Identification of Entrant's Abilities on the Basis Fuzzy Inference Systems

Svitlana Terenchuk[a], Yuliia Riabchun[a], Nataliia Poltorachenko[a], Iryna Aznaurian[a], Vitaly Levashenko[b], Daoud Mezzane[c]

[a] *Kyiv National University of Construction and Architecture, Povitroflotky Avenue, 31, Kyiv, 03037, Ukraine*
[b] *University of Zilina, Slovakia*
[c] *Université Cadi Ayyad, Marrakech, Morocco University 1, Address, City, Index, Country*

Abstract

The paper is devoted to solving such important social task as providing professional assistance to entrants at choosing specialty for study. The relevance of development and implementation intelligent infocommunication systems into entrant's professional abilities assessing process is shown. The aim of research is to create fuzzy inference system, which is unit of the Neuro-Fuzzy Inference System of Specialized Intellectual System of Entrant's Abilities Identification. It is proposed neuro-fuzzy inference system from pairs of fuzzy artificial neural networks of Takagi-Sugeno-Kanga categories and Sugeno-type fuzzy inference systems. The possibility of using fuzzy artificial neural networks of Takagi-Sugeno-Kanga categories to solve problem of estimation entrant's special abilities is rationaled. Also expediency of using fuzzy Sugeno-type inference system is rationaled and customizing up input data's membership functions is shown. Herewith input variables reflect the expression measure of entrant's interest in the profession and results of passing computer game tasks' different levels. So the created Sugeno-type fuzzy inference system, unlike existing ones, is based on rules that reflect the interests and abilities of the person to the profession. Thus for formation of personality portrait computer game tasks of professional orientation are used. Unified rules that form knowledgebase in fuzzy inference systems are based on the expert experience. At the same time the results of fuzzy inference system work confirms the system capability to solve the problem of person professional identification in fuzzy conditions without of rules-analogues in the system's knowledgebase.

Keywords 1

Decision support, membership function plot, personality portrait, fuzzy knowledgebase.

1. Introduction

Providing professional assistance to entrants, who cannot independently choose the direction of study, is a necessary condition for the training of qualified professionals. At the same time, the professional self-determination of school graduates often occurs spontaneously under the influence of various random management influences [1–3]. Contradictions between staffing requirements and graduates' perceptions of future professions also play an important role [4–6]. The presence of these factors ensures the relevance of the development of intelligent infocommunication systems to support decision-making in choosing a future profession.

The expediency of using gaming computer technology at stage of choosing a specialty is due to age of most entrants [1, 7, 8].

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EMAIL: terenchuksa@ukr.net (S. Terenchuk); super.etsy@ukr.net (Y. Riabchun); poltorachenko@gmail.com (N. Poltorachenko); aznaurian.io@knuba.edu.ua (I. Aznaurian); vitaly.levashenko@fri.uniza.sk (V. Levashenko); daoudmezzane@gmail.com (D. Mezzane)
ORCID: 0000-0001-6527-4123 (S. Terenchuk); 0000-0002-8320-4038 (Y. Riabchun); 0000-0002-2238-6130 (N. Poltorachenko); 0000-0002- 7085-7291 (I. Aznaurian); 0000-0003-1932-3603 (V. Levashenko); 0000-0001-6527-4123 (D. Mezzane)

The use of computer game technologies has a significant potential to solve the problem of self-identification, as modern computer technology allows:

- To fixate the characteristics of personality manifested in the game [8–10];
- To reflect the measure of interest gravity in the profession;
- To identifyt, assess and develop especial abilities of the individual [11].

However, introduction of game technologies in professional identification process involves existence of systems and technologies that will identify and assess mental properties and especial abilities necessary for the successful acquisition of knowledge and skills in mastering various professions.

2. Literature review and problem statement

The review of modern researches and publications has shown that entrant solves choice multicriteria problem in the conditions of fuzzy uncertainty at specialty choice. Artificial neural networks (ANNs) of different architectures are used in various intelligent decision support systems to solve similar problems [12]. Significant obstacle to use of ANN in Intelligent Decision Support Systems of Entrants is formation of reliable sample for training of model. This is due to the length of time between entrant's testing and graduate's ability to assess the choice made based on recommended conclusion of system [13–15]. The problem is that during study of personality in a higher education institution, even reliable model of environment of the Entrant' Decision Support System may lose adequacy due to changes in an external environment.

The loss of adequacy of the environment model may be caused by changes:

- Labor market demand;
- Specialist profile requirements.

The solution to this problem is seen in the introduction of neuro-fuzzy inference systems in the asses' process of entrant's professional abilities.

Neuro-fuzzy inference systems are systems in which [16–18]:

- The inference is based on a fuzzy logic apparatus it Fuzzy Inference Systems (FIS) are using;
- The weighing up criteria is setting by fuzzy ANNs, the structure of which corresponds to main FIS blocks.

The advantages of neuro-fuzzy inference systems are logical transparency and ability to combine advantages of ANN and FIS [19]. However, development of such the system involves the creation of FIS and the mapping of the fuzzy knowledge base of this FIS to memory card of the integrated ANN [17, 19, 20].

3. The aim and objectives of research

The aim of the study is to create Fuzzy Inference System, which is the Neuro-Fuzzy Inference System's unit of Specialized Intellectual System of Entrant's Abilities Identification.

To achieve this aim it is necessary to solve such problems:

- To rationale the choice of ANN and FIS pairs to solving the problem of identifying the entrant's abilities based on result computer game tasks of professional orientation;
- To customize up input data's membership functions;
- To form fuzzy rules for the prior knowledgebase within fuzzy inference system.

4. Creating Fuzzy Inference System for Specialized Intellectual System of Entrant's Abilities Identification

For support the decision on choice of specialty in [21] it proposed to use Specialized Intellectual System of Entrant's Abilities Identification, which is Intelligent Decision Support System. The task of forming a recommendatory conclusion in this system it assigned to the neuro-fuzzy inference system [22].

4.1. Rationaleing the choice of ANN and FISH pairs

The structure of neuro-fuzzy inference system is shown in Fig. 1.

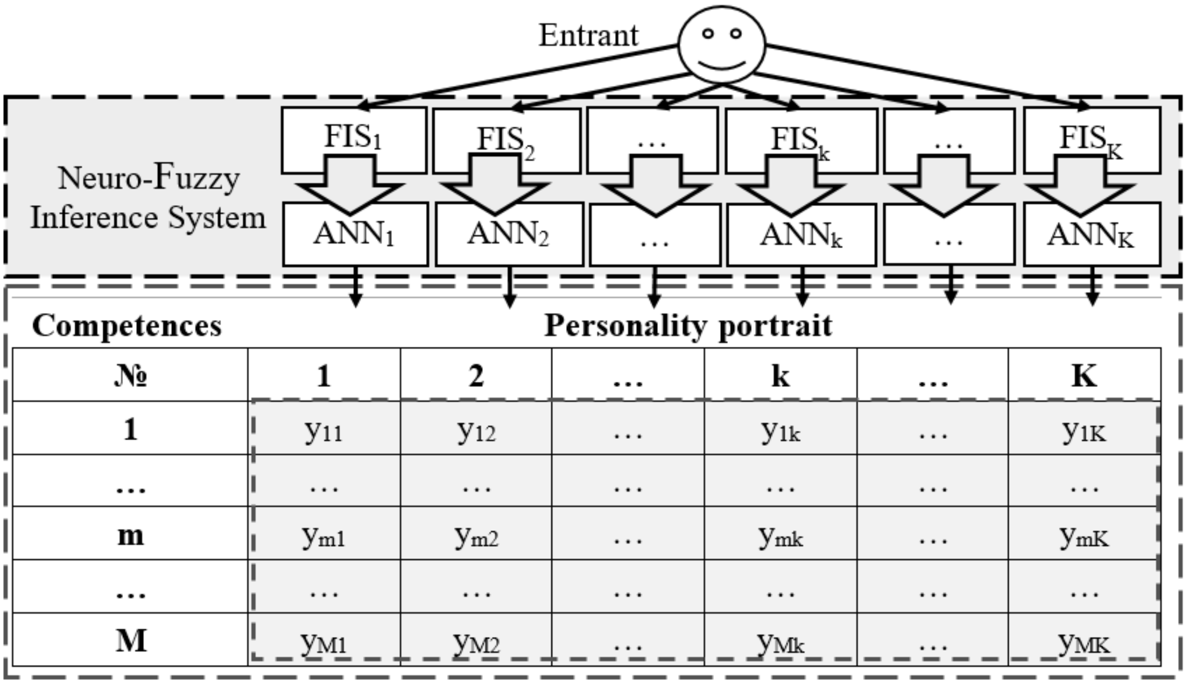

Figure 1. The formation scheme of entrant's personality portrait in the space of requirements to profile of the specialist

In [10, 21] to provide reasonable support for entrant's decision, he's personality portrait in space of the requirements for the specialist profile was propos is reproducing by use of computer game tasks professional direction. In this study standard specialist portrait is formed on the appropriate set of competencies.

In such conditions:

- Interest and ability of person to master various specialties are reflected in clear criteria [21], which are dynamic stochastic nature;
- The output variable can be defined as a linear combination of input values [16].

This means that the output of ANN_k (k=1,…,K) for the j- th (j=1,…,J) rules have the form:

$$\text{if } \left(x_1 \text{is } A_1^{(j)}\right)\ldots\left(x_n \text{is } A_n^{(j)}\right)\ldots\left(x_N \text{is } A_N^{(j)}\right) \text{then } y_j = \rho_{jo} + \sum_{n=1}^{N} \rho_{jn} x_n, \quad (1)$$

Where x_n (n=1,…,N) – input variables; ρ_{jn} – parameter to be set during training ANN.

Thus, the inference according to rules (1) can be implemented by use ANN Takagi-Sugeno-Kanga (TSK), because trained ANN of this category is able to solve the problem of fuzzy classification by clear-cut input data [17, 18].

The parameter ρ_{jn} (n=1,…,N; j=1,…,J) in this work is interpreted as weight of criterion, that reflects ability of person to perform professional activities within k-th (k=1,…,K) specialty (Fig. 1).

The Fuzzy Logic Toolbox software package of MATLAB system was used to create FIS. This choice is justified by availability of the system to a wide range of entities interested in an adequate assessment of the professional abilities of individual. Currently, this software package implements FIS type Mamdani and FIS type Sugeno. The models differ in the format of knowledgebase and defuzzification procedure [23–25].

Mamdani-type FIS are used in automated expert systems that operate with linguistic variables and fuzzy sets or need processing of textual information [20, 22]. However, the task of interpreting dynamic stochastic variables, reflecting the ability of entrant to acquiring special knowledge and skills as a result of doing game tasks, requires the use of a set of rules that reflect the functional relationship between input and output variables.

Sugeno-type FIS converts clear inputs (x_n) to clear outputs (y), using linguistic variables and fuzzy sets according to rules consisting of [20, 23]:

$$P_j:\ \text{if}\left(x_1 \text{is } T_{1,j}\right)\ldots\left(x_n \text{is } T_{n,j}\right)\ldots\left(x_N \text{is } T_{N,j}\right)\ \text{then } y = f\left(x_1, \ldots, x_n, \ldots, x_N\right). \quad (2)$$

In association (2) P_j – is the j-th line-conjunction in which the output is estimated by the linguistic term T_j.

The ability to present the output of FIS in the form of functions of the output variable from the input values gives Sugeno model significant advantage at solving the problem of assessing abilities of applicants, if the input variables are numerical values [16]. In addition, Sugeno-type FIS knowledgebase is compatible with TSK [23]. Thus, Sugeno-type FIS was chosen for formation of fuzzy knowledgebase of Specialized Intellectual System of Entrant's Abilities Identification. The structure and principle this model's output formation is described in [12, 21].

4.2. Customizing input data's membership functions

Examples of professional computer game tasks of different levels is shown in [12, 21]. Special abilities, that are required to varying degrees to master the specialty, are determined by experts taking into account the relevant sets of competencies.

According to [21], "recommendation conclusion", which is characterized by a set of terms for linguistic estimation: "recommended this specialty", "may be this specialty", "use up other attempt" and "recommended other specialty", is output variable FIS_k (k=1,…,K).

Five linguistic variables was proposed provide to FIS_k (k=1,…,K) input.

The set of input parameters consists the following variables:

- "expression measure of the interest" in the specialty;
- "passage fact of the 1-th level" of the selected task;
- "passage result of the j-th level" of the selected task (j=2,…4).

Fig. 2 shows customization of the membership function of input data's, which depicts expression measure of entrant's interest in the specialty.

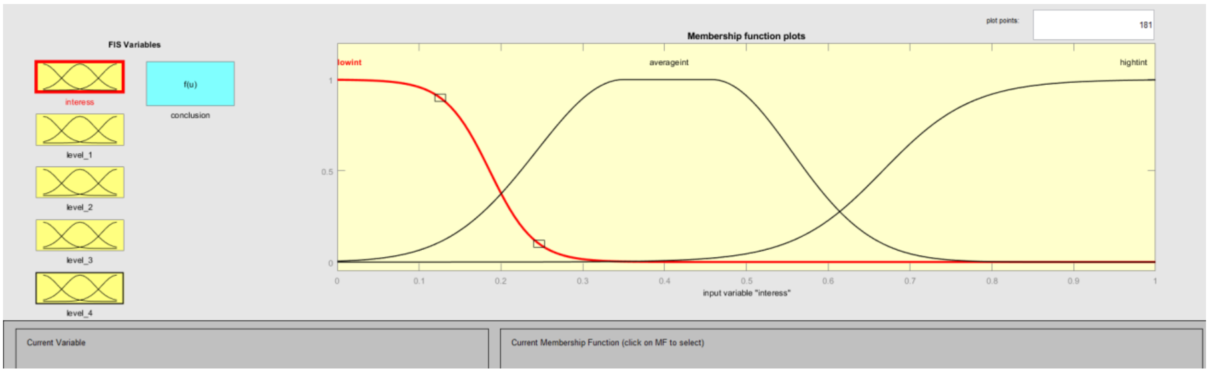

Figure 2: Linguistic estimation terms of input variable "expression measure of the interest"

On this stage of study:

- the expression measure of entrant's interest in the specialty is taken into account only by parameter ρ_{jo} (1), which is considered a function of task selection time;
- terms of linguistic estimation of this input variable is characterized by the set: "not expressed", "medium" and "high".

Fig. 3 shows the setting of the membership function plots of input estimation "passage fact of first level" of computer task of professional orientation certain time.

Linguistic estimation of the input variable "passage fact of the 1-th level" of the task is characterized by one of the terms "failed" or "passed". The time to complete tasks in each case is determined by experts.

Fig. 4–6 shows the membership function plots of the input variable, which reflects the passage results of computer game tasks of professional orientation.

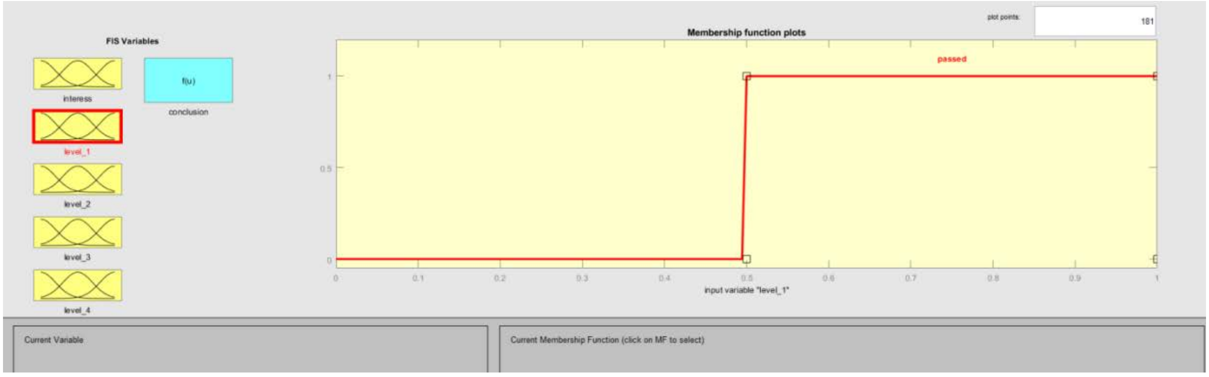

Figure 3: Linguistic estimation terms of input variable "passage fact of the 1-th level"

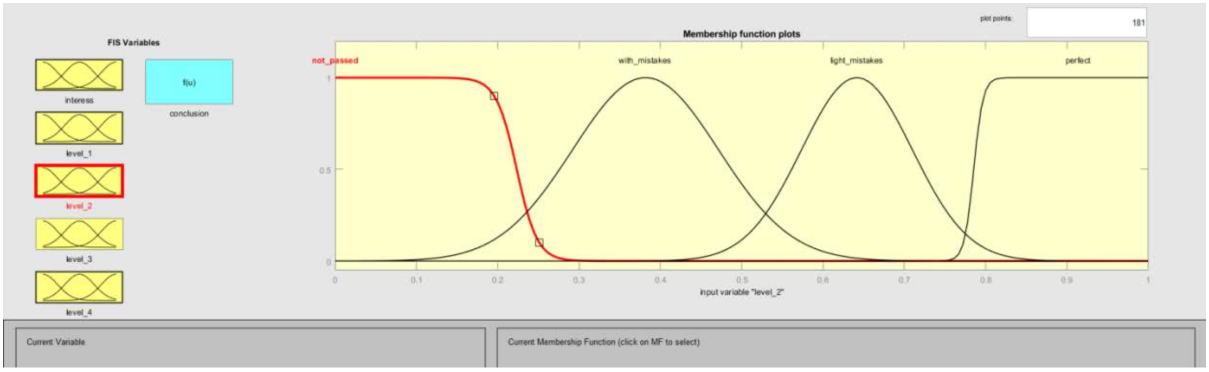

Figure 4: Linguistic estimation terms of input variable "passage result of the 2-th level"

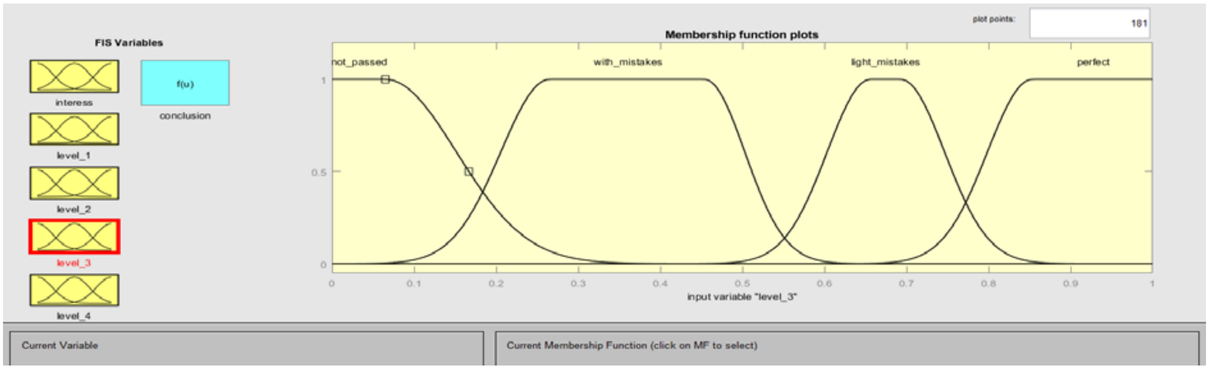

Figure 5: Linguistic estimation terms of input variable "passage result of the 3-th level"

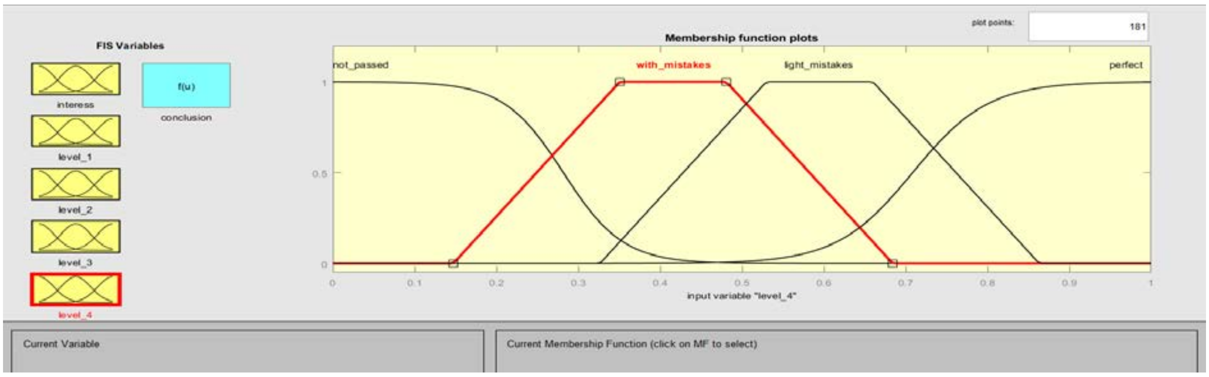

Figure 6: Linguistic estimation terms of input variable "passage result of the 4-th level"

The second level is considered passed if the task is completed at appropriate time and if during the task was made no more than two mistakes of first kind or no more than one mistake of second kind. Linguistic estimation of the input variable "passage result of the 2-th level" is characterized by the following set of terms: "failed", "passed with error of second kind", "passed with errors of first kind" and "passed without errors".

The third and fourth levels are considered passed if tasks are completed at appropriate time, and if no more than two mistakes of first kind were made during their performance.

Linguistic estimation of input variables "passage result of the 3-th level" and "passage result of the 4-th level" are characterized by the following set of terms: "failed", "passed with two errors", "passed with one error" and "passed without errors".

Task time and errors character are determined by experts. When selecting type, ranges and parameters of membership functions for input data, binding and adaptability heuristic were used [21].

4.3. Forming fuzzy rules for priori knowledge base within fuzzy inference system

Generalized rules that reproduce the expert's productive activities in the process of supporting the decision-making at professional identification have the form (3).

$$P_j:\ \text{if}\left(L_1 \text{is} T_{1,j}\right)\left(L_2 \text{is} T_{2,j}\right)\ldots\left(L_n \text{is} T_{n,j}\right)\ \text{then}(LY\ \text{is}\ TY_j), \qquad (3)$$

Where: L_n – linguistic estimation of input variable x_n; LY – linguistic estimation of original variable; $T_{n,j}$ – linguistic estimation terms of variables in the j-th ($j=1,\ldots,k_j$) row of fuzzy inference; k_j – quantity of conjunction rows in which the output is estimated by means of the term TY_j.

Fuzzy rules from which the rules base of the fuzzy knowledgebase FIS_k ($k=1,\ldots,K$), are formed, represent fuzzy logical implications of type (3) and have the form (4)–(7):

If (expression measure of the interest is high)
and (passage fact of the 1-th level is passed)
and (passage result of the 2-th level is passed without errors)
and (passage result of passing the 3-th level is passed without errors)
and (passage result of passing the 4-th level is passed without errors)
then (recommendation conclusion is recommend the specialty); (4)

If (expression measure of the interest is high)
and (passage fact of 1-th level is passed)
and (passage result of passing the 2-th level is failed)
and (passage result of passing the 3-th level is failed)
and (passage result of passing the 4-th level is passed without errors)
then (recommendation conclusion is maybe this specialty); (5)

If (expression measure of the interest is high)
and (passage fact of 1-th level is passed)
and (passage result of passing the 2-th level is passed with error of the second kind)
and (passage result of passing the 3-th level is passed with two errors)
and (passage result of passing the 4-th level is failed)
then (recommendation conclusion is use up other attempt); (6)

If (expression measure of the interest is not expressed)
and (passage fact of 1-th level is passed)
and (passage result of passing the 2-th level is passed with error of the second kind)
and (passage result of passing the 3-th level is passed with two errors)
and (passage result of passing the 4-th level is failed)
and (recommendation conclusion is recommend other specialty); (7)

5. Results and Discussion

The result of this work is the FIS_k ($k=1,\ldots,K$) knowledgebase, which contains unified rules to estimating Entrant's professional abilities (Fig. 7).

1. If (interess is hightint) and (level_1 is passed) and (level_2 is not_not_passed) and (level_3 is not_not_passed) and (level_4 is perfect) then (conclusion is maybe) (1)
2. If (interess is hightint) and (level_1 is passed) and (level_2 is perfect) and (level_3 is perfect) and (level_4 is perfect) then (conclusion is recomended) (1)
3. If (interess is averageint) and (level_1 is passed) and (level_2 is perfect) and (level_3 is perfect) and (level_4 is perfect) then (conclusion is recomended) (1)
4. If (interess is averageint) and (level_1 is passed) and (level_2 is light_mistakes) and (level_3 is light_mistakes) and (level_4 is perfect) then (conclusion is recomended) (1)
5. If (interess is averageint) and (level_1 is passed) and (level_2 is light_mistakes) and (level_3 is perfect) and (level_4 is perfect) then (conclusion is recomended) (1)
6. If (interess is averageint) and (level_1 is passed) and (level_2 is perfect) and (level_3 is light_mistakes) and (level_4 is perfect) then (conclusion is recomended) (1)
7. If (interess is averageint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is perfect) and (level_4 is perfect) then (conclusion is recomended) (1)
8. If (interess is hightint) and (level_1 is passed) and (level_2 is perfect) and (level_3 is with_mistakes) and (level_4 is perfect) then (conclusion is recomended) (1)
9. If (interess is hightint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is perfect) and (level_4 is perfect) then (conclusion is recomended) (1)
10. If (interess is averageint) and (level_1 is passed) and (level_2 is light_mistakes) and (level_3 is light_mistakes) and (level_4 is light_mistakes) then (conclusion is maybe) (1)
11. If (interess is averageint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is perfect) and (level_4 is light_mistakes) then (conclusion is maybe) (1)
12. If (interess is averageint) and (level_1 is passed) and (level_2 is perfect) and (level_3 is with_mistakes) and (level_4 is light_mistakes) then (conclusion is maybe) (1)
13. If (interess is hightint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is with_mistakes) and (level_4 is perfect) then (conclusion is maybe) (1)
14. If (interess is hightint) and (level_1 is passed) and (level_2 is light_mistakes) and (level_3 is perfect) and (level_4 is with_mistakes) then (conclusion is maybe) (1)
15. If (interess is hightint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is perfect) and (level_4 is light_mistakes) then (conclusion is maybe) (1)
16. If (interess is averageint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is with_mistakes) and (level_4 is not_passed) then (conclusion is not_recommended) (1)
17. If (interess is averageint) and (level_1 is passed) and (level_2 is not_passed) and (level_3 is with_mistakes) and (level_4 is with_mistakes) then (conclusion is not_recommended) (1)
18. If (interess is averageint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is not_passed) and (level_4 is with_mistakes) then (conclusion is not_recommended) (1)
19. If (interess is hightint) and (level_1 is passed) and (level_2 is light_mistakes) and (level_3 is light_mistakes) and (level_4 is with_mistakes) then (conclusion is try_again) (1)
20. If (interess is hightint) and (level_1 is passed) and (level_2 is light_mistakes) and (level_3 is perfect) and (level_4 is not_passed) then (conclusion is try_again) (1)
21. If (interess is averageint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is with_mistakes) and (level_4 is perfect) then (conclusion is try_again) (1)
22. If (interess is lowint) and (level_1 is passed) and (level_2 is with_mistakes) and (level_3 is with_mistakes) and (level_4 is perfect) then (conclusion is not_recommended) (1)
23. If (interess is averageint) and (level_1 is passed) and (level_2 is not_passed) and (level_3 is perfect) and (level_4 is perfect) then (conclusion is try_again) (1)
24. If (interess is hightint) and (level_1 is not passed) then (conclusion is try_again) (1)
25. If (level_1 is not passed) then (conclusion is not_recommended) (1)

Figure 7. The FISk (k=1,…K) knowledgebase

Fig. 8 shows an example of FIS_k (k=1,…,K), which is formed on the basis of all the rules loaded into the fuzzy knowledgebase of the system.

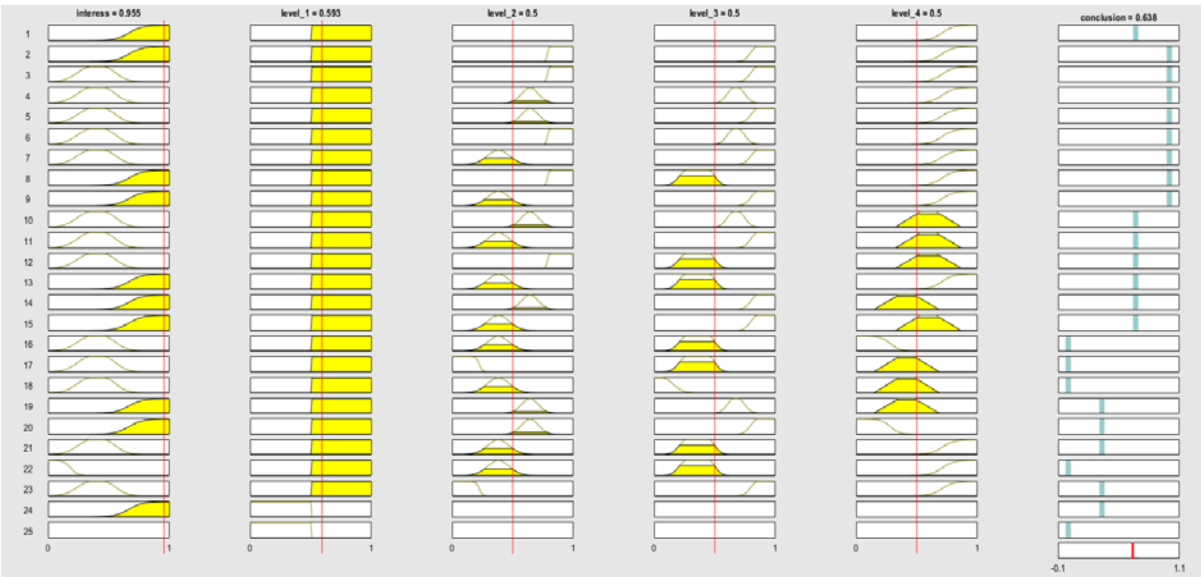

Figure 8: The example of work FIS_k (k=1,…,K)

Thus, the result of FIS work is a clear variable, on the basis of which a recommendation conclusion is formed (Table 1).

Table 1
The result of work FIS_k (k=1,…,K)

Linguistic variable	Fuzzy (clear) values of input variables	Recommendation conclusion
Expression measure of the interest	High (0.955)	
Passage fact of the 1-th level	Passed (0.593)	
Passage result of the 2-th level	Passed with errors (0.5)	0.638 maybe this specialty
Passage result of the 3-th level	Passed with two errors (0.5)	
Passage result of the 4-th level	Passed with errors (0.5)	

The result of FIS_k (k=1,…,K) work, shown in Fig. 8, confirms the system capability to solve the problem of person professional identification in fuzzy conditions (Fig. 4, 6) without of rules-analogues in the system's knowledgebase. At the same time, fuzzy linguistic estimates of input and output variables acquire clear values.

Thus, the use of the created FIS provides an opportunity to:

- Rules (3) received from experts and formalized in fuzzy logical implications form can be reflected into TSK architecture, which implements logical inference according to (1);
- To form a sample for TSK training based on simulation.

At this study stage, reliability of the model is ensured by experts, but the question of forming a test sample to verify the adequacy of the trained model requires acquisition of real statistics that is subject of further research.

6. Conclusions

1. It is proposed neuro-fuzzy inference system from pairs of fuzzy artificial neural networks of Takagi-Sugeno-Kanga categories and Sugeno-type fuzzy inference systems.
2. The possibility of using fuzzy artificial neural networks of Takagi-Sugeno-Kanga categories to solve problem of estimation entrant's special abilities is rationaled.
3. Expediency of using fuzzy Sugeno-type inference system is rationaled and customizing up input data's membership functions is shown. Herewith input variables reflect the expression measure of entrant's interest in the profession and results of passing computer game tasks' different levels.

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8. References

[1] Zakatnov, D.A. (2001) Psychological and pedagogical foundations of professional self-determination of schoolchildren. Scientific Notes of the Nizhyn Sovereign Pedagogical University IM. M. Gogol. Psychological and pedagogical science, No. 2. Pp. 26-31.

[2] Zazimko, O.V. (2002) The problem of identification and development of a technically gifted person in adolescence. Actual problems of psychology: Volume 6. Psychology of giftedness, V. 1. “BONA MENTE”. S. 45-58.

[3] Erik, H. Erikson. Identity, youth and crisis. New York: W. W. Norton Company. Per. from English - M.: Flinta, 2006. (Series: Library of Foreign Psychology). 342 s.

[4] Volodina E.R. New approaches to vocational guidance work. - [Electronic resource]. Access mode: http:// yppk.ru/index.php?option=com_content&view=article&id=156: 2013-03-27-05-44-33&catid=1:articles&Itemid=5.

[5] Identification. National Association for gifted children. [Electronic resource]. Access mode:: http://www.nagc.org/resources-publications/gifted-educationpractices/identification.

[6] Gordon, L.M. (2006). Howard Gardner. The encyclopaedia of human development. Thousand Oaks: Sage Publications, 2, 552-553.

[7] Wenger L.A. Game as an activity. Zap. psycho., 2008. № 3.

[8] Lebedeva T. Business games for business people. Time and thought. Odessa, 2007

[9] Honta, Victoria, (2019). Gaming training technologies and evaluation as one of the innovative forms of the spatial awareness development. Management of Development of Complex Systems, 37, 138 – 143.

[10] Riabchun Yu., Honcharenko T., Honta V., Chupryna Kh., Fedusenko O. Methods and Means of Evaluation and Development for Prospective Students’ Spatial Awareness. International Journal of Innovative Technology and Exploring Engineering, Vol.8, Issue. 11, 2019.

[11] Alekseeva G.M., Kravchenko N.V., Antonenko O.V., Gorbatyuk L.V. The use of game technologies in the process of professional training of students of pedagogical institutions of higher education. Pedagogy-Pedagogy-Pedagogy. Scientific Bulletin of the South Ukrainian National Pedagogical University named after KD Ushinsky G6 (119), 2017. Pp. 7-13.
[12] Khaddad A., Riabchun Y., Terenchuk S., Yeremenko B.Modeling of the Intelligent System of Searcfing Associative Images. PIC S&T-2019. Pp. 439-442.
[13] Sergienko NV Expert-educational systems of assessment of knowledge, skills, abilities on the basis of computer technologies of training. Series 2. Computer-based learning systems, 2006, № 4 (11). Pp. 3-8.
[14] Kuchakovskaya GA Models of creating a knowledge base of the expert system for choosing a specialty for university entrants. Educational Discourse, 2014. №1 (5). Pp.129-138.
[15] Yeremenko, B., Riabchun Yu., and Ploska, A. The introduction of intellectual system for evaluating professional abilities of applicants into the activities of educational institutions. Technology audit and production reserves, no.6/2(44), pp. 22–26, 2018.
[16] Tanaka, K., Yoshida, H., Ohtake, H., & Wang, H. O. A sum-of-squares approach to modeling and control of nonlinear dynamical systems with polynomial fuzzy systems. IEEE Transactions on Fuzzy systems, 2009. Vol. 17, Issue (4), 911-922.
[17] Zadeh LA. Fuzzy logic. Computer. 1988. Vol. 21, Issue 4. Pp.83-93.
[18] Hammah R., Curran J. Fuzzy cluster algorithm for the automatic identification of joint sets. International Journal of Rock Mechanics and Mining Science, 2010. Vol. 35, Issue 7. Pp. 889-905.
[19] Uskov, A.A., Kuzmin, A.V. Intelligent control technologies. Artificial neural networks and fuzzy logic. M.: Hot line, Telekom, 2004.143 p.
[20] Osowski S. Sieci neuronowe do przetwarzania informacji. Warszawa, 2000. 342 p. (польською).
[21] Yeremenko, B., Riabchun, Y., Ploskiy, V., Aznaurian I., Daoud Mezzane, Kryvinska N. Intelligent information technologies implementation to the process of professional self-identification // IntelITSIS’2021: 2nd International Workshop on Intelligent Information Technologies and Systems of Information Security, 2021. Pp. 168-177.
[22] Katasev, A.S. Neuro-fuzzy model for the formation of fuzzy rules for assessing the state of objects in conditions of uncertainty. Computer research and modeling, 2019. V.11, N. 3. P.477-492.
[23] Shtovba, S.D. Designing fuzzy systems using MATLAB. Moscow: Hotline-Telecom, 2007. 288 p.
[24] Dyakonov, V.P., Kruglov, V.P. Mathematical expansion packs MATLAV. Specialist. ref. SPb.: Peter, 2001.480 p.
[25] Leonenkov, A. Fuzzy modeling in MATLAV and fuzzyTECH. SPb.: BHV - Petersburg, 2003. 736 p.