The Decision Support System Education Career Choice Using Fuzzy Model

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Abstract

The decision support system has been developed to select the direction of study for applicants. It is based on a two-level mathematical model, which includes, at the first level, an expert system, and at the second level, a fuzzy inference model to describe the selection process, which are complex and non-linear.

The developed expert system gives an idea of the area of knowledge to which the future specialty can be attributed. The fuzzy model allows you to determine a specific specialty for future education. To assess the influence of the input parameters on the output variable of the choice of the direction of training, five fuzzy choice models are used, which are built on the input linguistic variables. Their terms, membership functions, and intervals of the universe are given. A knowledge base for each model has been developed, consisting of production rules, which are presented in the form of fuzzy linguistic statements. Experimental studies have been carried out, which confirm the effectiveness of the developed models. The ability to be tested using the system and get results in the form of the name of the specialty will improve the informed choice.

Keywords 1

DSS, expert system, fuzzy model, linguistic variable, software, specialty, question answering systems

1. Introduction

Education plays a significant role in the modernization of society and the economy. Without competitive education, the transition to an innovative economy is impossible, since the quality of labor resources directly depends on the level of education.

One of the important problems of the country's socio-economic development is the problem of training highly qualified specialists in various fields of activity. The choice of a higher educational institution plays an important role in the process of a person's professional self-determination. It is very difficult to make this choice, because the educational services market is very wide and diverse. Every year new areas of activity and specialties appear.

The issue of choosing the direction of study is an acute issue, since today a huge number of students, having received a diploma, do not work in their specialty, or do not finish their studies at the university due to the loss of interest in their future specialty [1]. This is due to the fact that the specialty was chosen incorrectly, taking into account the interest of the applicant. According to the results of 2019 [1], only 50% of graduates work in the profession that they received at the university. Therefore, the funds spent on training are spent ineffectively. And young Ukrainians spend their time learning professions in which they will never work.

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The problem of choosing the most suitable specialty is faced by everyone entering an educational institution. Today, only a small number of graduates are being tested to assess personal qualities and aptitudes for the future profession. In order to choose a future profession for yourself, you need to analyze a large amount of information, select key parameters and draw a conclusion. This layer of work is entrusted to the applicants and their parents.

In connection with this fact, a conscious choice of a specialty that will not only be in demand, but also be suitable for this particular graduate is an urgent practical task.

The increase in the amount of information that applicants analyze, the need to take into account a large number of interrelated factors and the changing environment, urgently require the use of information technology for decision-making. In this regard, it is advisable to introduce a decision support system (DSS) in the task of choosing a future specialty. Such a system will be able to assess the potential of the applicant, provide a choice of alternative solutions and improve the quality of the choice of profession.

2. Literature review

So in work [2] the assessment of student career in the field of programming in the JAVA language is described. For this, the authors have developed an expert system. The system evaluates the student's strengths and decides whether the profession of a JAVA developer is suitable for him. The expert system allows you to measure the student's ability based on questions of different difficulty levels.

The authors [3] also devoted their work to the problem of choice of study and future career. It is suggested to use machine learning methods to choose the right field of education to shape your career. The authors proposed a career counseling model (CAM) that uses a decision support system based on such parts: user interface, inference engine, knowledge base. Based on the processing of information of the user's personal skills and for personality analysis, qualification forecasting, personality forecasting, reporting on recommendations, additional forecasting are performed.

The purpose of the study [4] is to develop and evaluate the effectiveness of a career decision support system using multiple intelligences to determine the dominant intelligence of a student. The authors propose a system that identifies the dominant intelligence of the student and suggests courses that are most compatible with the dominant intelligence of the student. The author compiled a knowledge base based on the information of an expert in solving the problem This base is composed of a set of rules IF-THEN. based on the rule base, the respondent's overall score is determined in each of several IQ categories in descending order. The highest score represents the dominant intelligence of the respondent. a similar approach based on expert opinion is used in work [5]. The means of implementation differs.

The articles [6-7] also describe research findings related to the impact of the use of expert systems in guidance for student selection. The work [8] experience has been extended to create a develop online tool for career counseling and provide services and guidance for students in career areas.

The aim of this project [9] is to develop an expert system of career counselors based on the Mayer-Briggs personality assessment. He advises the user based on his / her personality. This is achieved using the Myers-Briggs Indicator Fact Generation (MBTI) method. A rule-based system is used to compare factors and common occupations based on sixteen personality types.

In the article [10], the authors present a career decision support system. This system should help students plan their careers. For this, determinants are selected. Students rate the sectors of work for each factor. The scores are then combined and calculated using a simple scoring model approach. The system will suggest the most suitable sector of work for the student.

In the work [11], the authors use the use of heuristics, knowledge-based decision-making rules, using the certainty factor (CF).

The article [12] proposed a fuzzy conceptual framework for shaping career advice. The model consists of two parts. In the first part, the student took into account grades in different subjects and professional interests in different fields. On the basis of this, fuzzy sets are formed. The second part proposes available courses, aspects of work related to the abilities of students.

Thus, it was confirmed that for the implementation of the decision support system when choosing decisions, it is relevant to use expert systems, question answering systems and fuzzy logic. The work combines two approaches.

3. Methodology

For the task it was decided to use fuzzy logic, since it most broadly describes the problem of data selection by a person with various options of choice. Since the choice of a specialty primarily involves the choice of a field of knowledge, it is necessary to provide for the possibility of testing an applicant in order to help him choose a direction. To select a field of knowledge, it was decided to use a questionnaire, which forms the basis of the expert system. After that, on the basis of the mathematical apparatus of fuzzy logic, the choice of a specialty follows. The general structure of the model for choosing a specialty is shown in **Figure 1**.

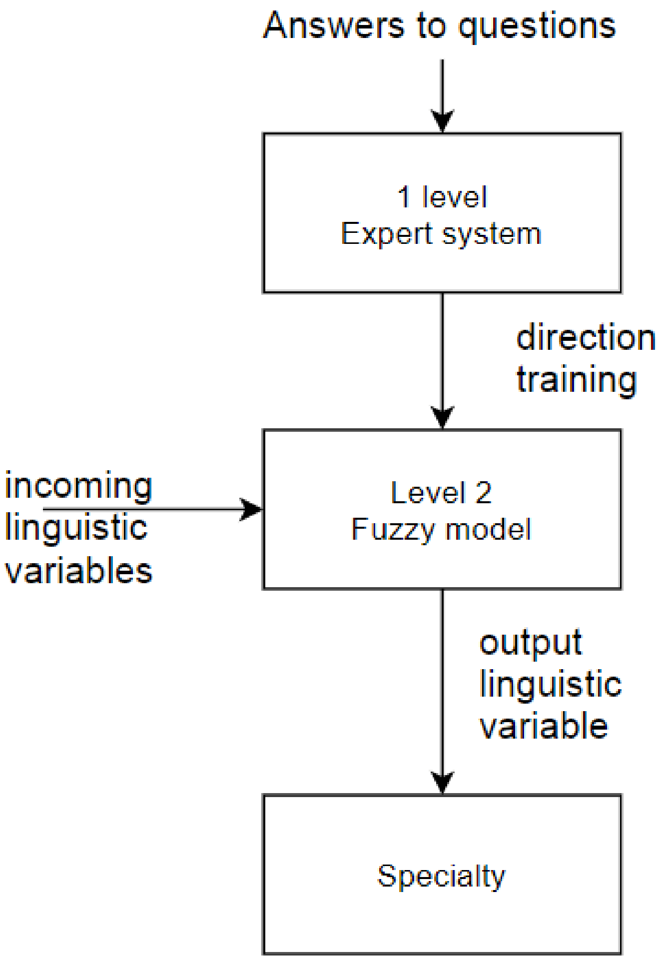

Figure 1: Two-level model for choosing a specialty when entering higher education

3.1. Expert system

The first level of the model includes an expert system based on a built-in knowledge base, which is based on the methodology of E. Klimov [13]. It allows you to determine the direction of training, namely, the definition of the type of person for the separation of the field of knowledge. The system is based on the fundamental question: "If there were only two professions in the world, which job would you prefer out of the two?" The main idea is that all people can be divided into 5 types, each of which determines the future profession: man-nature, man-man, man-artistic image, man-sign system, man-technology. The selected five factors were used as outputs to define the area of expertise.

At the second level, relative to the branch of knowledge, a specialty is selected on the basis of fuzzy inference.

To analyze the results at the first level of the model, according to the chosen methodology, a production knowledge model is used. A modification of the chosen methodology for determining the profession consists in calculating values for five main categories for this, a percentage is used.

For each category, there is a set of eight questions that clearly characterize that category. Some questions fall into several categories at the same time. If the user answered all eight questions "yes", then for this category his percentage sets 100%.

In addition to the set, when the user selected all the questions from the category correctly, there is also an error in the case of answering the opposite questions. In such a case, the percentage shift is calculated and the value is calculated according to the weight adjustment of the question.

The results obtained after interacting with the expert system is a branch of knowledge. After that, the data is transferred to the input to the subsystem based on the fuzzy model, where at the output the specialty for the applicant is determined with a note of the degree of confidence.

In some cases, when there is only one specialty in the field of knowledge, or the difference between the two specialties is not significant, the user receives only the name of the field of knowledge. If there are several different specialties in the field of knowledge, these data are transmitted to the input of the fuzzy subsystem.

3.2. Fuzzy model

To describe the choice of the direction of study, the sets "model type", "area of knowledge" and "specialty" are used. In this technique, the number of elements in the "model type" set is constant. The formal direction of learning is represented by a tuple:

$$D=\langle \{TM\}_{i=1}^{5}, \{FK\}_{j=1}^{n}, \{S\}_{z=1}^{m} \rangle, \quad (1)$$

where $\{TM\}_{i=1}^{5}$ are set «model type»; $\{FK\}_{j=1}^{n}$ are set «field of knowledge»; $\{S\}_{z=1}^{m}$ are set «specialty».

The set «model type» $\{TM\}$ is used to describe the choice of the direction of study and consists of many attributes $\{p_l^K\}_{l=1}^{8}$, namely eight questions that delimit each model.

The set «field of knowledge» $\{FK\}$ is describes the "area of expertise" for choosing a direction of study and consists of attributes $\{p_b^{FK}\}_{b=1}^{2}$: p_1^{FK} is knowledge area code, p_1^{FK} is name of the area of expertise. For Ukrainian education for 2020, it is accepted that the number of fields of knowledge is equal to 29, then the set "field of knowledge" takes the following form: $\{FK\}_{j=1}^{29}$.

The set $\{S\}$ characterizes the choice of the direction of study, namely the specialty, this set consists of attributes $\{p_k^S\}_{k=1}^{2}$: p_1^S is specialty code, p_1^S is the name of the specialty. For Ukrainian education in 2020 it is accepted, the number of specialties is equal to 282, then a lot of "specialty": $\{S\}_{z=1}^{282}$.

It was decided to build a model for choosing the direction of study on the example of the list of areas of knowledge and specialties of the State Higher Educational Institution "Priazovsk State Technical University", the city of Mariupol, which reduces the number of areas of knowledge and specialties.

According to the number of elements in the "model type" set, it is necessary to construct five fuzzy models for choosing the direction of training. General view of the model for choosing a direction of study:

$$FS=<\{V\}_{i=1}^{n}, \{W\}_{j=1}^{1}, \{R\}_{k=1}^{m}>, \quad (2)$$

where the set $V=\{V_1, V_2,... V_m\}$ is the set input variables; set of output linguistic variables is $W = \{\omega_1\}$; the set rules of fuzzy productions is $R=\{R_1,R_2,...,R_m\}$.

For the "Human-nature" model, the fuzzy model has the following form:

$$FS_{nature}=<\{V\}_{i=1}^{4}, \{W\}_{j=1}^{1}, \{R\}_{k=1}^{23}>, \quad (3)$$

where the set $V=\{\text{Alternative Energy Sources}, \text{Heat production}, \text{Environment}, \text{Help}\}$ is the set input variables; the set of output linguistic variables: $W=\{\omega_1\}$; the set rules of fuzzy productions: $R=\{R_1,R_2,...,R_{23}\}$.

Output variable terms: T = {"183 Environmental Protection Technologies", "163 Biomedical Engineering", "141 Power Engineering, Electrical Engineering and Electromechanics", "144 Heat Power Engineering"}.

For the "Human-Human" model, the fuzzy model has the following form:

$$FS_{human}=<\{V\}_{i=1}^{3},\{W\}_{j=1}^{1},\{R\}_{k=1}^{12}>. \quad (4)$$

where the set V={Help,Teaching ,Management } is the set input variables; the set of output linguistic variables: $W=\{\omega_1\}$; the set rules of fuzzy productions: $R=\{R_1,R_2,...,R_{12}\}$.

Output variable terms: T = {"23 Social work", "014.04 Secondary education. Mathematics "," 242 Tourism "," 073 Management "," 075 Marketing "}.

For the "Human-artistic image" model, the fuzzy model has the following form:

$$FS_{artistic\,image}=<\{V\}_{i=1}^{4},\{W\}_{j=1}^{1},\{R\}_{k=1}^{10}>, \quad (5)$$

where the set V={Ukrainian writing ,Object design ,English Writing , Design design } is the set input variables; the set of output linguistic variables: $W=\{\omega_1\}$; the set rules of fuzzy productions: $R=\{R_1,R_2,...,R_{10}\}$.

Output variable terms: T = {"191 Architecture and urban planning", "192 Construction and civil engineering", "035.034 Philology. Slavic languages and literatures (including translation), the first one is Russian", "035.041 Philology. Germanic languages and literatures (translation inclusive), the first one is English"}.

For the "Human-Sign System" model, the fuzzy model has the following form:

$$FS_{sign\,system}=<\{V\}_{i=1}^{4},\{W\}_{j=1}^{1},\{R\}_{k=1}^{32}>, \quad (6)$$

where the set V={Basics of mathematics ,State welfare ,Management , development } is the set input variables; the set of output linguistic variables: $W=\{\omega_1\}$; the set rules of fuzzy productions: $R=\{R_1,R_2,...,R_{32}\}$.

Output variable terms: T = {"113 Applied Mathematics", "051 Economics", "076 Entrepreneurship, Trade and Exchange Activity", "072 Finance, Banking and Insurance", "071 Accounting and Taxation", "122 Computer Science"}.

For the "Human-Technician" model, the fuzzy model has the following form:

$$FS_{technics}=<\{V\}_{i=1}^{6},\{W\}_{j=1}^{1},\{R\}_{k=1}^{64}>, \quad (7)$$

where the set $V=\left\{\begin{matrix}\text{Working with metal creation,Work with transport,}\\ \text{Work with equipment,Working with metal interaction,}\\ \text{Process automation, Working with metal structure}\end{matrix}\right\}$ – is the set input variables; the set of output linguistic variables: $W=\{\omega_1\}$; the set rules of fuzzy productions: $R=\{R_1,R_2,...,R_{64}\}$.

Output variable terms: T = {"151 Automation and computer - integrated technologies", "136 Metallurgy", "131 Applied mechanics", "132 Materials science", "133 Industrial engineering", "275.02 Transport technologies. On railway transport "," 275.03 Transport technologies. By road"}.

Table 1 shows the terms of the input linguistic variables of all five fuzzy models, indicating the universe. The membership functions are the sigmoid membership function for open ranges and the Gaussian function for the middle ranges.

Table 1

Terms of model input variables

Input variable	Terms	Universe range
	FS_{nature}:	
Alternative Energy Sources	T = {"presence", "absence"}	X = [0,10];
Heat production	T = {"presence", "absence"}	X = [0,10];
Environment	T={"worries", "does not bother"};	X = [0,10];
Help	T={"low", "medium", "high"};	X = [0,12];
	FS_{human}:	
Help	T ={"low", "medium", "high"};	X = [0,12];
Teaching	T = {"presence", "absence"}	X = [0,10];
Management	T = {"partial", "complete"};	X = [0,10];
	$FS_{\text{artistic image}}$:	
Ukrainian writing	T = {"presence", "absence"}	X = [0,10];

Object design	T = {"low", "high"};	X = [0,10];
English Writing	T = {"presence", "absence"}	X = [0,10];
Design design	T = {"low", "high"};	X = [0,10];
	$FS_{\text{sign system}}$:	
Basics of mathematics	T ={"low", "medium", "high"};	X = [0,12];
State welfare	T = {"medium", "high"};	X = [0,10];
Management	T = {"medium", "high"};	X = [0,10];
development	T={"absent", "medium", "high"};	X = [0,12];
	$FS_{technics}$:	
Working with metal creation	T = {"main", "additional"};	X = [0,10];
Work with transport	T = {"car", "rail"};	X = [0,10];
Work with equipment	T = {"low", "high"};	X = [0,10];
Working with metal interaction	T = {"low", "high"};	X = [0,10];
Process automation	T = {"presence", "absence"}	X = [0,10];
Working with metal structure	T = {"low", "high"};	X = [0,10];

For a system that has several inputs, which are represented as linguistic variables, the production model is as follows:

$$\begin{gathered} \text{input}(x_1, x_2, \ldots, x_n); \\ \text{if } x_1 \text{ is } A_{11} \wedge x_2 \text{ is } A_{12} \wedge \ldots \wedge x_n \text{ is } A_{1n} \text{ then } y \text{ is } B_1; \\ \text{if } x_1 \text{ is } A_{21} \wedge x_2 \text{ is } A_{22} \wedge \ldots \wedge x_n \text{ is } A_{2n} \text{ then } y \text{ is } B_2; \ldots \\ \text{if } x_1 \text{ is } A_{m1} \wedge x_2 \text{ is } A_{m2} \wedge \ldots \wedge x_n \text{ is } A_{mn} \text{ then } y \text{ is } B_m; \\ \text{otput}(y), \end{gathered} \tag{8}$$

where xj is input linguistic variables, j = 1,…n; y is output linguistic variable; Aij and Bi are terms linguistic variables input and output respectively.

To check the adequacy of the developed model for choosing the direction of training, modeling was carried out. For this, these models were implemented in the FUZZY TECH [14] system. The data obtained using FUZZY TECH were compared with the results obtained using the developed system. There are many models for evaluating the forecast (that is, the results obtained by development tools in accordance with the data obtained using modeling by third-party resources).

First, it is possible to assess the ratio of actual data with a forecast, that is, data obtained by modeling five models in the FUZZY TECH environment to the data obtained as a result of the developed system.

Secondly, it is possible to calculate the forecast accuracy indicator, that is, an estimate of how accurately the fuzzy inference model describes the data in question, obtained when simulating in the FUZZY TECH environment.

Thirdly, you can perform graphical analysis, that is, build a graph and visually assess the adequacy of the developed system according to the data obtained during modeling.

3.3. Results

A modular system was formed, divided into several parts. In the first part, the user is asked to take a test to assess his preferences. After passing the test, the system collects and analyzes the result. In the second part, based on the results obtained, the system of fuzzy choice of the direction of study is activated.

The implementation of these modules was done in JavaScript. A number of libraries have been developed that generate linguistic variables, register rules, build dependency systems, and model results based on input parameters.

The system is implemented as a web application, it includes a knowledge base, a fuzzy inference mechanism. The choice of the direction of study according to certain models of the branch of knowledge is based on expert knowledge. The user interface allows you to enter data to determine the grade, and compare the results obtained across multiple choices.

An expert system has been developed and implemented as a web service that allows the user to quickly and without additional steps pass a test to determine the level of a person's motivation for various activities. The user answers thirty questions, agreeing with the statement, or skipping questions, disagreeing with the statement. After passing the test, an intermediate test result is issued, indicating the type of models (**Figure 2**).

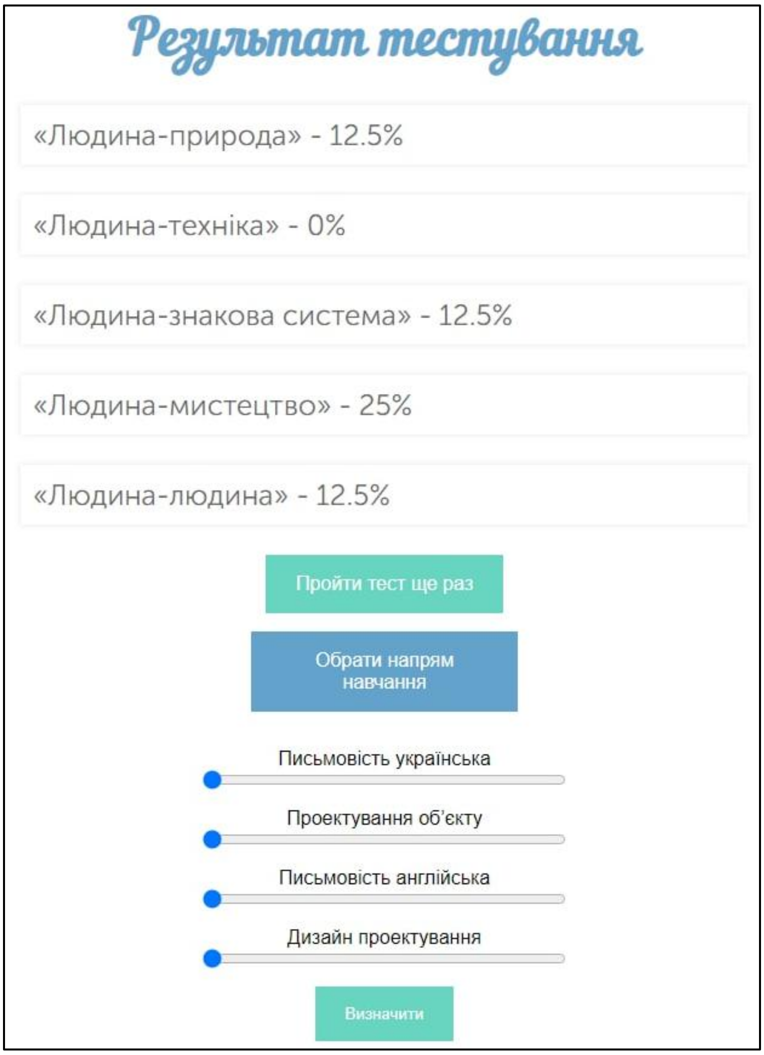

Figure 2: Results after passing the test

For the highest metric of the model type, the corresponding fuzzy model is activated. Next, the user specifies the value for each input variable with the sliders and by pressing the definition button, he receives the result for a specific choice of the direction of study - specialty (**Figure 3**).

Figure 3: Results of fuzzy modeling output variable specialty, indicating the term of a specific specialty

3.4. Experimental research

The simulation results in FUZZY TECH were compared with the results of the developed decision support system.

The results for each of the five developed models were considered. The value of the output variable was compared. For the analysis, the numerical values were evaluated, not the values of the terms of the linguistic variables. An example analysis is shown in Table 2.

Table 2
Results for comparative analysis

Man-nature		Man-man		Man-artistic image		Man-sign system		Man-technology	
System	FT	System	FT	System	FT	System	FT	System	FT
0,82	0,8	0,76	0,8	0,55	0,5	0,1	0,2	0,41	0,5
0,88	0,8	0,77	0,8	0,12	0,1	0,15	0,2	0,33	0,3
0,64	0,7	0,83	0,8	0,25	0,2	0,35	0,3	0,78	0,8
0,76	0,8	0,91	0,9	0,62	0,6	0,456	0,5	0,1	0,1
0,71	0,8	0,7	0,75	0,78	0,7	0,47	0,5	0,9	0,95
0,32	0,6	0,55	0,5	0,8	0,8	0,58	0,5	0,98	0,99
0,51	0,8	0,6	0,7	0,95	1	0,69	0,7	0,51	0,5
0,55	0,7	0,71	0,75	0,56	0,6	0,44	0,5	0,66	0,7
0,56	0,7	0,82	0,8	0,32	0,4	0,23	0,25	0,2	0,2
0,47	0,5	0,34	0,3	0,57	0,6	0,96	1	0,33	0,35
0,5	0,6	0,62	0,7	0,22	0,2	0,74	0,75	0,9	0,9
0,56	0,5	0,41	0,5	0,61	0,6	0,56	0,6	0,91	0,9
0,73	0,7	0,52	0,55	0,9	0,9	0,22	0,3	0,55	0,6
0,58	0,5	0,6	0,6	0,98	1	0,76	0,8	0,59	0,6
0,59	0,6	0,6	0,5	0,1	0,1	0,13	0,2	0,26	0,3
0,45	0,4	0,62	0,55	0,2	0,25	0,55	0,6	0,34	0,3
0,78	0,69	0,81	0,8	0,3	0,35	0,65	0,7	0,69	0,7
0,91	0,95	0,12	0,2	0,4	0,45	0,6	0,6	0,71	0,7
0,22	0,2	0,77	0,7	0,98	0,99	0,87	0,85	0,22	0,2
0,6	0,65	0,31	0,3	0,97	0,99	0,81	0,8	0,65	0,6
S=0,11439		S=0,056524		S=0,040311		S=0,050018		S=0,033985	

An estimate of the standard deviation based on a biased estimate of variance (sometimes simply called sample variance [15]) can be used to calculate the accuracy score:

$$S=\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (9)$$

Analyzing the results of the standard deviation, you can see that it does not exceed 0.1, that is, the error is insignificant.

An example of a graphical comparison of the results is shown in **Figure 4**. The figure shows the simulation results in the environment of all parameters described in formula (2). Also shown are the results that were obtained after the introduction of model (2) into the decision support system for choosing a profession.

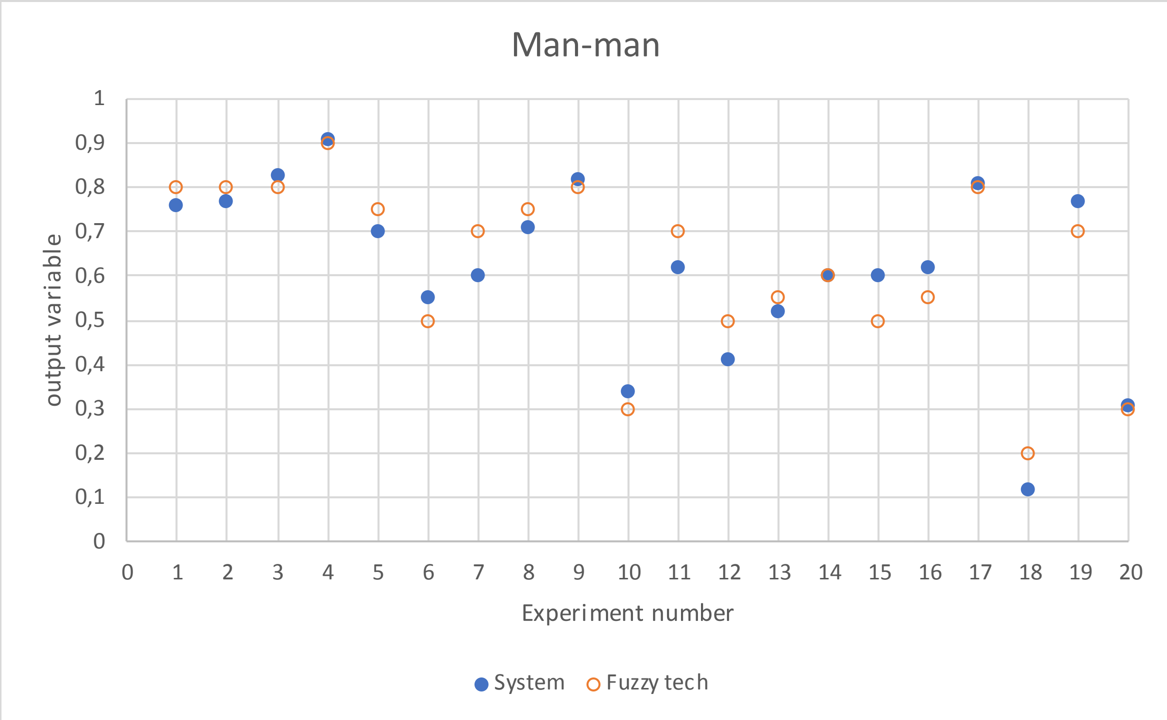

Figure 4: Comparison of the choice of specialty model "Human-human"

To check the developed expert system, a study was carried out. For this, 300 students were selected, who are already studying in the fourth year, and underwent practical training, getting acquainted with their future profession. They first indicated by what percentage they believed that they had chosen the right specialty, after which they were tested and the results obtained were compared. The specialty was checked, the chosen by the students corresponds to the direction of training, taking into account a large percentage of compliance with one of the five categories. The results have been interpreted linguistically, where a percentage of 0-25% is a low match; 25-50% average match; 50-75% good match; 75-100% high match. The test results are shown in the **Figure 5**.

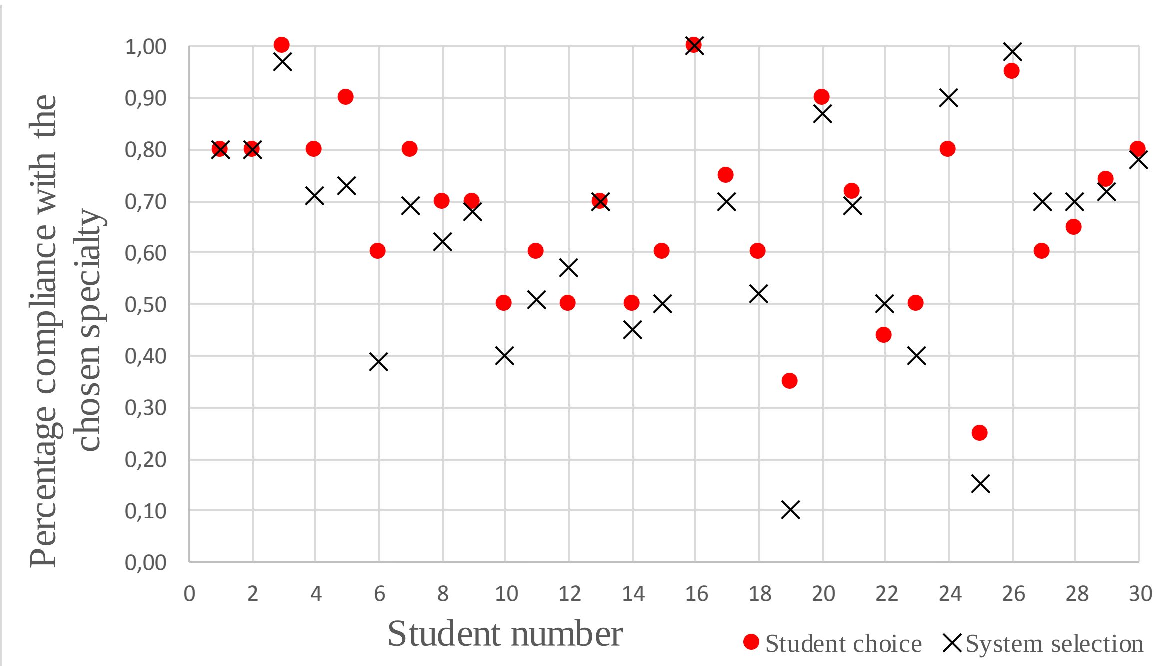

Figure 5: Comparison of the choice of specialty and system (fragment)

Analyzing the results obtained, we can conclude that the values are in the same ranges. Based on the fact that students already have practical experience in their profession, the data can be considered almost the same. The results obtained after the work of the expert system are slightly lower than the results of the survey of students, this is due to the fact that a person almost always has several possible directions of his professional development. And for these students there were also percentages in other categories. Students confirm that they also noticed a tendency towards these directions in themselves, but did not think about it. Since the subjects already had established views on their profession, and made conclusions whether they made the choice successfully or not, we can assume that the system is working correctly.

4. Conclusions

In the work, a two-level model was built for choosing a direction of study. At the first stage, an expert system was implemented, which, based on the Klimov methodology, allows you to choose one of five types of model of preference for the direction of study. And then, at the second level, with the help of a fuzzy apparatus, namely the Mamdani algorithm, a fuzzy choice of the direction of training was implemented, where the names of specialties act as the terms of the output variable. Experimental studies were carried out, the results of the expert system and the survey of students were compared. The fuzzy system was modeled using FUZZY TECH, and then the data were compared with the results from the developed system. The deviation showed a value that does not exceed 0.1, that is, the data are similar. In cases where the data do not coincide with the graphical method, it was found that they are in the same ranges of values of the terms of the output linguistic variable - specialty.

The developed system can be used in career guidance work to facilitate the choice of a future specialty both in schools and individually. This approach will significantly increase the correct choice of specialty and improve the indicators for graduates to work in the profession they have acquired.

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