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Research paper

The Procedure for Identifying the Compliance of the Performer's Competencies with the Stated Requirements Based on The Bayesian Approach

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Abstract.

The article proposes a procedure for the selection of personnel to perform specific activities based on a comparison of the general professional and professional competences obtained in the training process to the required level of qualification in order to effectively allocate labor resources. In this paper, a fragment of an example of the implementation of the procedure based on the use of professional standards for the large group 06.000 - Communication, information and communication technologies. The use of posterior probabilities calculated during the implementation of the procedure allows management personnel to make a decision on the selection of personnel with the most appropriate qualification for solving a particular task.

Keywords: *professional standard, Bayesian theorem, competencies, labor functions, a priori probability, a posteriori probability*

1.Introduction

According to studies by the International Institute of Social and Economic Science [1], recently in the world, and especially in economically developed countries, there has been a tendency towards a general decline in the quality of preparedness of highly qualified personnel, and in general, the number of such people has decreased. These processes force large companies to pay more attention not only to the selection of candidates for hiring, but also to the effective use of each employee according to his level of training.

Traditionally, in studies on the selection of technology employees to perform a specific task, the final decision is taken by the decision maker, who is directly responsible for the selection results. However, it should be borne in mind that when selecting employees, it is necessary to take into account not only the position they occupy, but also the conformity of their level of training with the requirements for executors in the process of solving the problem. It should be noted that recently the question of how important is the compliance of the performer's competencies declared at the task formulation stage with the functional requirements [2 - 5] is increasingly being discussed.

In the process of selecting employees, the decision maker has to choose how well competencies, in particular professional ones formed, correspond to the peculiarities of the task being solved.

Currently, there is a large amount of specialized literature explaining decision-making decision makers, but the problem of why they change their decision in the selection process is much less often discussed. An analysis of such changes and their probable prediction can be made using Bayesian theorem.

It is quite natural that the decision maker forms the initial impression about the employees, which is subsequently repeatedly reviewed by them on the basis of the updated information received by the decision maker in the selection process. And, as a rule, in the conditions of insufficient awareness of the level of training of the employee in question, the decision maker makes a decision based on his opinion, including on the personal characteristics of the applicants.

Very little is known about the motives of the decision maker, as a result of whose decisions some of the employees are eliminated long before the final selection stage. Often, the decision maker's decision is related to obtaining negative information about the applicant during the selection, etc. For example, these reactions may be due to race or gender, attitude to the working conditions of applicants, etc.

At the final stage of the decision on the selection of employees, the decision maker compares and selects possible alternative options.

As noted above, during the selection of employees for solving a specific task, the decision maker already has some beliefs or opinions that are continuously reviewed by him in the selection process.

Among the various statistical evaluation methods, the Bayesian models are the most optimal. They can be used to determine the best way for a candidate to work, make it possible to identify possible gaps in the strategies of the organization employing personnel, and also to identify the circumstances in which the decision maker seeks to make decisions that are ineffective for the company when selecting potential employees or tasks, i.e. Bayesian models are advisory rather than merely descriptive.

2.Methods

Formalized decision-making goal: let you need from the set $V = \{\upsilon_1, \upsilon_2, ..., \upsilon_n\}$ of solutions, the performance indicators of which are about the same, choose the most appropriate υ^* for implementation.

To achieve the goal, we use the Bayes theorem [6 - 8].

$$P(H_i / A_{(j)}) = \frac{P(A_{(j)} / H_i) \cdot P(H_i)}{\sum_{i=1}^{n} P(A_{(j)} / H_i) \cdot P(H_i)}, i = \overline{1,n} \quad (1)$$

where H_i – is the assumption (hypothesis) that the variant υ_i is optimal;
$A_{(j)}$ – the result of the examination (event) on the optimality of the variant υ_j ;
n – is the number of variants considered (the power of the set V);
$P(H_i)$, $P(H_i / A_{(j)})$ – are the a priori and a posteriori probabilities of the hypothesis H_i respectively;
$P(A_{(j)} / H_i)$ – is the probability of the event $A_{(j)}$ if the hypothesis Hi (likelihood) holds.

If an event occurs, $\overline{A}_{(j)}$, then the posterior probability $P\left(H_i / \overline{A}_{(j)}\right)$ is calculated using a formula similar to (1), i.e.

$$P\left(H_i / \overline{A}_{(j)}\right) = \frac{P\left(\overline{A}_{(j)} / H_i\right) \cdot P(H_i)}{\sum_{i=1}^{n} P\left(\overline{A}_{(j)} / H_i\right) \cdot P(H_i)}, \quad (2)$$

where $P\left(H_i / \overline{A}_{(j)}\right)$ – posterior probability of the hypothesis Hi at the event $\overline{A}_{(j)}$.

Probabilities $P(H_i)$, $P\left(H_i / A_{(j)}\right)$, $P\left(H_i / \overline{A}_{(j)}\right)$ naturally satisfy the condition of completeness of a group of events, i.e.

$$\sum_{i=1}^{n} P(H_i) = 1, \sum_{i=1}^{n} P(H_i / A_{(j)}) = 1, \sum_{i=1}^{n} P\left(H_i / \overline{A}_{(j)}\right) = 1$$

$$P(A_{(j)} / H_i) + P\left(\overline{A}_{(j)} / H_i\right) = 1$$

и

3.Main Part

When using the Bayesian approach to solving such problems, an important role is played by the formalization of the "stop" rule in the process of conducting examinations. On the one hand, reducing the number of options saves money spent on conducting examinations. On the other hand, confidence is needed that a further increase in the number of examinations will not lead to the adoption of another option when choosing.
When solving the task of selecting an employee, it was decided to use the following provisions:
- only those employees who perform the same work functions, including generalized ones, are subject to evaluation;
- it is possible to evaluate only those employees who have the same level of qualification;
- labour functions can be considered through the generated competencies.
According to the first statement, it is necessary to consider individual groups of classes according to the tasks to be solved (groups of classes are listed in each professional standard), while the same professional standard corresponds to different groups of classes.
Let's consider the example of professional standards for the enlarged group 06.000 - Communication, information and communication technology [9, 10]. Table 1 presents a fragment of the summary table of compliance of professional standards with a group of occupations.

Table 1 - Compliance of professional standards with a group of occupations

Code	Group of occupations	Professional standard
2519	Developers and analysts of software and applications not included in other groups	06.037 Software support specialist for information and communication networks
		06.035 Web and multimedia developer
		06.032 Computer Systems and Network Security Specialist
		06.033 Information Security Specialist in Automated Systems
		06.040 Quality Assurance Specialist for Information and Communication Systems
		06.031 Specialist in automation of information and analytical activities in the field of security
		…
2513	Web and multimedia application developers	06.035 Web and multimedia developer
		…
2523	Computer Network Specialists	06.037 Software support specialist for information and communication networks
		06.030 Information security specialist in telecommunication systems and networks
		…
1223	Heads of research and development	06.034 Technical Information Security Specialist
		06.032 Computer Systems and Network Security Specialist
		06.031 Specialist in automation of information and analytical activities in the field of security
		…
2511	System analysts	06.031 Specialist in automation of information and analytical activities in the field of security
		06.032 Computer Systems and Network Security Specialist
		06.033 Information Security Specialist in Automated Systems
		06.030 Information security specialist in telecommunication systems and networks
		…
…	…	…

According to the second statement, the qualification level of the evaluated employees must be the same or differ by no more than one position. From the point of view of the authors, the best is the division by training levels, for example, undergraduate, graduate or postgraduate studies.

The selection of job functions should be considered on the basis of the selected group of occupations and skill level. Collections of work functions were formed for different sets of groups of occupations, professional standards and qualification levels. When forming the lists, it was taken into account that a number of labour functions for different professional standards have similar names (semantically and / or pragmatically). Below is a fragment of the list of labour functions on the example of class 2511 System Analysts and 7 skill levels:

1. Automated information and analytical support for decision-making processes
2. The solution of typical tasks of information processing in the IAS of state bodies ensuring national security
3. Solving typical problems of analyzing information in the IAS of state authorities ensuring national security
4. Conducting a pre-project survey of performance activities and information needs of the automated units
5. Analysis of information security threats
6. Organization of the functioning of special-purpose communication networks and their means of communication
7. Conducting a security analysis of computer systems
8. Carrying out routine maintenance of information protection systems for automated systems

...

34. Analysis of system problems of information processing at the level of information and communication system

Implementation

The knowledge base is a text file (which can later be encrypted), which includes three sections with the following structure:

- Block of description of KB (Description of the knowledge base);
- Block of evidence:

Certificate number 0 (any text (no more than 1000 characters), ending with a new line)
Certificate number 1
...
Certificate No. N (one blank line follows the last certificate, and the second section ends)

- Block of outcomes:

Outcome # 0, P [, i, Py, Pn]
Exodus # 1, P [, i, Py, Pn]
...
Exodus # M, P [, i, Py, Pn]

The meaning of the first two blocks is clear from the given scheme. The last block requires more detailed consideration. It lists the output rules: each is set on a separate line; the listing ends with the end of the file.

At the beginning of the description of the inference rule, an outcome is specified, the probability of which varies according to this rule. This is text that includes any characters except commas. The decimal point indicates the a priori probability of a given outcome (P), i.e. probability of outcome in the absence of additional information. After that, a comma goes a series of repeating fields of three elements. The first element (i) is the number of the corresponding question (symptom, evidence). The next two elements (Py = P (E / H) and Pn = P (E / HH)) - respectively, the probability of receiving the answer "Yes" to this question, if the possible outcome is correct and incorrect. These data are indicated for each question associated with a given outcome.

Table 2 - Summary table of the compliance of labour functions with professional standards

Questions \ Professional Standards	06.030	06.031	…	06.033
Automated information and analytical support for decision-making processes	+	-	…	-
Solution of typical tasks of information processing in the IAS of state authorities ensuring national security	+	+	…	+
Solving typical problems of analyzing information in the IAS of state authorities ensuring national security	+	+	…	+
Conducting a pre-project survey of performance activities and information needs of the automated units	+	+	…	+
Information Security Threat Analysis	-	+	…	-
The organization of the functioning of special-purpose communication networks and their means of communication	+	-	…	-
Conducting a security analysis of computer systems	-	+	…	+
Carrying out routine maintenance of information protection systems of automated systems	+	-	…	-
…	…	…	…	…
Analysis of system problems of information processing at the level of information and communication system	-	+	…	-

(+ - presence, - - negation)

Table 3 - Calculations of probabilities

		06.030	06.031	…	06.033
		0,091	0,065	…	0,084
Automated information and analytical support for decision-making processes	Py	0,7143	0	…	0
	Pn	0,0263	0,0583	…	0,3158
Solution of typical tasks of information processing in the IAS of state authorities ensuring national security	Py	0,8571	0,7448	…	0,8543
	Pn	0,0118	0,0333	…	0,0258
Solution of typical tasks of information processing in the IAS of state authorities ensuring national security	Py	0,6713	0,6995	…	0,7105
	Pn	0,0151	0,0523	…	0,1508
Conducting a pre-project survey of performance activities and information needs of the automated units	Py	0,7871	0,7051	…	0,6014
	Pn	0,0331	0,0217	…	0,1018
	Py	…	…	…	…
	Pn	…	…	…	…
Analysis of system problems of information processing at the level of information and communication system	Py	0	0,6709	…	0
	Pn	0,0215	0,0513	…	0,0827

3.1. Implementation of the program:

Group of classes 2511 System analysts, 7th level of qualification
Questions:

1. Automated information and analytical support for decision-
2. The solution of typical tasks of information processing in the IAS of state bodies ensuring national security
3. Solving typical problems of analyzing information in the IAS of state authorities ensuring national security
4. Conducting a pre-project survey of performance activities and

...
34. Analysis of system problems of information processing at the level of information and communication system

06.030, 0.091, 1, 0.7143, 0.0263, 2, 0.8571, 0.0118, 3, 0.6713, 0.0151, 4, 0.7871, 0.0331, …, 34, 0, 0.0215
06.031, 0.065, 1, 0, 0.0583, 2, 0.7448, 0.0333, 3, 0.6995, 0.0523, 4, 0.7051, 0.0217, …, 34, 0.6709, 0.0513
…
06.033, 0.084, 1, 0, 0.3158, 2, 0.8543, 0.0258, 3, 0.7105, 0.1508, 4, 0.6014, 0.1018, …, 34, 0, 0.0827

4.Results

After launching the advising management decision support system and loading the knowledge base, a window appears with the initial probability values of the standards considered and with the list of questions used to calculate the final probabilities (Fig.1).
Initial probabilities are ordered by value for a more visual representation. The list of questions is set in a ranked form according to the degree of their influence on the calculated probabilities.

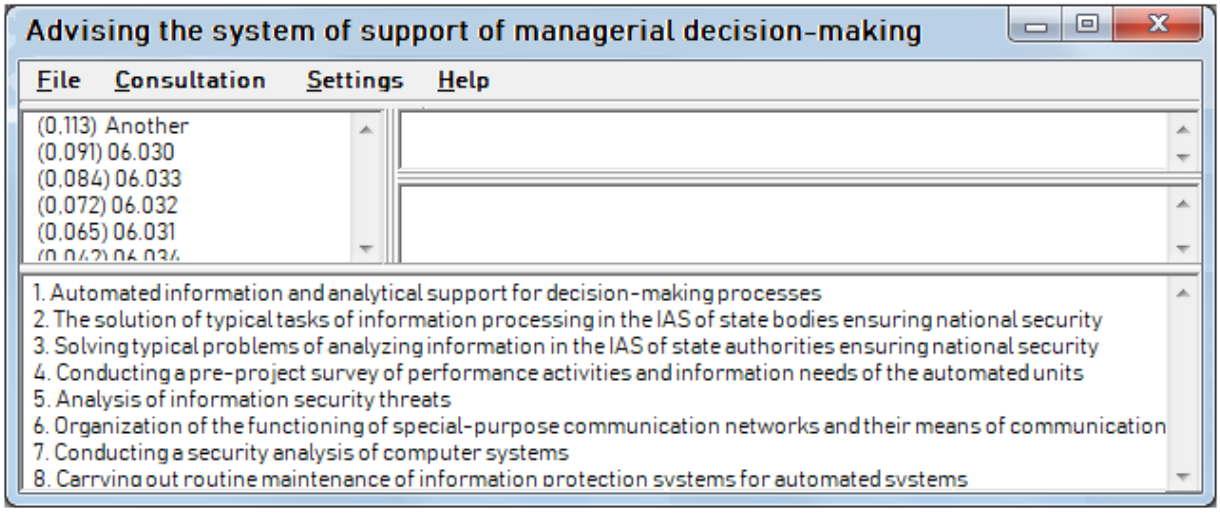

Fig. 1. Initial state of the advising system after loading the knowledge base

Figure 2 presents the intermediate results of the calculation of probabilities obtained after processing the first question. It can be seen that the probabilities of a number of standards have been recalculated.

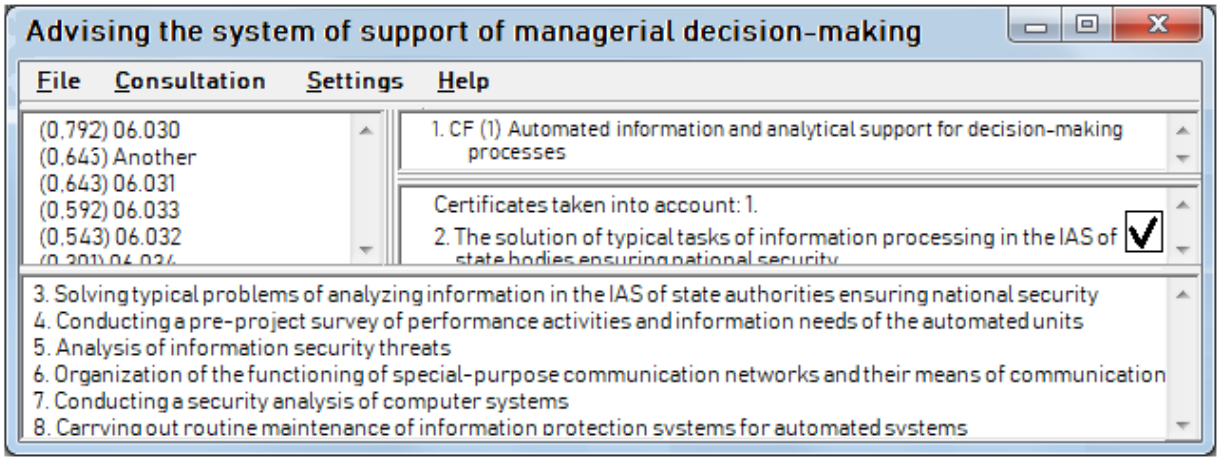

Fig. 2. The state of the advising system after processing the first knowledge base record

After processing all the questions from the knowledge base, the advising system provides the final results of the probability calculations (Fig.3). After the end of the consultation, you can view the final protocol, which reflects all the questions with the corresponding answers received and the calculated probability values. As can be seen from the final protocol (Fig.4), a number of probabilities are either insignificant or have received zero values.

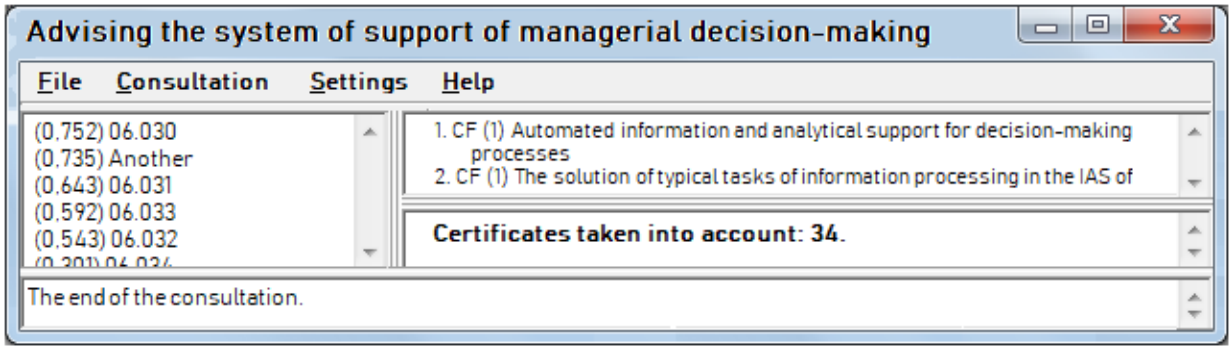

Fig. 3. Final state of the advising system after processing all records in the knowledge base

Consultation Protocol

Group of classes 2511 System analysts, 7th level of qualification

Consultation completed

Processed certificates:
1. CF (1) Automated information and analytical support for decision-making processes
2. CF (1) The solution of typical tasks of information processing in the IAS of state bodies ensuring national security
3. CF (1) Solving typical problems of analyzing information in the IAS of state authorities ensuring national security
4. CF (0) Conducting a pre-project survey of performance activities and information needs of the automated units
...
34. CF (0) Analysis of system problems of information processing at the level of information and communication system

The result of the consultation:
(0.752) 06.030
(0.735) Another
(0.643) 06.031
...
(0.001) 06.037
- (0.000) 06.036

Fig. 4. Protocol of the program

5.Conclusions

1. Using the Bayesian approach allows you to formalize the task of selecting employees to solve the problem.
2. The calculation of a posteriori probabilities makes it possible to make informed decisions regarding the group of preferred applicants for the position.
3. The proposed approach is convenient for operational decision making under stochastic uncertainty.

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