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Possible Models and Algorithms for the Intellectual System of Professional Direction

A.R.Akhatov,
Department of Information Technology, Samarkand State University, Samarkand, Uzbekistan.
D.R.Mardonov,
Department of Information Technology, Samarkand State University, Samarkand, Uzbekistan.
F.M.Nazarov,
Department of Information Technology, Samarkand State University, Samarkand, Uzbekistan.
Christo Ananth,
Department of Information Technology, Samarkand State University, Samarkand, Uzbekistan.
T. AnanthKumar,
IFET College of Engineering, India.

Abstract---This article examines the development and refinement of possible mathematical models for the intellectual system of career guidance. Mathematical modeling of knowledge expression in the career guidance system, Combined method of eliminating uncertainties, Chris-Naylor method in the expert information system of career guidance, Shortliff and Buchanan model in the expert information system of career guidance and Dempster-Schafer in the expert information system of career guidance method has been studied. The algorithms of the above methods have been developed. The set of hypotheses in the expert system is the basic structure of the system that determines the set of possible decisions of the expert system. This set, which is crucial in decision-making, should be sufficiently complete to describe all the possible consequences of situations that arise in the subject area. Therefore, it is important to improve the mathematical models of the intellectual system of career guidance.

Keywords--- Digital Technologies, Career Guidance, Probabilistic Models, Chris-Naylor Method, Shortliff and Buchanan Model, Dempster-Schafer Method. Intelligent Systems.

I. Relevance and Validity of the Topic

The development and introduction of career guidance mechanisms based on digital technologies will not only increase professional quality, but also bring economic benefits. Widespread use of psychodiagnostics methods in pedagogical practice can reduce the activity of young people, as it gives them the status of a client or subject who knows everything about him in front of an experienced teacher or psychologist. These approaches make a person dependent on a particular counselor, resulting in a complete inability to predict the future independently and consciously. In addition, there are individual characteristics that are often overlooked in the career guidance process when understanding the advice of professional counselors. Of all the counselors, the professional counselor often identifies situations that reveal the ability for a narrow range of professional career indicators based on a direct interview [1]. This method of professional counseling leads to a significant increase in time, but at the same time it leads to a one-sided approach to identification, which does not allow to see the holistic state of a person's individual abilities in relation to the world of professions.

The development of mathematical modeling of knowledge expression in the career guidance system is the basis for the development of automated information systems. The peculiarity of knowledge expression systems used in the construction of expert systems in education is that they often model human activities that are carried out informally. Knowledge is not always accurate, and ambiguous knowledge is common. People solve problems and draw conclusions in an obscure knowledge environment on a daily basis, and it will be necessary for intelligent systems to present and use obscure knowledge in order to have capabilities such as flexibility, broad outlook, and adaptability. The set of hypotheses in the expert system is the basic structure of the system that determines the set of possible decisions of the expert system. This set, which is crucial in decision-making, should be sufficiently complete to describe all the possible consequences of situations that arise in the subject area.

Obviously, even for the simplest and easiest subject area to formalize at first glance, it is possible to suggest several models of its descriptions that differ from each other in the composition of assumptions. The content of the hypotheses of each formal model of the subject area is determined by the knowledge in the field and the experience of the expert involved in the design of this model. Therefore, it is advisable to develop and implement mechanisms to automate mathematical models of vocational guidance based on the rating data of students.

II. Mathematical Modeling of Knowledge Expression in the System of Vocational Guidance

With the help of a professional knowledge engineer or independently developing a model of the field of science, the situations that may arise in this field of science are considered. At the same time, it rejects in advance situations that, in its view, are impossible or unlikely to occur. The subject area itself is, in fact, a more or less clearly defined area of problem or activity. In this case, career guidance is used as a subject area. As the area of the topic under consideration is large, it should be divided into small problems (respectively, goals - small goals, tasks - small tasks) without violating the overall logical structure. As a result, the expert system consists of several modules (blocks). Since the basis of the expert system is a knowledge base that includes the experience of experts, it is decided on the basis of several knowledge bases.

The basis for the development of many hypotheses of the expert system of career guidance is a set of possible situations from the point of view of the specialist. Situations are situations in which students can choose a career from a variety of specialties offered at a higher education institution, one or more of which are given to the user by a system of experts in response to a description of his or her skills, abilities and desires. All professions belong to five main groups: "Man - nature", "Man - technology and inanimate nature", "Man - man", "Man - the system of signs", "Man - artistic image". However, with the emergence of interdisciplinary specialties, such as Applied Informatics, there is a need to expand the existing topology of professions by introducing a new group of professions that combine interdisciplinary specialties [4].

The solutions and decisions of the expert systems are determined by the hypotheses put forward by this expert system as recommendations. Based on his experience, an expert can predict which situations in a particular subject area will occur more frequently and which will occur less frequently. Thus, based on his experience, that is, the statistics he has collected during his professional career, the probability of the need for an expert system to make a specific decision in almost every particular case is determined. Experience has shown that the use of unstructured feedback from individual experts in solving many complex scientific and technical problems is not sufficiently effective due to the diversity of relationships between the main elements of such problems and the inability to cover them all. When using the traditional procedures of preparing the knowledge base of a career guidance expert system, it is not always possible to take into account the wide range of personal characteristics that affect a particular profession. All of this forces a person to turn to specialist recruitment teams as professionals with specific skills in a particular area of life.

An expert is an experienced professional who is able to quickly and accurately assess objects and situations in a particular area of professional activity, as well as decision-making advice for those responsible for decision-making. The term is derived from the Latin “expert” (experienced) carrier of special, hard-to-access or formalized knowledge, called deep knowledge. Expert systems are the main tool in intelligent information systems. In order to form knowledge in expert systems, it is necessary to form the knowledge of expert groups [7]. The composition of expert groups is important when creating groups of experts, so that in groups with different composition there is less disproportion of knowledge between experts, and the process of group decision-making is faster.

The following are the main types of inquiries used in collective expertise: discussion, questioning and interviewing, the method of collective formation of ideas, or brainstorming. In the process of forming the knowledge base in intelligent information systems, two main functions are performed: they form hypotheses (specialties, areas of study, etc.), select the necessary conditions (personal characteristics, tendencies, etc.). It is recommended to use the method of expert assessment to reduce the level of subjectivity of expert opinions. Its essence is that both the coefficient of uncertainty determined and the values of the relevant parameters are the result of collective creativity. A group of experts in the field under consideration are accepted as experts. The generalized opinion of the experts obtained as a result of the processing is taken as the solution to the problem. The complex use of intuition (unconscious thinking), logical thinking, and quantitative evaluation allows them to obtain an effective solution to a problem with formal processing. Each N specialist is given a specific value of uncertainty coefficients for each individual quality associated with the profession (specialty), where the average value of each is:

$$\bar{p} = \frac{1}{p} \cdot (p_1 + p_2 + \ldots + p_n) \qquad (1)$$

In formula (1) above, p is used as the value of the result coefficient. Weight coefficients can be assigned according to the level of experience of specialists and are calculated taking into account $v_1, v_2, \ldots, v_n,$:

$$\bar{p} = \frac{1}{Nv} \cdot (p_1 v_1 + p_2 v_2 + \ldots + p_n v_n), \; v = \sum_{i=1}^{N} v_i \qquad (2)$$

here $\bar{p}$ is the average value of the uncertainty coefficient (chance),

p_i - is the value of the uncertainty coefficient set by the i-expert,

v_i - is the value of experience in accordance with the qualification level of the i-expert,

v - is the value representing the qualifications of N experts in the system under consideration.

The reliability of group expertise assessment depends on the total number of experts in the group, the proportion of different experts in the group, and the characteristics of the experts. It is important to assess the level of expertise of an expert in information systems. v_i determines the level of competence of an expert. It can include both theoretical knowledge and practical skills. The literature lists a number of ways for professionals to gain weight, but notes that there is no generally accepted assessment of the qualifications of professionals. It takes 3 to 12 competencies to describe the professional competencies of any position, but in some cases there may be exceptions. Differential methods of self-assessment are differentiated methods of assessment, in which the assessment is, as a rule, based on two groups of criteria: the criteria that characterize the expert's acquaintance with the main sources of information in this field and the expert's expertise on the criteria that characterize the acquaintance with the objects.

Table 1: Determining the Level of Knowledge of Specialists in Systems

Source of arguments	**The degree to which the source influences the expert opinion**		
	high	average	low
The level of theoretical knowledge of the problem	0,25	0,2	0,1
Practical experience	0,3	0,2	0,1
Get acquainted with the characteristics of professions	0,3	0,25	0,15
Get acquainted with the situation in the country	0,05	0,05	0,05
Getting acquainted with the situation abroad	0,05	0,05	0,05
Ability to anticipate the logic of events	0,05	0,05	0,05
The total	1,0	0,8	0,5

In systems, experts indicate the level of clarity of the problem on a 10-point scale and the sources of evidence for their opinions. Their basis is determined by summing the scores in the developed reference table (Table 1).

The expert receives such a table without numbers and symbols (with symbols), determining the degree of influence of each source on his opinion. Once you have used the data table, it is the sum of the scores for all the sources cited by the experts. In addition, the expert's complex self-assessment is determined and calculated according to formula (3):

$$v_i = \frac{K_{a(i)} + C \cdot K_{z(i)}}{2}, \qquad (3)$$

where Vi is the self-assessment of a single specialist,

$K_{(ai)}$ is the detection coefficient, ie. self-assessment of *i*-th, according to the level of knowledge of the specialist (in fractions of units according to the reference table),

$K_{(zi)}$ is the coefficient of familiarity, ie. i-expert self-assessment is determined on the basis of acquaintance with the object, self-assessment of familiarity multiplied by 0.1 (1 - 10);

C is the familiarity coefficient and *K* is the relative weighting coefficient.

In most cases, a value of $C = 0.1$ is obtained, but many experts believe that *C* should be determined taking into account the specific characteristics of the object under investigation. Another problem that humans and machines face is that many things in life are not specific. It is not enough to study the problems of knowledge acquisition in order to form a coherent knowledge base with uncertainties [10].

The information model of the career orientation process based on uncertain knowledge allows students to consider the qualitative criteria of belonging to any specialty. Building a model allows you to work with quality parameters based on heuristic thinking.

In a career-oriented expert system, it is advisable to use a production model as a model to express knowledge, which is required due to its simplicity and similarity to the rules used by an individual in the thinking process. One of the advantages of production systems is the ability to use the properties of data uncertainty, in which case the coefficient of confidence and (or) the coefficient of possibility are noted. Production expert systems consist of a knowledge base, a workspace (facts database) and software. The expansion of the use of standard production methods in expert systems is the use of fuzzy inference methods.

III. A Combined Method of Overcoming Uncertainties

When building expert systems, it should be borne in mind that in real life, human knowledge is not always complete, and there may be a certain set of conjectural ideas. Nevertheless, based on such knowledge, people are still able to draw very reasonable conclusions and make wise decisions. Therefore, for intelligent systems to be truly useful, they must take into account the incomplete accuracy of knowledge and operate successfully in such conditions.

It is recommended to use the Bayes approach to eliminate uncertainty, but using only one approach does not completely solve the problem under consideration, so additional tools should be used to account for uncertainty in knowledge. It should be noted that G.V. Rubina and co-authors consider several methods in their work for the construction of integrated expert systems on the computer, in particular, the Bayesian and Dempster-Schefer methods [6]. However, our experience shows that using these two methods is not enough. The next method proposed is to eliminate uncertainties by a combination of three methods: Chris-Naylor, Shortliff-Buchanan, Dempster-Schafer methods. This approach is called a combined method of overcoming uncertainties. The proposed algorithm for resolving uncertainties is as follows:

1. If experts indicate only one uncertainty coefficient as input parameters, then the Chris-Naylor method is used.
2. Experts should use the Shortliff and Buchanan method in a situation where it is difficult to form a priori probabilities for rules (this happens very often).
3. When two uncertainty coefficients (confidence and chance) are set, the combined method based on Chris-Naylor, Shortliff and Buchanan, Dempster-Schaefer methods is used as the output method.

As a result, based on the developed algorithm, it is possible to eliminate uncertainties in the intelligent systems of career guidance. The perfection of career guidance intellectual information systems is determined by the level of mathematical models it contains.

IV. Chris-Naylor Method in the Expert Information System of Career Guidance

Based on the algorithm described in the above paragraphs, unambiguous knowledge is used in the construction of the identification system. The main parameters of the system have a probability property (the degree of probability about a person belonging to a particular profession). Therefore, the Bayes approach can be used to express knowledge in such a system.

In many systems, the Bayes theorem is used to help combine data from different sources. Its essence is to find a way to obtain the apostery probabilities of these hypotheses, based on the a priori probabilities of any hypothesis and fact, depending on which facts are confirmed for that hypothesis [9]. This probability can be very small, in fact it can even be zero. But that doesn’t stop us from making calculations as if there was some possibility.

This approach is based on the Chris-Naylor method, which allows you to draw conclusions that each step is an iterative process of making a decision that partially alters (confirms / rejects) the probability of the hypothesis. We use it to create a knowledge presentation model of a career guidance expert system.

In this system, H is defined for a part of the knowledge base for each hypothesis (specialization) that can be obtained and can be considered as a target hypothesis:

1. $P(H)$ is the a priori probability of the specialty (hypothesis);
2. The probability of the appearance of a definite x characteristic of the specialty at P_1 - H;
3. Probability of occurrence of incorrect x characteristic of specialization in P_2 - H.

The principle of operation of the Chris-Naylor method, identified in the study, is as follows.

First of all, the probability of the hypothesis is equal to the previous probability, for example, $1/10$, if from the knowledge base we take approximately equal proportions for 10 specialties.

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At each stage, the probability of all specializations for any individual characteristic is recalculated according to formulas (4) and (5):

$$P(H/x) = \frac{P \cdot P_1}{P \cdot P_1 + P_2 \cdot (1-P)} \quad (4)$$

$$P(H/!x) = \frac{P \cdot (1-P_1)}{P \cdot (1-P_1) + (1-P_2) \cdot (1-P)} \quad (5)$$

Here, the conditional probability of recommending the specialty *P(H / x)* **-** *H* is determined by taking into account the occurrence of x personal characteristic.

In addition, the probability of the resulting apostery is calculated by *P(H)*,ie. *P(H) = P(H/x).*

An approach known as the Situation Assessment (C) method is used to select cases. The method is explained by the assessment of each individual characteristic, which reflects its role in the process of drawing conclusions [11]. The effect on the hypothesis is calculated as the absolute difference between the probability of the hypothesis and the probability of the non-occurrence.

In the simplest case, the value of each case can be calculated as the sum of the maximum variations of the probabilities on all the hypotheses available in the knowledge base, which can lead to the following [11]:

$$C = \sum_{i=1}^{m} | P(H_i / x) - P(H_i /!x), \quad (6)$$

where m is the number of hypotheses (specialties) in the knowledge base. The value of a state is calculated from the knowledge base for each feature of the personality *x*. The system can then find the maximum C and request information for the appropriate condition. It follows that the value of cases does not remain constant, as subsequent $P(H_i / x)$s are constantly improving. The values of the cases do not always remain the same, and as the $P(H_i / x)$ probabilities are determined, they lead to a constant change in the values of the cases.

The probability value is recalculated, taking into account that the *Q* response received from the user at each stage in each specialty has a level of -5 to +5 in one step. +5 means "Yes", -5 means "No" and "I don't know" means "0".

All other response options will be located at intermediate points on the scale. The gradation of the answers can be changed according to the experts ’definition, for example, from -3 to 3. As a result, corrections are added to the current probability, a process that is carried out using formulas (7) and (8).

$$P(x/Q) = \frac{Q - a_1}{a_2 - a_1}, \quad (7)$$

Here *x* is the personal characteristic, *Q* is the defined answer

$$Q[E] \in [a_1, a_2] = [-5,5] \;\; yoki \; [a_1, a_2] = [-3,3]$$

$$P(!x/Q) = 1 - P(x/Q). \quad (8)$$

After the user asks the *Q* rating in question, it is necessary to recalculate the probabilities for all the specialties in which this individual feature is recorded. The final expression of posterior probability (9) will look like this:

$$P(H/Q) = P(H/x) \cdot P(x/Q) + P(H/!x) \cdot P(!x/Q) \quad (9)$$

As a result, the probability of any set of specialties is very low, so it will be insignificant in recalculating the assessments of the cases that apply to them. As the probability of certain specializations increases, the probability of their probability changing under the influence of the remaining circumstances related to that specialization (personality traits) increases.

As a result, the cost of these cases will be higher, so more questions will be asked about them. The establishment of the fact of termination of a logical conclusion occurs when the whole set of circumstances is determined. At each stage, after recalculating the subsequent probabilities of the specialties, the following values are calculated:

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To know when and where to stop $P_{min}(H)$ and $P_{max}(H)$ designations,

$P_{min}(H)$ is the probability that the probability value identifies all designations that have not been considered;

$P_{max}(H)$ is the maximum value of probability that can be achieved if all the features not taken into account can be worked out in this hypothesis.

The following criteria algorithm is proposed to perform a logical conclusion before considering all the signs of probability in information systems:

1. If the $P_{max}(H)$ for any hypothesis (specialty) H at the current stage is greater than the $P_{min}(H)$ for any other hypothesis, such a hypothesis can be excluded from consideration.
2. If at the current stage the $P_{min}(H)$ for hypothesis H is greater than $P_{max}(H)$ for any other hypothesis, such a hypothesis can be accepted as a target or continued if necessary, i.e. it can be used to obtain multiple solutions.
3. Calculate the minimum and maximum values that can be achieved for each hypothesis.
4. Find the maximum possible minimum for the above probabilistic assumptions.
5. The hypothesis that the maximum possible value exceeds the maximum of these minimums is checked. If available, go back to point 3 and make another request. If not, the user is given a result that must be returned.

In order to implement the developed algorithm, we express it in the form of the following block diagram in a special algorithmic language.

As a result, probabilistic hypotheses can be determined and the probability magnitude hypothesis can be determined to be reliable or unreliable. For example, a hypothesis is considered reliable if the probability is greater than 0.9, and unreliable if it is less than 0.3. If the probability of all hypotheses is low, it is necessary to determine whether additional data should be collected or otherwise.

V. Shortliff and Buchanan Model in the Expert Information System of Career Guidance

In the expert information system of career guidance, rating information is included. Determining the probability of sending incoming information to the profession on the basis of models gives effective results. The choice of the Shortliff and Buchanan method in career guidance serves to determine the probability of a particular relationship by a human expert by evaluating it with value. At the same time, it is rare for a probability relationship of 0.7 to be true, and it is not taken into account that it may be incorrect. It is also important that the method proposed by Shortliff and Buchanan allows non-experts to use expert knowledge. The advantages of the system based on the Shortliff and Buchanan method and expert rules over the conditional Bayes probability system are:

- Use of fundamental knowledge and laws in the system;
- Experience can be used to address small groups of specialties that do not have sufficient material;
- Ease of modification, there is no need to build a pre-configured decision tree because the rules are not clearly related to each other;
- Changing rules and adding new rules does not require the analysis of complex relationships with other parts of the system;
- Helps to search for possible inconsistencies and contradictions in the knowledge base;
- Simple explanatory mechanisms can be used;
- The user is only aware of that part of the process, the decision he needs.

The biggest challenge is to directly link the hypotheses and their relevant properties. Trying to get such information about the interdependence of professional tendencies and abilities in a particular profession can be a bit daunting. An alternative to the acquisition of complete knowledge is to use the knowledge of the specialist psychologist about the necessary interests, aptitudes and personal qualities that meet the requirements of certain professions. If the knowledge is obtained from an expert, it is not necessary to fully collect the conditional probabilities and their complex relationships. Instead, ideas that can be interpreted as knowledge can be collected and processed to assess probabilities.

Another assumption that confirms the choice of the theory of confidence factors is that knowing the rules themselves is more important than knowing algebra to calculate their accuracy. A measure of confidence is an informal assessment that a human expert adds to a conclusion, such as "probably so," "almost certainly," or "it's absolutely unbelievable."

In this method, reliable information is expressed as a degree of uncertainty. If the sum of all relevant data or cases (set of necessary knowledge and skills) is denoted by x $x = (x_1, x_2, .., x_v)$, H_j j-hypothesis (faculty or specialty), P(H_j ./x) - for the respondent there is a direction of study on the basis of x cases conditional probability, P(H_j ./x) conditional probability components are calculated as follows.

$$P(H_j / x) = \frac{P(H_j)P(x/H_j)}{\sum_j P(H_j)P(x/H_j)} \qquad (10)$$

here $P(H_j)$ is the a priori probability of the hypothesis. The probability of occurrence of the attribute values $P(x/H_j)$ is taken from the objects of the case class H_j *x*. For example, the expression $P(x/H_j) = a$ can be expressed by a hypothesis (faculty or specialty) in the presence of H_j x_k signs that there is a *100a* possibility to confirm the H_j hypothesis.

In career guidance, the Shortliff and Buchanan models require professionals to evaluate data in favor of a hypothesis or in favor of rejecting it. To do this, the concepts of confidence measure MB and uncertainty measure MD, designed to show the severity coefficient of cases, were introduced. The similarity of the functions proposed by different authors is that the degree of support for the facts is always proportional to the difference between the conditional probability of the case under the given hypothesis and its a priori probability: *P(x/H)-P(x)* or the a priori probability of rejecting his hypothesis is expressed as follows:

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$$P(x/H) - P(x/\neg H)$$

In addition, it is inversely proportional to the conditional probability of x. The lower the expectation of encountering such empirical facts, the less important the existence of their initial probability.

MB[H,x] = αH indicates the degree of reliability of the hypothesis for the specialty.

MD[H,x] = βH denotes the degree or measure of uncertainty for a specialty in a hypothesis.

In this case, the x condition may be a hypothetical condition in turn, rather than an event that can always be observed. Thus, *MB[* H_1, H_2 *]* can be written to show an increase in confidence in the H_2 hypothesis, provided that the H_1 hypothesis is correct.

Similarly, *MD[H, x]* returns a measure of uncertainty in the hypothesis if the H hypothesis is correct. For example, in the phrase “To be successful in the career of a programming engineer, you must enjoy the project you create,” *MB[H, x]=0,7* is defined by a simple rule established by an expert. Here, 0.7 simply reflects the examiner's level of confidence that n is correct, given that x is correct. However, in this example, *MD[H, x]=0,* since there are no other conditions to increase the uncertainty in H based on x. According to the theory of subjective probabilities, it can be said that the individual probability of a hypothesis reflects the reliability of *P(H)* to *H* at any given time, according to expert estimates. Thus, expression *1-P(H*) can be seen as an estimate of the expert's uncertainty about reliability. If the probability *P(H/x)* is greater than *P(H),* then observing x leads to an increase in the expert's confidence in *H.*

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Assume, conversely, that if the probability *P(H/x)* is less than *P(H)*, then observing x reduces the expert's level of confidence in H and at the same time increases his uncertainty about H's reliability. . Thus, MB[H,x] and MD[H,x] are represented as follows.

$$MB[H,x] = \frac{P(H/x) - P(H)}{P(H)} \quad (11)$$

$$MD[H,x] = \frac{P(H) - P(H/x)}{P(H)} \quad (12)$$

Therefore, the measure of the increase in the reliable data in the uncertainty fraction of *MB[H, x]* is evaluated as the result of observing the hypothesis *H* of *x*. The same cannot be said for or against the hypothesis. Furthermore, when *P(H/x) = P(H)*, that is, the hypotheses do not depend on the circumstances, however, it is related to *MB[H, x] = MD[H, x]*.

In this case, given that MD and MB cannot be negative, the result is determined more firmly.

$$MB[H,x] = \begin{cases} 1, & if\ P(H) = 1 \\ \dfrac{\max[P[H/x], P(H)] - P(H)}{1 - P(H)} \end{cases} \quad (13)$$

$$MD[H,x] = \begin{cases} 1, & if\ P(H) = 0 \\ \dfrac{\max[P[H/x], P(H)] - P(H)}{1 - P(H)} \end{cases} \quad (14)$$

Thus, the values of the confidence interval and the uncertainty measure of the hypothesized information are within the following limits:

0 < MB[H, x] < 1 va *0 <MD[H, x] < 1.*

In the career guidance system, it is possible to regulate the operation of the system of reliable information of the situation. The best guarantee of the correctness of decision-making is the integrity of this knowledge.

The relationship between confidence and uncertainty in decision making is established by the CF data confidence coefficient, which is in the form (15).

CF(H|E) = MB(H|E)-MD(H|E)(15)

If the probability coefficient of the considered hypothesis is close to 1, the level of confidence in the specialty increases, and when it is close to -1, the specialization proposed as a hypothesis is rejected. If the value of the coefficient is close to 0, then the circumstances are assessed as insufficient to determine or deny specialization.

In improving the knowledge base, professionals should determine the value of a confidence level for each rule that reflects a list of circumstances or personal qualities required for a particular profession. These values determine how adequate the rules are. If the expert has set the value of the confidence level to a to support the hypothesis, then it is not necessary to reject the hypothesis with confidence level *1-a*, because when *x* confirms condition H, the following relation (16) is established.

$$CF[H,x] + CF[\neg H,x] \neq 1 \quad (16)$$

In CF, the expressions MD and MB can be denoted by P[H / x] and P(H)

$$CF[H,x] = \begin{cases} \dfrac{P[H/x] - P(H)}{1 - P(H)}, if\ \ P(H/x) \geq P(H) \\ \dfrac{P[H/x] - P(H)}{P(H)}, if\ \ P(H/x) < P(H) \end{cases} \quad (17)$$

Students are trained to combine professional situations into complex hypotheses, and the following approximate assessment methods are provided.

$$MB[H_1, x_1 \wedge x_2] = \min(MB[H_1, x_1], MB[H_1, x_2]) \quad (18)$$

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$$MD[H_1, x_1 \wedge x_2] = \max(MD[H_1, x_1], MD[H_1, x_2]) \quad (19)$$

Career orientation The final confidence coefficients for each of the hypotheses are calculated according to formula (22) using data from formulas (20) and (21).

$$MB[H_1 \wedge H_2] = \begin{cases} 0, \; if \quad MD[H_1, H_2] = 1 \\ MB[H_1, x_1 \wedge x_2] + MB[H_1, x_3 \wedge x_4](1 - MB[H_1, x_1 \wedge x_2]) \end{cases} \quad (20)$$

$$MD[H_1 \wedge H_2] = \begin{cases} 0, \; if \quad MD[H_1, H_2] = 1 \\ MB[H_1, x_1 \wedge x_2] + MB[H_1, x_3 \wedge x_4](1 - MD[H_1, x_1 \wedge x_2]) \end{cases} \quad (21)$$

This allows you to combine the results of any number of rules by repeatedly using the rule of voluntary combination of cases.

As for the problem of choosing the profession under consideration, when determining the signs of professionalism and determining the factors that determine the propensity to them, the knowledge engineer should calculate the value of each of the x_i factors calculated in the project for all options. Let Hj be the recommended professional H_j based on the data. Due to the high complexity of the formation of knowledge base P(H/x) tables, empirical rules that determine the impact of a combination of factors in decision making can be summarized in the form of gathering inquiries from professionals and rules that shape this information. Tables are created to simplify calculations. The first is derived from the confidence coefficients of simple hypotheses, in which the calculation is performed according to the formulas (2), (3), (6); the second is calculated from the confidence coefficients of complex hypotheses and according to formulas (6), (9), (10); the data in the second table are combined for the accumulated confidence coefficients of the third and the calculations are performed according to formulas (6), (11), (12).

Table 2: Confidence Coefficients of Simple Hypotheses in Career Guidance

Variables	Variable name	P(H/x)	P(H)	MB	MD	CF
x_1	Situation №1	$P(H/x_1)$	$P_1(H)$	$MB[H, x_1]$	$MD[H, x_1]$	$CF[H, x_1]$
x_2	Situation №2	$P(H/x_2)$	$P_2(H)$	$MB[H, x_2]$	$MD[H, x_2]$	$CF[H, x_2]$
--						
x_n	Situation №N	$P(H/x_n)$	$P_n(H)$	$MB[H, x_n]$	$MD[H, x_n]$	$CF[H, x_n]$

Table 3: Confidence Coefficients for Complex Assumptions in Career Orientation

Variables	Hypothesis formula	$P(H, x_n \wedge x_{n+1})$	$MB(H, x_n \wedge x_{n+1})$	$MD(H, x_n \wedge x_{n+1})$	$CF(H, x_n \wedge x_{n+1})$
Y_1	$P(H, x_1 \wedge x_2)$	$P_1(H, x_1 \wedge x_2)$	$MB_1(H, x_1 \wedge x_2)$	$MD_1(H, x_1 \wedge x_2)$	$CF_1(H, x_1 \wedge x_2)$
Y_2	$P(H, x_3 \wedge x_4)$	$P_2(H, x_3 \wedge x_4)$	$MB_2(H, x_3 \wedge x_4)$	$MD_2(H, x_3 \wedge x_4)$	$CF_2(H, x_3 \wedge x_4)$
--					
Y_n	$P(H, x_n \wedge x_{n+1})$	$P_n(H, x_n \wedge x_{n+1})$	$MB_n(H, x_n \wedge x_{n+1})$	$MD_n(H, x_n \wedge x_{n+1})$	$CF_n(H, x_n \wedge x_{n+1})$

Table 4: Reliable Factors in Career Guidance

Hypothesis	MB	MD	CF
$P(H/y_1)$	$MB(H/y_1)$	$MD(H/y_1)$	$CF(H/y_1)$
$P(H/y_1 \cdot y_2)$	$MB(H/y_1 \cdot y_2)$	$MD(H/y_1 \cdot y_2)$	$CF(H/y_1 \cdot y_2)$
--			
$P(H/y_1 \cdot y_2 .... y_n)$	$MB(H/y_1 \cdot y_2 .... y_n)$	$MD(H/y_1 \cdot y_2 .... y_n)$	$CF(H/y_1 \cdot y_2 .... y_n)$

For each of the career-oriented hypotheses, the confidence coefficients of the last row of Table 3 are combined and compared in a single table, with the hypothesis with the highest confidence coefficient recommended as the best

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option. The use of the Shortliff and Buchanan method is a tool that allows the expert system to combine cases in solving this problem. The model presented in the study allows for expert decision-making in career guidance.

VI. Dempster-Schafer Method in the Expert Information System of Career Guidance

An expert system of career guidance provides the opportunity to intellectualize the system through the use of a number of models and methods. There are some problems with the implementation of the Bayesian approach to determining professional suitability: the need to pre-determine the a priori probability of each case, the expression of unreliable information with the Bayesian probability, depending on the subjective opinion of the individual. This probability does not allow for a sufficiently effective description of professional suitability. In analyzing subjective unreliable data, we propose to use the Dempster-Schafer probability method. Dempster-Schaefer theory is based on two ideas:

- The first is to obtain a level of reliability from subjective cases about the problems associated with it in order to make a decision;
- The second is to use the rule of aggregation of cases to make a decision if it is based on more than one interrelated situation.

Dempster probability method offers concepts such as low and high probabilities. Shafer improved Dempster's theory and modified them accordingly as a function of reliability and probability, respectively, to give these concepts a subjective meaning [3].

The probability measure of reliability is a quantitative characteristic of the relative frequency of events that does not contradict the simultaneous occurrence of event B during the experiment. Under experimental conditions, it has a limited number of results, each of which is likely to occur during the experiment.

According to the definition of a reliability measure, observations describe the relative frequency of events that allow the occurrence of event B to occur and are numerically equal to the probability that event B will occur.

Using Dempster-Schaefer theory, it is possible to combine expert opinions very effectively. In cases of uncertainty, the expert is characterized by a certain degree of confidence in his decisions [5]. In the case of a professional expert system, an uncertainty interval consisting of two coefficients is assigned: the reliability coefficient obtained by the Shortliff and Buchanan methods is determined by n; *p* is the probability obtained by the Chris-Naylor method (chance).

Hence, let us define the reliability and probability functions [2], the reliability function of $H \subseteq P_0(U)$ events is defined by *Bel(H)* and the probability function is defined by *Pl(H)* as follows.

$$Bel(H) = \sum_{H_i : H_i \subseteq H} P(H_i),\ Pl(H) = \sum_{H_i : H_i \subseteq H \neq 0} P(H_i), \qquad (3.4.1)$$

Here U is a set, which is called a different field in case theory,

$P_0(U)$ is the set of all subdivisions of the set U, H_1 is the hypothesis (specialization), $P(H_2)$ is the main probability.

As a result, the decision-making method based on Dempster-Schafer theory is implemented as follows.

When the current situation leads to several assumptions of reliability on the same hypotheses, it will be possible to combine decisions to assess the reliability of the hypothesis.

The uncertainty coefficients x_1 and x_2 are treated according to the simple decisions $[n_1, p_1]$ and $[n_2, p_2]$, respectively [8]:

The uncertainty coefficients and the simple solutions and x_2, respectively, are treated as follows [8]:

$$\neg x_1 : [1 - p_1, 1 - n_1],$$
$$x_1 \vee x_2 : [n_1 + n_2 - n_1, p_1 + p_2 - p_1 \cdot p_2],$$
$$x_1 \wedge x_2 : [n_1 \cdot n_2, p_1 \cdot p_2],$$

here*x* is the assignment of cases;

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H - result of cases (hypothesis)

As a result, the *x* -> *H* type relationship is determined by two assumptions:

$$[Bel(x \to H), Pl(x \to H)] \text{ va } [Bel(\neg x \to H), Pl(\neg x \to H)]$$

In career orientation, the reliability and probability functions can be thought of as the lower and higher probabilities of certain boundary intervals. Then we can construct the lower and upper distribution functions of a random quantity. Let the given coefficients *x* be a certain interval [s, t] and the coefficients *x*–> *H* be $[n_1, p_1]$ and $[n_2, p_2]$, respectively, the uncertainty coefficients for H are given in formulas (3.4.2) and (3.4.3). is suitable:

$$n = \begin{cases} n_1 s + n_2(1-s), & if \quad n_1 \geq n_2, \\ n_1 t + n_2(1-t), & if \quad n_1 < n_2, \end{cases} \qquad (3.4.2)$$

$$p = \begin{cases} p_1 s + p_2(1-s), & if \quad p_1 \geq p_2, \\ p_1 t + p_2(1-t), & if \quad p_1 < p_2, \end{cases} \qquad (3.4.3)$$

Let the combined uncertainty of H based on two relations $x_1 \to H$ and v be given by the values $[n_1, p_1]$ and $[n_2, p_2]$ with intermediate limits:

$$n = \frac{n_1 p_2 + n_2 p_1 - n_1 n_2}{1 - n_1(1-p_2) - n_2(1-p_1)}, \qquad (3.4.4)$$

$$p = \frac{p_1 p_2}{1 - n_1(1-p_2) - n_2(1-p_1)} \qquad (3.4.5)$$

As the number of rules in the knowledge base in expert information systems increases, it leads to an exponential increase in the time required for calculations. In this regard, a strict hierarchy of hypotheses is determined, and it is necessary to generalize the interrelated cases. Based on this, the Dempster-Schafer theory is applied to the alternatives, the data are analyzed, and all possible solutions are identified.

VII. Designing an Expert Information System for Career Guidance

It is necessary to develop an expert information system for the intellectualization of the career guidance process. Usually the expert system is assumed to have made the right decision, i.e. the decision is said to be correct. For the decision to be correct, the models and algorithms in the expert system must be adequate and correct. If the decision of the expert system shows low values in all cases, we consider the decision of the system to be incorrect. If the solution of the system is equal to half of the hypotheses in the knowledge base, the solution of the system is considered controversial. From the above considerations, it can be seen that the notion of the truth of a hypothesis is largely subjective.

By identifying a limited set of occupations (hypotheses), an expert can determine the coefficients of probability and confidence for each case related to a particular set of occupations based on personal experience or rating data he or she has previously collected. Based on this, the following algorithm was developed for the decision-making process in the system of career guidance:

Whether there is any knowledge base based on the expert system of the profession in question, the stages of the system's algorithm for its decision-making process are carried out in the following steps.

Step 1. Set the initial values of the reliability coefficients of the professional status. As mentioned above, the initial values are determined on the basis of a priori coefficients set by experts in the design of the expert system.

Step 2. Select the calculation method. At this stage, the method of drawing conclusions based on the models presented in the third chapter is selected.

In the current situation, recommendations are developed in the expert system in accordance with the chosen method.

Step 3. Check the need for further calculations. This stage is very important in the operation of the expert system. The knowledge base of an expert system can store hundreds and thousands of individual cases that confirm or refute certain hypotheses. In the simplest scenario of the recommendation formation process, the final decision-making, i.e., the expert system for decision-making, must determine the approval or denial of all circumstances that have any effect on a particular item. In a large knowledge base, such a scenario leads to the practical impossibility of decision-making in the decision-making process, as a rule, due to the existence of time constraints.

We use the following concept to build a function to verify the need to continue the decision-making process to make a recommendation:

The limit of hypothesis recommendation is the value of the reliability coefficient or probability of the hypothesis, where the expert system automatically leads to the recommendation of the profession in the process.

The value of the recommendation limit should be between 0 and 1, a negative value indicates that it is not appropriate for the profession. For both coefficients, it is recommended to equate this value to one or the other, which corresponds to the maximum propensity for the proposed profession.

Step 4. Analyze the situation and review it according to the user's personal qualities. In order to promote any profession as a recommendation, it is necessary to constantly take into account many parameters that characterize the user's inclinations, interests, and so on.

Step 5. Based on the rating data, the user should choose the level of compliance of the observed interests, tendencies, achievements in the profession with the needs of the profession.

Step 6. Interpret user data. Once the user rating is obtained, certain calculations are performed according to the above models.

Step 7. Improving hypotheses. Examine all hypotheses of the expert system for finality. The hypothesis is considered to be firmly concluded when all the hypotheses and cases affecting the reliability coefficient are completely deduced.

An expert career guidance information system will be developed based on the developed algorithm. As a result, based on this information system, the level of professional orientation of students according to the rating data is determined. Professional orientation refers to the degree of engineering, research, or management in a particular field.

VIII. Conclusion

This research paper is based on the development of mathematical models for an intelligent system of career guidance based on multifactor rating data. Intellectual production of expert information algorithm of the non-professional process. Employment of expert information systems of production professional orientation allows to make the optimal decision on employment.

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