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IDENTIFICATION OF ENTRANT'S ABILITIES ON THE BASIS OF SUGENO-TYPE FUZZY INFERENCE SYSTEMS

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Abstract. In the conditions of effective training in aviation for dispatchers and pilots, it requires the use of infocommunication systems capable of working under conditions of fuzzy uncertainty in real time. The functioning of such systems is based on fuzzy inference systems. However, the development and implementation of these systems requires the creation of fuzzy knowledge bases. Therefore, special attention in this study is paid to the creation of a system of fuzzy inferences and the formation of a fuzzy knowledge base of this system. The result is a lozenge-type fuzzy inference system. The fuzzy knowledge base of the system contains the rules according to which, based on the results of test computer game problems of varying complexity, a conclusion is formed about the applicant's ability to acquire knowledge and skills in a certain specialty. When developing the rules, both the results of passing different levels of professionally oriented computer test games were taken into account, and the interest of dispatchers and pilots was taken into account. Therefore, the proposed fuzzy rules of the knowledge base of the fuzzy inference system make it possible to assess not only the ability of the controller or pilot to solve certain problems. This dependence of the input dataset on time allows the implementation of a fuzzy inference system of the Sugeno type, using clear input data in the formation of inferences.

Keywords: pilots, dispatchers, membership function plot, priory knowledgebase, fuzzy rule.

Introduction

Demand at intelligent info communication systems to support decision-making in choosing a future profession is provided by such factors of modern reality as (Kaleta & Skorupski, 2019):

1. Graduates' fuzzy understanding about regarding fulfilment of personnel to requirements of future professions;
2. Deficit or lack of experience in use of personal abilities in performing working activities.

In such conditions the use of computer game technologies has a significant potential to solve the problem of self-identification, as modern computer technology allows (Valizadeh et al., 2021):

1. To fixate the characteristics of the personality manifested in the game;
2. To reflect measure of interest in the profession and the ability to study in the relevant professional field;
3. To identify, evaluate and develop especial abilities of the individual (Skorupski & Uchroński, 2016).

Besides the expediency of using gaming computer technology at the stage of choosing a specialty is due to the age of most entrants (Kaleta & Skorupski, 2019; Valizadeh et al., 2021; Mazandarani & Xiu, 2022). However, the introduction of game technologies in the professional identification process involves the existence of systems and technologies that will identify and assess the mental properties and especial abilities necessary for the successful acquisition of knowledge and skills in mastering various professions.

A review of various sources allows us to establish the fact of using a fuzzy system in solving such studies. The research is to develop a human (passenger/crew) comfort model to establish the relationship between indoor living conditions and ship movement, with the main goal of enabling a better understanding and understanding of

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the factors that can make a person more comfortable on board a ship during its operation. For this, a new passenger comfort index (PCI) was developed using a Sugeno-type fuzzy inference system that takes into account seven variables, namely motion sickness, air temperature, average radiation temperature, relative humidity, air speed, activity level. passengers and the insulation of their clothing. PCI is calculated implicitly as a result of linguistic rules, which are expressed as if-then clauses (Ng & Ölçer, 2012).

The following are being looked at, as they can, on the basis of the singing behavior, establish risks. Studies are considered that can, on the basis of certain behavior, establish risks. The research is to identify operational risk events related to fintech because historical data is not available. To do this, the study analyzes the literature to list possible OR events that can trigger an OR in banks partnering with Fintech firms. In the second step, bank operational risk analysts and managers are asked to give their opinion on 23 potential OR trigger events in the form of an expert questionnaire (Khalil & Alam, 2020).

1. Materials and methods

The material of this study is Fuzzy Inference Systems, which is the Neuro-Fuzzy Inference System's unit of the Specialized Intellectual System of Entrant's Abilities Identification (Wang et al., 2019; Peña et al., 2018; Miyata & Omori, 2018).

Neuro-Fuzzy Inference System's structure is shown in Figure 1 (Anjomshoae et al., 2021).

The following abbreviations are used in Figure 1 and below:

1. FIS is Fuzzy Inference Systems;
2. ANN is artificial neural network.

In the table showing personality portrait in Figure 1, variables y_{mk} ($m=\overline{1,M}$; $k=\overline{1,K}$) are estimates of qualities that are to some extent necessary for the acquisition of knowledge, skills and abilities in k-th ($k=\overline{1,K}$) specialty.

The recommendatory conclusion on expediency of studying in certain specialty is formed on comparison of entrant's personality portrait and etalon card. The recommendatory conclusion on expediency of studying in certain specialty is formed on comparison of entrant's personality portrait and etalon card (Yeremenko et al., 2021).

In Honta (2019) to rational support entrant's decision was propose is reproduce he's personality portrait in the space of the requirements for the specialist profile (Figure 1) by use of computer game tasks professional direction.

In such conditions:

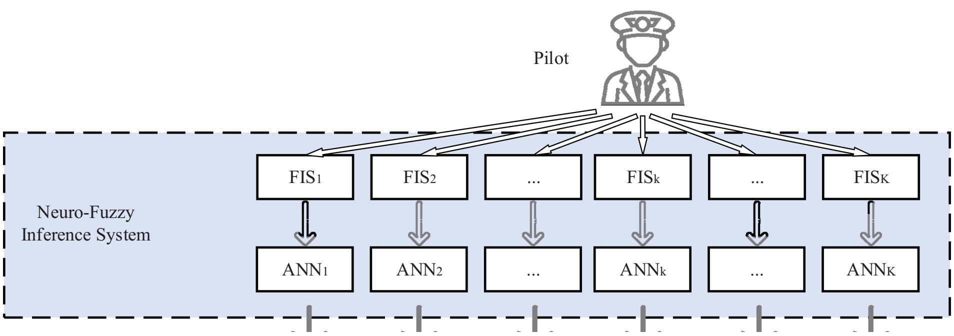
1. Interest and ability of person to master various specialties are reflected in numerical criteria, which are dynamic stochastic nature;
2. The output variable can be defined as a linear combination of input values.

This means that inference of ANN_k ($k=\overline{1,K}$) for the j-th ($j=\overline{1,J}$) rules have the form:

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

where: x_n ($n=\overline{1,N}$) – input variables; ρ_{jn} – parameter to be set during training ANN.

The conclusion according to Equation (1) can be realized by such ANN as Takagi-Sugeno-Kanga. The structure and principle this model's output formation is described in Riabchun et al. (2019). In this research parameter



Competences — **Personality portrait**

№	**1**	**2**	**...**	***k***	**...**	***K***
1	y_{11}	y_{12}	...	y_{1k}	...	y_{1K}
...	...	…	...	…	...	...
m	y_{m1}	y_{m2}	...	y_{mk}	...	y_{mK}
...	...	…	...	…	...	...
M	y_{M1}	y_{M2}	...	y_{Mk}	...	y_{MK}

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

ρ_{jn} ($n=\overline{1,N}; j=\overline{1,J}$) is interprets as weight of criterion that characterizes the ability of person to perform professional activities within k-th ($k=\overline{1,K}$) specialty. So, trained artificial neural network Takagi-Sugeno-Kanga is able to play role of expert in solving professional identification problem.

In Riabchun et al. (2019) it is shown how, based on the results of observation or experts assessments, through Fuzzy Decision Trees one can automatically obtain fuzzy logic rules of the Takagi-Sugeno type with membership functions and weights. That's why for identify of entrant's abilities is chooses Sugeno-type model. However, automatic mapping of the preory knowledgebase on ANN memory mapp involves Creation of FIS.

Sugeno-type FIS use linguistic variables and fuzzy sets at convert numerical inputs (xn) to numerical outputs (y), according to rules:

$$P_j\colon \begin{array}{l} \text{if}\left(x_1 \text{is} T_{1,j}\right)\ldots\left(x_n \text{is} T_{n,j}\right)\ldots\left(x_N \text{is} T_{N,j}\right)\text{then} \\ y=f\left(x_1,\ldots,x_n,\ldots,x_N\right). \end{array} \tag{2}$$

where: P_j – is the j-th line-conjunction in which the output is estimated by the linguistic term T_j.

Thus, FIS knowledge base of the Sugeno type is compatible with the ANN of the TSK category, which in is proposed to be used to solve the problem of assessing the entrant's abilities (Wei et al., 2021).

In this study, difference to (Anjomshoae et al., 2021), personality portrait is proposed to forms on the basis of assessments' his character traits, abilities and interest in professions (Table 1).

In this case, the parameter ρ_{j0} in Equation (1) reflects the measure of entrant's interest to the specialty.

The Fuzzy Logic Toolbox software package of the MATLAB system (Natick, Massachusetts, USA) was used to create FIS. This choice is justified by the availability of the system to a wide range of entities interested in an adequate assessment of the professional abilities of the individual. Currently, this software package implements FIS type Mamdani and FIS type Sugeno (Riabchun et al., 2019).

The ability to present the output of FIS in the form of functions of the output variable from the input values gives the Sugeno model a significant advantage at solving the problem of assessing the abilities of applicants, if the input variables are numerical values (Riabchun et al., 2019).

Such research methods were used in the work, as:

1. Analysis of the process of assess person's professional abilities during fuzzy rules formation for prior knowledgebase of fuzzy inference system;
2. Qualimetric methods of input data processing during the formation of recommendatory conclusions on the choice of specialty.

2. Results and discussion

The result of this research is Sugeno-type FIS$_k$ ($k=\overline{1,K}$).

It is propose submitting five linguistic variables at the input FIS$_k$ ($k=\overline{1,K}$).

The input set of parameters contains the following variables:

1. "Measure of interest" (MI) to problem that solve (Figure 2);
2. "Passage fact of 1st level" (L_1) of the test (Figure 3);
3. "Passage result of 2nd level" (L_2) of the test (Figure 4);
4. "Passage result of 3rd level" (L_3) of the test (Figure 5);
5. "Passage result of 4th level" (L_4) of the test (Figure 6).

Figure 2 shows customization of membership function plots of variable that characterizes measure of entrant interest at problem that his solve.

On this research stage:

1. Expression measure of entrant's interest to problem that solve is taken into account only by the parameter ρ_{j0} (1):
2. Parameter ρ_{j0} is considered a function of task selection time;
3. Terms of linguistic estimation of this input variable is characterized by the set "not expressed", "medium" and "high".

Figure 3 shows setting of membership functions plots of variable "passage fact of 1st level" of the professional orientation computer task per certain time.

Table 1. Input variable's identification

No	Specialty ($1\le k\le K$):	1	…	k	…	K
1	Character traits ($1\le j\le J_T$):	$T1j$	…	Tkj	…	K
	Weights ($0\le w_{kj}^T\le 1$):	w_{1j}^T	…	w_{kj}^T	…	TKj
2	Abilities ($1\le j\le J_A$):	$A1j$	…	Akj	…	w_{Kj}^T
	Weights ($0\le w_{kj}^A\le 1$):	w_{1j}^A	…	w_{1j}^A	…	AKj
3	Interest ($1\le k\le K$):	$I1$	…	Ik	…	w_{1j}^A
	Membership function ($0\le \mu_k^I\le 1$):	μ_1^I	…	μ_k^I	…	IK

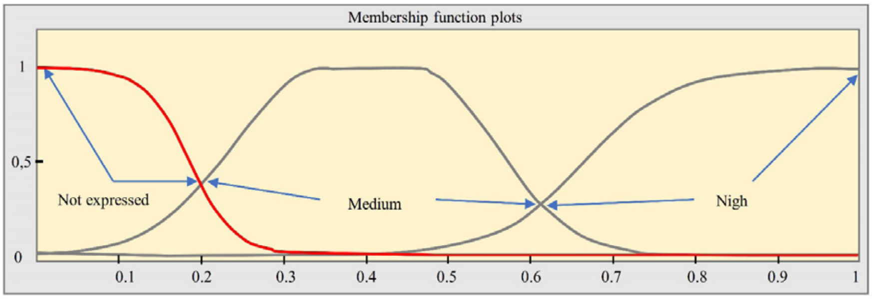


Figure 2. Linguistic estimate's terms of variable "measure of interest"

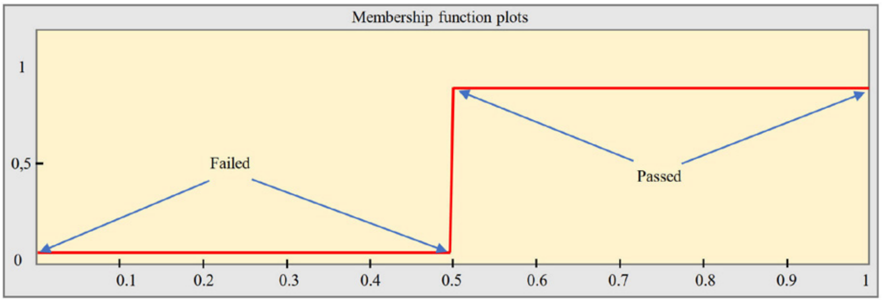


Figure 3. Linguistic estimate's terms of variable "passage fact of 1st level"

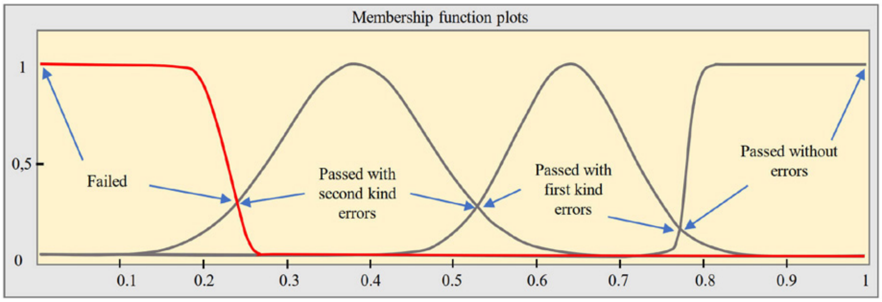


Figure 4. Linguistic estimate's terms of variable "passage result of 2nd level"

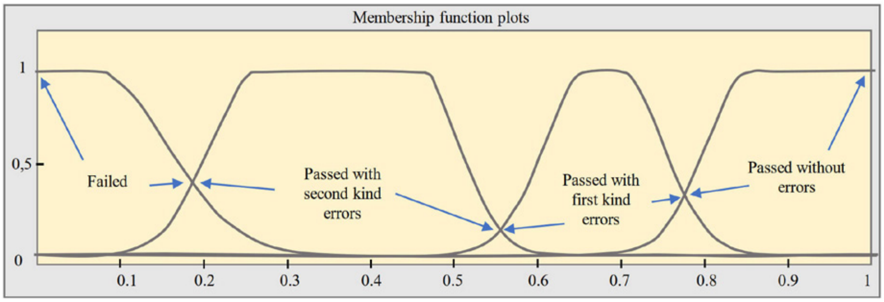


Figure 5. Linguistic estimate's terms of variable "passage result of 3rd level"

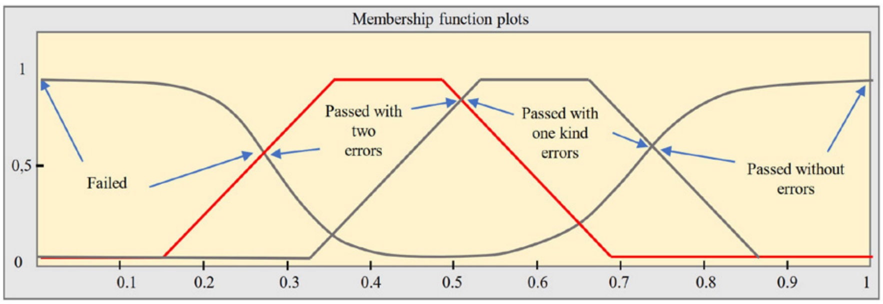


Figure 6. Linguistic estimate's terms of variable "passage result of 4th level"

Linguistic estimation of the input variable is characterized by one of the terms "failed" or "passed". The time to complete the tasks in each case is determined by experts.

Figure 4–6 shows settings the membership functions plots of the variable, which reflects the passage results of the computer game tasks of professional orientation.

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

The third level are considered passed if tests are finished at appropriate time, and if no more than two first kind mistakes were made during their performance.

The fourth levels are considered passed if tests are finished at appropriate time, and if no more than one mistake of first kind were made during their performance.

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

In contrast to other variables, trapezoidal membership functions were used to describe the Linguistic estimate's terms of variable "passage result of 4th level" such as "passed with two errors" and "passed with one error". This will reduce the level of ambiguity in the assessment process.

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 (Katasev, 2019; Honta, 2019).

Examples of computer's game tasks of different levels are shown in Wang et al. (2019).

Special abilities, that are required to varying degrees to master the specialty, are determined by experts taking into account the relevant sets of competencies.

Unified rules that reproduce expert's productive activities during supporting entrant's decision at future profession have the form (Equation (3)).

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

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

The model's output is TY = {yi}, i = 1,...,4 (Table 2):

1. "Recommended this specialty" (i = 1);
2. "Maybe this specialty" (i = 2);
3. "Use another attempt" (i = 3);
4. "Choose another specialty" (i = 4).

On the basis of fuzzy rules formed by experts, fuzzy knowledgebase FIS_k ($k=\overline{1,K}$) was created, according to which recommendatory conclusion on expediency of entry to study in the chosen specialty is formed. Fuzzy rules take into account estimate's character traits, abilities and interest in the profession.

Table 2 shows fragment of rules base formed experts it was created as this research result.

Table 2. The rules base fragment of the fuzzy knowledgebase FIS_k ($k=\overline{1,K}$)

TL = MI = {l_i}, i = 1, 2, 3	Passage fact of L_1	Passage fact of L_2	Passage fact of L_3	Passage fact of L_4	TY = {y_i}, i = 1,...,4
High	failed	failed	failed	failed	y_3
High	passed	failed	failed	failed	y_3
High	passed	passed	failed	failed	y_3
High	passed	passed	passed	failed	y_2
High	passed	passed	passed	passed	y_1
High	passed	failed	failed	passed	y_2
High	passed	passed	failed	passed	y_1
High	passed	failed	passed	passed	y_1
High	passed	failed	passed	failed	y_3
…	…	…	…	…	…
Medium	failed	failed	failed	failed	y_4
Medium	passed	passed	passed	failed	y_2
Medium	passed	passed	passed	passed	y_1
Medium	passed	failed	failed	passed	y_3
Medium	passed	passed	failed	failed	y_3
Medium	passed	failed	passed	passed	y_2
Medium	passed	passed	failed	passed	y_2
Medium	passed	failed	failed	failed	y_4
…	…	…	…	…	…
Not expressed	failed	failed	failed	failed	y_4
Not expressed	passed	failed	failed	failed	y_4
Not expressed	passed	passed	failed	failed	y_3
Not expressed	passed	passed	passed	failed	y_2
Not expressed	passed	passed	passed	passed	y_2
Not expressed	passed	failed	passed	failed	y_4
Not expressed	passed	passed	failed	failed	y_4
Not expressed	passed	passed	failed	passed	y_2
…	…	…	…	…	…

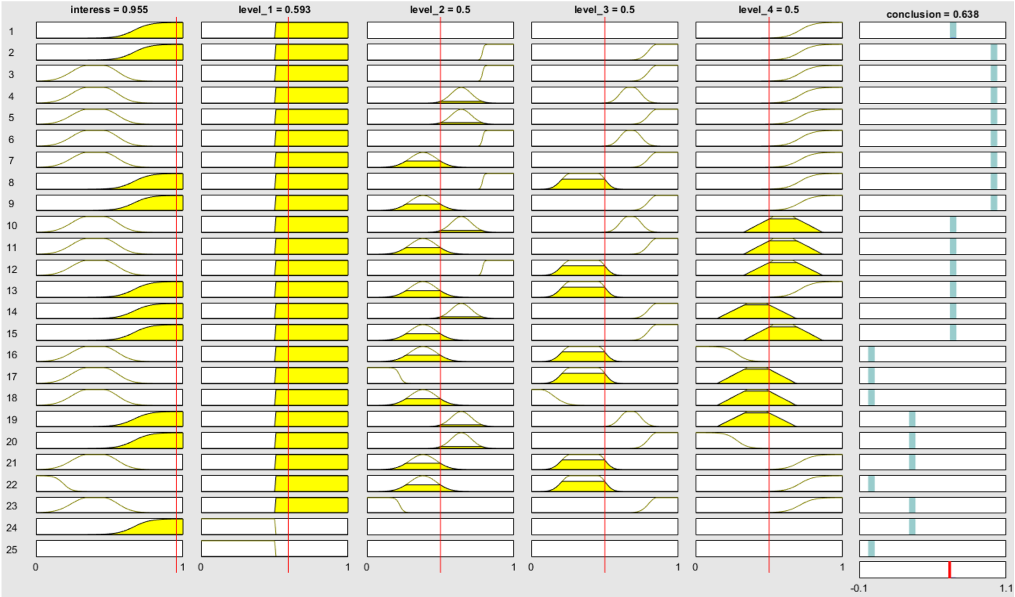


Figure 7. The example of work FIS_k $(k = \overline{1,K})$

Table 3. The result of work FIS_k $(k = \overline{1,K})$

Linguistic variable	Fuzzy values of input variables	Numerical values of input variables
Measure of the interest	High	0.955
Passage fact of 1st level	Passed	0.593
Passage result of 2nd level	Passed with errors	0.5
Passage result of 3rd level	Passed with two errors	0.5
Passage result of 4th level	Passed with errors	0.5

Figure 7 shows an example of FIS_k $(k = \overline{1,K})$ work, which formed on the basis of all rules loaded into fuzzy knowledgebase of the system.

Thus, FIS' results work are a numerical variable, on the basis of which the recommended conclusions are formed (Table 3).

Numerical value of output variable is 0.638. This numerical value corresponds recommendation conclusion is "maybe this specialty".

The result of FIS_k $(k = \overline{1,K})$ work, shown in Figure 7, confirms the system capability to solve the problem of the person professional identification in fuzzy conditions (Figure 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:

1. Rules №3 (Table 3) received from experts and formalized in the fuzzy logical implications form can be reflected into the TSK architecture, which implements logical inference according to №1;
2. To form a sample for TSK training based on simulation.

At this study stage, the 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 the acquisition of real statistics that is the subject of further research (Hadjimichael et al., 2009).

Conclusions

1. A fuzzy inference system of the Sugeno type is created in the Fuzzy Logic Toolbox of the MATLAB system. The system is capable of forming a recommendatory conclusion about the capabilities of the controller or pilot in unclear conditions.
2. An analysis of modern methods and tools for diagnosing the psychological qualities of a person's abilities has shown that the development and implementation of training for the position of a dispatcher or pilot using intelligent decision support systems to determine the necessary skills and reactions when performing important tasks is a very important step.
3. The created system forms a conclusion about the ability of an applicant for the position of a dispatcher or pilot to acquire knowledge, skills and abilities in a particular specialty based on the fulfillment of professional test

game tasks. This takes into account not only the results of passing different levels of professionally oriented computer test games. The degree of severity of the peculiarities of the work of the pilot and dispatcher is also taken into account.

4. When developing a fuzzy knowledge base of a fuzzy inference system, its compatibility with a fuzzy artificial neural network of the Takagi-Sugeno-Kanga category was taken into account. Since the neural network is supposed to be used in intelligent infocommunication systems to support decision-making when choosing a future profession.
5. Further research is planned to be carried out in order to develop an appropriate knowledge base and further information processing using a neural network. This approach will make it possible to clearly build the logic of checking the skills of the controller and the pilot.

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