (t_G) from the proposed system of many games.

The time of each level passing reflects the speed of decision-making when performing professionally oriented tasks, and the relative criterion τ_i provides an opportunity to compare it with the etalon time of the task of a certain level $(L_i,\ i=1,\ldots,I)$. The transition from clear to fuzzy characteristics by the passing time is carried out taking into account the nature of the game task, which at this stage of the study is determined by experts. When assigning membership functions to the input and output data at this stage of system development, binding and adaptation heuristics are used.

3.4 Game technologies implementation in the process of assessment of professional abilities of the entrant

To implement the testing of professional abilities of the entrant by assessing the results of game tasks, the IDSSE knowledge base (Fig. 1) uses a database consisting of certain entities (specialties, entrants, tests and the results of their passing). Processing and comparing these data with the etalons determines the compliance of the individual's ability to study by a particular specialty.

Table 1 – 3 shows examples of tasks that reflect the spatial imagination of the individual.

In the game "Architect" (Table 1) the entrant is offered tasks of different levels, during which he can feel like an architect, project manager, planning engineer and foreman. The game reflects the ability to master the specialty 191 Architecture and Urban Planning.

Table 1

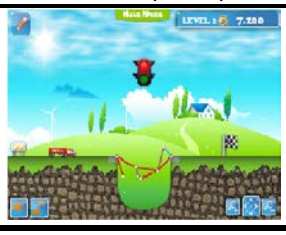
Fragment of a test task by specialty 191

Level 1	Level 2	Level 3	Level 4
			

In the game "Building a bridge" (Table 2) the entrant is offered tasks related to the buildings construction of varying complexity. The game reflects the ability to master the discipline "Resistance of Materials", which is relevant to the specialties 192 Construction and Civil Engineering.

Table 2

Fragment of a test task by specialty 192

Level 1 (start)	Level 1 (Error)	Level 2 (Error)	Level 3 (success)
			

In the game "Plumber game" (Table 3) the entrant is offered tasks related to the design and construction of water supply networks. The task is complicated by the time limit given for passing the level. The game reflects the ability to master the specialty 194 Hydraulic Engineering, Water Engineering and Water Technology.

Table 3

Fragment of a test task by specialty 194

Level 1	Level 2	Level 3	Level 4
			

Each of the tests for assessing professional abilities contains game tasks of different levels. It is proposed to determine the weight of each level of tasks by criteria: $p_1=0,1;\ p_2=0,2;\ p_3=0,3;\ p_4=0,4$, that reflecting the ability to perform professional tasks (Table 4.).

With this choice of coefficients $\sum_{i=1}^{4} p_i = 1$ and the evaluation, criteria acquire clear values. However, taking into account the number of attempts and analysis of errors that the entrant may make, when performing tasks of different levels, the criteria become fuzzy. In this case $\vec{P}=\overrightarrow{(0,1;\ 0,2;\ 0,3;\ 0,4)}$ is the vector of maximum estimates. Assess the ability to performing tasks

of professional orientation in the paper is proposed by the criterion $\tau_i = \frac{T_i}{t_i}$, where t_i is the time spent on the passing of the i-th level of the task, T_i is the appropriate time spent by a specialist.

Table 4
An example of fuzzyfication and defuzzyfication of data that characterize the results of game tasks of different levels

G_n^{194}	Level 1 (elementary)	Level 2 (required)	Level 3 (acceptable)	Level 4 (sufficient)
p_i	0.1	0.2	0.3	0.4
t_i	[15; 30]	[30; 60]	[45; 90]	[60; 120]
T_{et}	15	30	45	60
τ_i	[1; 2]	[1; 2]	[1; 2]	[1; 2]
$\mu_A^G(L_i)$	[0,1; 0,2]	[0,2; 0,4]	[0,3; 0,6]	[0,4; 0,8]
$\mu_B^P(y)$	<0.2		[0,2; 0,6]	>0,6
Linguistic assessment	Choose another specialty		possibly	Recommended

An example of fuzzyfication and defuzzyfication of data characterizing the results of a game that has 4 levels is shown in Table 4.

For example, in the game "Plumber game" (Table 3) the conclusion is determined by the following characteristics of time (s):$15 \le t_1 \le 30, 30 \le t_2 \le 60, 45 \le t_3 \le 90, 60 \le t_4 \le 120$.

In this case, the fuzzy semantics of the conclusion is determined by the rule:

- If $\mu_{A\to B}(x \to y) > 0{,}6$ recommendation conclusion is "yes";
- If $0{,}2 \le \mu_{A\to B}(x \to y) \le 0{,}6$ recommendation conclusion is "possibly";
- If $\mu_{A\to B}(x \to y) < 0{,}2$ – recommendation conclusion is "no".

The formation scheme of the entrant's personality portrait is shown in Fig.2.

The process of forming a recommendatory conclusion based on the results of career guidance testing has performed according to the scheme shown in Fig.4.

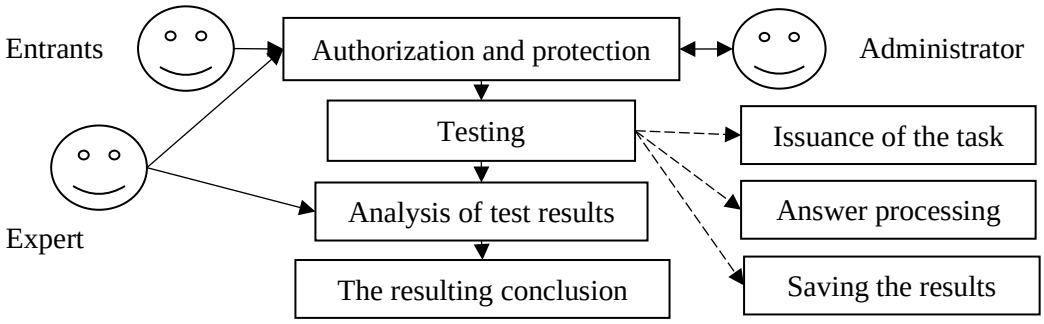


Figure 4: The formation scheme of the recommendatory conclusion for the entrant

Processing of answers and providing a recommendation is performed by a fuzzy inference system of the third type. In this case, in the process of supporting the decision to justify the recommendation conclusion, the rule $\mu_{A\to B}(x \to y) = \sum_{i=2}^{4} p_i \tau_i + p_1(min)$ is used.

Realization of the IDSSE system involves the use of an artificial fuzzy neural network Takagi-Sugeno-Kang (Fig.5), which is combined with a fuzzy inference system of the third type [24, 25]. The architecture and algorithm of Takagi-Sugeno-Kang training is described in detail in [19, 25]. Takagi-Sugeno-Kang adaptation to the problems decision of professional abilities of entrants' estimation has shown in [19].

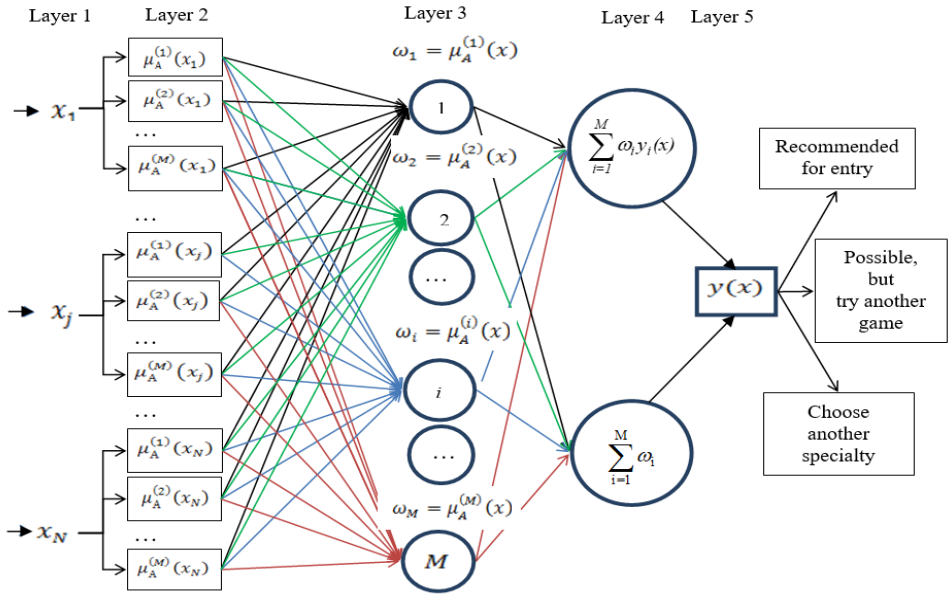


Figure 5: Model structure of fuzzy neural network Takagi-Sugeno-Kang

4. Conclusions

In this work, which is a continuation of research [19, 25], a scheme of interaction of the entrant with the IDSSE system is proposed, which, in contrast to the existing ones, performs the selection of professional test tasks. This work contains fragments of game tasks of professional orientation and the scheme of formation of the recommendatory conclusion on the results of these tasks. In addition, criteria for assessing the ability to perform professional tasks has proposed. At this stage of IDSSE development, it has proposed to use binding and adaptation heuristics, statistical data of students test results of different specialties of Kyiv National University of Construction and Architecture to assign affiliation measures. It is planned to use an artificial neural network of the Takagi-Sugeno-Kanga category to further adjust the parameters. One of the main advantages of this neural network is its integration with a fuzzy output system of the third type based on Sugeno-type rules. The limitations of the use of the proposed intelligent system include the need to present test results only in numerical form.

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