UDC 004:65.012.8:36
DOI: 10.15587/2706-5448.2024.303763

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DESIGNING A SEMI-AUTOMATED DECISION-MAKING SYSTEM FOR SELECTING RECIPIENTS OF SOCIAL SERVICES

The object of this research is the decision-making process in the context of selecting recipients of social services using a semi-automated expert system. The main focus is on improving the mechanisms of assessment and selection of candidates eligible for assistance, in order to ensure a more efficient and objective allocation of resources.

The problem addressed in this study is the need to improve the accuracy and efficiency of decision-making processes in social services through the implementation of semi-automated systems. In particular, reducing subjective influence in selection processes, as well as reducing the time and resources required to process applications.

The study shows that the introduction of a semi-automated system can significantly reduce the response time to applications, increase the accuracy of candidate selection and ensure greater transparency in the decision-making process. The system, based on data analysis algorithms and production rules, is able to adapt to changing conditions and requirements, providing solutions based on up-to-date information.

The effectiveness of the semi-automated system is due to the use of modern technologies for processing large volumes of data and the use of complex mathematical models for the analysis of this data. The implementation of a modular system with individually adjustable parameters allows the system to accurately evaluate each case based on the expected criteria, ensuring a high level of adaptability and accuracy.

The results of the research can be applied in practice in various social security institutions, where there is a need to automate the processes of selection and decision-making. Important conditions for the effective implementation of the system are the availability of sufficient technical support, a high level of qualification of the personnel engaged in putting the system into operation, as well as a clear understanding of the rules and procedures that regulate social protection. In addition, to guarantee the successful application of the system, it is necessary to ensure compliance with all regulatory and legislative requirements, especially regarding the protection of personal data.

Keywords: *expert decision-making block, expert system, production rule, social sphere, social service.*

Received date: 22.03.2024
Accepted date: 09.05.2024
Published date: 14.05.2024

How to cite

Kykyna, Y. (2024). Designing a semi-automated decision-making system for selecting recipients of social services. Technology Audit and Production Reserves, 3 (2 (77)), 6–9. doi: https://doi.org/10.15587/2706-5448.2024.303763

1. Introduction

Decision-making processes differ depending on the industry in which they occur. For example, in the field of management, it is critically important not only to carefully plan and make informed decisions, but also to consider the consequences of these decisions at all stages of their implementation. This aspect of management requires a systemic approach, which includes the analysis of potential impacts of decisions on various sectors of the organization, as well as on its stakeholders [1, 2]. In the fields of technology and education, it is necessary to respond adaptively to changes in conditions and characteristics of input data to ensure the efficiency of processes and compliance with educational needs. This is especially true of technological innovation and the rapid updating of knowledge, which requires flexibility in teaching methods and design from educational institutions and technical enterprises. Adaptation to these changes often includes the integration of the latest technological solutions and rethinking of approaches to learning and work, which allows to improve the quality of education and the productivity of technical processes [3, 4].

It is obvious that the development of the components and structure of expert systems to solve specific problems can significantly increase the efficiency of decision-making processes. Expert systems that are integrated into organizational processes are able to simulate human expertise and use accumulated knowledge to solve complex problems that traditionally depended on the qualifications of specialists. These systems use artificial intelligence algorithms to analyze data and provide recommendations, which significantly reduces the time and errors associated with the human factor [5].

The development of such systems requires a clear understanding of the domain area in which they are applied, as well as the ability to accurately formulate requirements for solving problems. The key components of an effective expert system are a knowledge base that includes facts and rules, an inference engine that uses this knowledge to draw conclusions, and a user interface that allows end users to easily interact with the system [6].

The processes that arise when solving problems in the social sphere are extremely important for research [7], especially when it comes to the problem of selecting recipients of social services [8, 9]. This issue deserves special attention because of its social significance and complexity, as well as the impact it has on the lives of individuals and communities in general. The process of selecting recipients includes the analysis of a large number of variables, such as socio-economic status, health, age and other critically important parameters that require accurate assessment and objectivity.

One of the key aspects is the development and implementation of fair and transparent mechanisms for assessing the needs and priorities of potential recipients. This includes creating complex criteria and algorithms that can effectively process input information and generate informed decisions. The importance of scientific research in this area also lies in the identification and elimination of systemic prejudices and shortcomings that may unconsciously affect the selection process, distorting its fairness and efficiency.

The aim of the research is the development of instrumental means to increase the efficiency of decision-making processes in the selection of recipients of social services. The main hypothesis of the research is the design mechanisms of systems for semi-automated selection of recipients of social services, the use of which will make it possible to configure such systems according to the specifics of the task. The practical value is that automating part of the decision-making process can help avoid the human errors and subjectivity that sometimes affect manual processes. The system can analyze large amounts of data and determine the suitability of candidates according to pre-established criteria, providing greater accuracy in determining the legitimacy of the selection.

2. Materials and Methods

The object of research is the decision-making process in the context of selecting recipients of social services using a semi-automated expert system.

In order to effectively conduct the research, the market of social services, the peculiarities of the interaction of various actors in this market, regulations and restrictions were analyzed.

In the course of the research, a systematic approach was used, which made it possible to make it effective and relevant to the problems under investigation.

3. Results and Discussion

3.1. Formalization of the task of selecting recipients of social services. The task of selecting recipients of social services is to identify and classify individuals or groups that meet certain criteria in order to gain access to various social resources and services. Such criteria include social benefits, housing programs, medical care, educational programs, and support in special circumstances.

Let's present the task of selecting recipients of social services as the task of forming a target group of persons (TG) from a set of given persons (O), or in other words, selecting such a subset from the input set of elements, the elements of which meet the previously set criteria [10]. Formally, this can be written as follows:

$$<O,C,R> \xrightarrow{\Omega} TG,\ TG \subseteq O, \quad (1)$$

where O – input set of objects; C – set of features that characterize these objects; R – rules for selecting objects in the target group; TG – target group; Ω – rule that specifies the sequence of stages of the decision-making process.

The task of the research is to build such a rule Ω, the implementation of which would allow in a semi-automated form, with minimal involvement of experts, to make effective decisions regarding the formation of the target group (1).

Let's present the rule Ω in the form of a tuple:

$$\Omega =< St_1, St_2, ..., St_K, DR >, \quad (2)$$

where St_k – the k-th stage of decision-making, $k=\overline{1,K}$, K – the number of stages; DR – decision-making rules at each of the stages and connections between stages.

Let's enter the notation:

– $O=\{O_1,O_2,...,O_N\}$ – input set of objects;

– $C=\{C_1,C_2,...,C_M\}$ – set of characteristics used to describe objects;

– $\overline{x}_i=(x_1^i,x_2^i,...,x_M^i)$, vectors that characterize the objects, where are the values of the feature C_j of the object O_i, $i=\overline{1,N}$, $j=\overline{1,M}$;

– $I\subseteq\{1,2,...,N\}$ – set of object numbers under consideration.

3.2. Development of components of the expert system for the subject area. The analysis of the subject area shows that when solving the problems of the social sphere, the decision-making process can be divided into successive stages, the scheme of which is presented in Fig. 1.

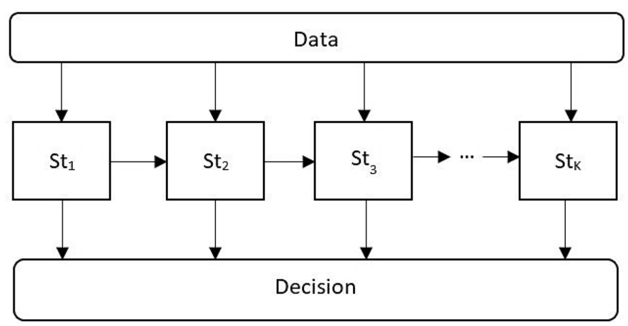

Fig. 1. Division of the decision-making process into components in tasks of the social sphere

As can be seen in Fig. 1, in the processes of selecting recipients of social services there are situations when decisions can be made at early stages, avoiding the involvement of additional stages. This allows to optimize and shorten the overall process. It is worth noting that the diagram in Fig. 1 may reflect a more complex structure with possible conditional ramifications.

The composition of decision-making stages for the creation of a target group can be carried out on the basis of components, the functional description of which is given below.

Blocks of automated decision-making

Decision making block type 1 «No». The block can be used to screen out objects that will definitely not belong to the target group based on at least one of the given characteristics. The production rule for the block operation is as follows:

$$\forall i \in I: \text{ if } \exists j \in J_1 : x_j^i \notin S_{1i} \text{ then } \overline{x}_i \notin TG, \quad (3)$$

where $J_1 \subseteq \{1,2,...,M\}, J_1 \neq \varnothing$, S_{1j} – set of admissible values of the j-th feature.

Decision making block type 2 «No». This block can be used to filter objects by a set of features. To build a production rule, the following functions are introduced:

$$\chi_j(\bar{x}_i) = \begin{cases} 1, \text{ if } x_j^i \in S_{2j}, \\ 0, \text{ otherwise,} \end{cases} j \in J_2, \quad (4)$$

where $J_2 \subseteq \{1,2,...,M\}$, $J_2 \neq \varnothing$; S_{2j} – set of admissible values of the j-th feature; $i \in I$.

The corresponding production rule for this block was constructed as follows:

$$\forall i \in I: \text{if } \sum_{j \in J_2} \chi_j(\bar{x}_i) \leq \Delta_2 \text{ then } \bar{x}_i \notin TG, \quad (5)$$

where Δ_2 – the integral threshold value of the checksum for Block 2.

Decision making block type 3 «Yes». The block is designed to make a decision on including the object in the target group based on a set of characteristics.

The production rules for this block are as follows:

$$i \in I: \text{if } \forall j \in J_3 \; x_j^i \in S_{3j} \text{ then } \bar{x}_i \in TG, \quad (6)$$

where $J_3 \subseteq \{1,2,...,M\}$, $J_3 \neq \varnothing$; S_{3j} – set of admissible values of the j-th characteristic.

Decision making block type 4 «Yes». The block is used to decide whether to include an object in the target set by the value of the objective function. To construct a production rule, consider a set of feature numbers $J_4 \subseteq J$ and set a function $\varphi_j(\bar{x}_i)$ for each, which, according to the given rule, translates the j-th value into a numerical normalized form. In the case when the component values are already numerical and normalized $\varphi_j(\bar{x}_i) = x_j^i$.

The production rule for a given block is as follows:

$$\forall i \in I: \text{if } \sum_{j \in J_4} \alpha_j \varphi_j(\bar{x}_i) \in S_4 \text{ then } \bar{x}_i \in TG, \quad (7)$$

where α_j – the given numerical values of the weighting coefficients of the corresponding features in the target function, $j \in J_4$; S_4 – numerical interval that specifies the permissible value of the objective function.

Decision making block type 5 «No». The block is intended for use in screening out objects that do not belong to the target group by the value of the target function. Similarly, to how it is implemented in block 4, a set of feature numbers $J_5 \subseteq J$ is specified and for each $j \in J_5$ a function $\varphi_j(\bar{x}_i)$ is defined, which, according to the given rule, translates the j-th value into a numerical normalized form. In the case when the component values are already numerical and normalized $\varphi_j(\bar{x}_i) = x_j^i$. Then the production rule can be constructed as follows:

$$\forall i \in I: \text{if } \sum_{j \in J_5} \beta_j \varphi_j(\bar{x}_i) \notin S_5 \text{ then } \bar{x}_i \notin TG, \quad (8)$$

where β_j – the given numerical values of the weighting coefficients of the corresponding features in the target function, $j \in J_5$; S_5 – numerical interval that specifies the permissible value of the objective function.

Decision making block type 6 «Yes-No». The block is intended for making a final decision on whether or not the object belongs to the target group. This block completes the decision-making process. Let's consider a set of feature indices $J_6 \subseteq J$ and, similarly to the previous blocks, set the function $\omega_j(\bar{x}_i)$ for each feature. Then, the production rule for making a decision is as follows:

$$\forall i \in I: \text{if } \sum_{j \in J_6} \gamma_j \omega_j(\bar{x}_i) \in S_6 \text{ then } \bar{x}_i \in TG \text{ else } \bar{x}_i \notin TG, \quad (9)$$

where λ_j – the given numerical values of the weighting coefficients of the corresponding features in the target function, $j \in J_6$; S_6 – numerical interval that specifies the permissible value of the objective function.

Expert blocks of decision-making

Expert blocks implement semi-automated decision-making. During the operation of these blocks, the conclusions of competent experts are processed and a decision is made regarding the inclusion or exclusion of the object in the target group. Experts provide their conclusions based on personal analysis of input data, conducting additional actions to obtain missing data. Such expert actions, as a rule, require additional time and other resources.

According to what decisions can be made by these blocks, they are divided into three types:

– expert decision-making block type 1 «Yes», which allows to make decisions about the inclusion of the object in the target group;
– expert decision-making block type 2 «No», which allows to make decisions about not including the object in the target group;
– expert decision-making block type 3 «Yes-No», which allows to make decisions both about the inclusion of the object in the target group and about its non-inclusion.

Thus, the Expert decision-making block type 3 is the final block in the decision-making process.

3.3. Discussion of the research results. The development of an expert system for semi-automated decision-making in the tasks of selecting recipients of social services consists in the logical integration of the various modules described above, according to the logic of the decision-making process. Each module has two outputs: one output forms a ready-made solution, suspending further processing of object data, while the second output allows the transition to the next module. One of the advantages of such expert systems is the ability to selectively analyze a large number of objects, allowing at each stage to filter out those that do not require further consideration, which can significantly reduce decision-making time.

This framework allows organizations to manage information flows and resources more efficiently, reducing the risk of system overload and improving overall service quality. In addition, the automation of some components of the decision-making process contributes to the unification of evaluation approaches and methods, providing more stable and predictable results.

Thanks to such a system, it is possible to immediately implement changes in the selection criteria or the decision-making process based on the gained experience and feedback. This ensures the flexibility of the system and its ability to adapt to changing conditions and needs of society. For example, in the case of social services, the system can quickly respond to changes in legislation or changes in public health priorities, ensuring that services meet the current needs of the population.

One of the main limitations of the study may be the insufficient or low quality of the input data that is required for analysis and decision making. Incomplete, out-of-date, or inaccurate data can negatively impact research results and system performance. Also, privacy, ethics and legal compliance issues, especially in areas related to personal data and social security, may limit the scope of research and use of systems. It is important to ensure that the system complies with all regulatory requirements and data protection principles.

The next stage of research on a semi-automated decision-making system for selecting social service recipients may include several key areas for deepening understanding and optimizing the system, including expanding the implementation of the development.

4. Conclusions

The research focuses on the creation of a universal tool for the development of expert systems in the social sphere. The main goal of such systems is the possibility of semi-automatic analysis of large volumes of data in order to effectively filter out the necessary information and optimize decision-making processes. Within the framework of the study, an analysis of decision-making processes in the social sphere was carried out and typical components of decision-making support systems were developed. By considering the task of forming groups of recipients of social services, the method of building the logical structure of the expert system is shown. The result is a convenient and easy-to-use approach. The software product developed on its basis can be used by social workers without the need to involve analysts. The general analysis of the developed universal tool for designing expert systems in the social sphere confirms its effectiveness and potential for further application. The research results show that the use of such a system can significantly facilitate the processes of data analysis and decision-making in the social sphere. Further research and improvement of this tool can contribute to improving the quality of social service provision and optimization of resources in the social sphere. Being accessible and easy to use, this tool has the potential to be a valuable asset for institutions and professionals in the social sphere in making informed and effective decisions in the process of providing social assistance.

Conflict of interest

The author declares that he has no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the study and its results presented in this paper.

Financing

The study was performed without financial support.

Data availability

The paper has no associated data.

Use of artificial intelligence

The author confirms that he did not use artificial intelligence technologies when creating this work.

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