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Mathematical Modeling Professional Direction Expert System

A.Akhatov, D.Mardonov, F.Nazarov, A.Rashidov

Samarkand state university

Abstract – The development and introduction of career guidance mechanisms based on digital technologies will not only increase professional quality, but also bring economic benefits. The development of mathematical modeling of knowledge expression in the career guidance system is the basis for the development of automated information systems. This study examines the mathematical modeling of a career guidance system based on multifactor rating data. The Shortliff and Buchanan models in the expert information system of career guidance and the performance functions of this model are described in detail.

Keywords – Digital Technology, Rating, Career Orientation, Mathematical Modeling, Shortliff and Buchanan Model.

I. INTRODUCTION

Automating processes controlled by digital technologies creates opportunities to minimize costs as well as work efficiency.

Ensuring youth employment is an urgent and long-term task of state socio-economic policy and development of the country. Today, the employment of young people is not enough to ensure that they have a decent job and to select talented and mature professionals in front of the employer (Ivanova, 2010; Ivashina, 2006; Axatov, 2020).

The increase in the number of graduates, in turn, creates competition among them for successful employment. The current socio-economic conditions, dominated by market relations, place a number of demands on the person seeking self-realization, in particular:

- have a well-paid job today;
- achieve high results on the service ladder;
- sufficient to be successful in any professional activity, etc.

To do this, it is necessary to create an online communication environment between the employer and the specialist using digital technologies, that is, to form a rating of each specialist on their knowledge and achievements in the educational process (Ivashina, 2006; Mardonov, 2020; Chandra, 2021). Due to this, the employer will be able to select the staff with the highest rating, and specialists with the highest rating will be able to choose a quality job. As a result, students will be able to work harder and have a healthy competitive environment in order to be ranked higher.

II. REVIEW LITERATURE:

Shortliff and Buchanan model in the expert information system of career guidance

Rating information is included in the expert information system of career guidance. Determining the probability of sending incoming information to the profession on the basis of models gives effective results (Ivashina, 2006; Axatov, 2020; Kordheydari, 2022). 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 (Ivanova, 2010; Kryukovskiy, 2010). 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 (Kryukovskiy, 2010; Ivashina, 2007). 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) - direction of study on the basis of *x* cases for the respondent H_j conditional probability of existence, the conditional probability components of P(H_j ./x) are calculated as follows.

$$P(H_j/x)=\frac{P(H_j)P(x/H_j)}{\sum_j P(H_j)P(x/H_j)} \tag{1}$$

where $P(H_j)$ is the a priori probability of the hypothesis. The probability of occurrence of $P(x/H_j)$ attribute values. H_j is obtained from objects in the *x* state class. For example, the expression $P(x/H_j)=a$ can be expressed as a hypothesis (faculty or specialty) when there is a *100a* possibility to confirm the H_j hypothesis when there are signs of H_j x_k .

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:

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

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] $= \alpha$ indicates the degree of reliability of the *H* hypothesis for specialization.

MD[H,x] $= \beta$ indicates the degree or measure of uncertainty for the specialization in the *H* 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 (Kapterev, 1999; Neylor, 1991). If the probability P (*H/x*) is greater than P (*H*), then observing x increases the expert's confidence in H.

Suppose, conversely, that if P (*H/x*) is less than the probability 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.

$$MB[H,x] = \frac{P(H/x) - P(H)}{P(H)} \tag{2}$$

$$MD[H,x] = \frac{P(H) - P(H/x)}{P(H)} \tag{3}$$

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.

$$MB[H,x] = \begin{cases} 1, \quad agar P(H) = 1 \\ \dfrac{\max[P[H/x], P(H)] - P(H)}{1 - P(H)} \end{cases} \tag{4}$$

$$MD[H,x] = \begin{cases} 1, \quad agar P(H) = 0 \\ \dfrac{\max[P[H/x], P(H)] - P(H)}{1 - P(H)} \end{cases} \tag{5}$$

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

$0 < MB[H, x] < 1$ and $0 < MD[H, x] < 1$.

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 determined by the CF data confidence coefficient, which is in the form (6).

$$CF(H|E) = MB(H|E)-MD(H|E) \quad (6)$$

If the confidence 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 put forward 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 (Ivanova, 2010; Ivashina, 2007). These values determine how adequate the rules are. If the expert set the value of the confidence level to support the hypothesis at *a*, then it is not necessary to reject the hypothesis with confidence level *1-a*, because when x confirms the condition H, the following 7) relation determined.

$$CF[H,x] + CF[\neg H,x] \neq 1 \quad (7)$$

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

$$CF[H,x] = \begin{cases} \dfrac{P[H/x]-P(H)}{1-P(H)}, \; if \; P(H/x) \geq P(H) \\ \dfrac{P[H/x]-P(H)}{P(H)}, if \; P(H/x) < P(H) \end{cases} \quad (8)$$

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

$$MB[H_1, x_1 \wedge x_2] = \min(MB[H_1, x_1], MB[H_1, x_2]) \quad (9)$$

$$MD[H_1, x_1 \wedge x_2] = \max(MD[H_1, x_1], MD[H_1, x_2]) \quad (10)$$

Career orientation The final confidence coefficients for each of the hypotheses are calculated according to formula (2) using data from formulas (11) and (12).

$$MB[H_1 \wedge H_2] = \begin{cases} 0, if \; MD[H_1, H_2] = 1 \\ MB[H_1, x_1 \wedge x_2] + MB[H_1, x_3 \wedge x_4](1 - MB[H_1, x_1 \wedge x_2]) \end{cases} \quad (11)$$

$$MD[H_1 \wedge H_2] = \begin{cases} 0, if \; MD[H_1, H_2] = 1 \\ MB[H_1, x_1 \wedge x_2] + MB[H_1, x_3 \wedge x_4](1 - MD[H_1, x_1 \wedge x_2]) \end{cases} \quad (12)$$

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. In this case, let x_j be the recommended professional specialty H_j. Due to the high complexity of the formation of knowledge base P(H/x) tables, empirical rules that determine the effect of a combination of factors in decision making can be summarized in the form of collecting inquiries from professionals and rules that shape this information. Tables are created to simplify calculations (Novikov, 2000; Nazarov, 2020). 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 1. 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	$P(H/x_2)$	$P_2(H)$	$MB[H,x_2]$	$MD[H,x_2]$	$CF[H,x_2]$
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x_n	Situation №N	$P(H/x_n)$	$P_n(H)$	$MB[H,x_n]$	$MD[H,x_n]$	$CF[H,x_n]$
Source						

Table 2. 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	$P(H,x_n \wedge x_{n+1})$	$P_n(H,x_n \wedge x_{n+1})$	$MB_n(H,x_n \wedge x_{n+1}$	$MD_n(H,x_n \wedge x_{n+1}$	$CF_n(H,x_n \wedge x_{n+1})$

Source

Table 3. Reliable factors in career guidance.

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

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

Source

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 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.

III. Discussion

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 [108]. 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. Conclusion

The study examined the issue of career guidance. Mathematical models of expert information systems for career guidance are given. The problem of modeling based on Shortliff and Buchanan methods in career orientation is analyzed.

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