Information Technology Development for Social Services Consumers' Choice

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Abstract

The problem of processing and analyzing data in selecting consumers for the provision of social services is considered. The specifics of the actors' interaction in determining the rules and limitations for such analysis are identified.

Methods and algorithms for data analysis that can be used to select or filter out potential consumers of social services are developed. The algorithm of the developed combined method of calculating scores to form a set of social service consumers based on the analysis of their socio-demographic portraits is illustrated. The algorithm of the adapted fuzzy consumer selection method using the procedure of fuzzy logical inference is presented.

Keywords

Conceptual scheme of data processing, methods of filtering and selection, product rules, fuzzy inference, linguistic variables

1. Introduction

Digitalization in Ukraine and the world is accelerates [1]. For example, in the European Union, 25 national plans focused on Industry 4.0 are being developed between 2011 and 2022 [2]. Industry 4.0 itself is characterized by information technology used to process a large amount of data required to control automated production [3]. Industry 5.0, extending beyond the production of goods and services for profit, encourages to combine human intelligence, and creativity with the capabilities of technology [4]. Digitalization is spreading to more and more areas, including the social sphere. For example, in Ukraine, the Unified Portal of Public Services [5], launched in 2019, is designed to allow citizens to communicate with the state, receive public services, education, etc. The electronic healthcare system eHealth [6] was introduced in 2016 and is a multi-component information and telecommunication system that automates the record keeping of medical services and management of medical information in electronic form. These and other innovations, which have been successfully implemented in various areas of human activity, demonstrate the success of the digitalization process and the need to continue it.

Thus, the development and implementation of information technologies to automate processes in the social sphere and beyond is an urgent and priority interdisciplinary task. Representatives of various spheres of human activity are involved in its solution. The effectiveness of decisions made on their basis depends on their adequacy of relevance to real processes. A large number of scientific works are devoted to the study of this problem.

Thus, in [7, 8] the introduction of digital technologies into the activities of various business entities is analyzed. The positive and negative effects of digitalization are noted. Despite the dynamic development of the social sphere, the appearance of new actors, requests, and services motivates researchers to develop new approaches and tools for organizing and processing data in it [9, 10, 11]. Many modern scientific studies are devoted to analyzing and solving problems in the economic sphere

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through information technology [12-14]. Scientists are also deeply studying the problems that occur in the medical field [15, 16], etc. This study is devoted to the problem of data analysis and processing in the process of social services provision [17]. Providers of such services are public, social institutions whose activities are aimed at ensuring the interests of citizens. The main risks of their activities lie in the threat to commit damage to service recipients and the social environment in which they live [9]. One of the most important problems is the consumer selection problem for the social services provision. To reduce the probability of these risks, it is important to develop relevant methods, models, and tools for data and knowledge processing to improve the efficiency of decision-making processes in this area. ***The aim of this study*** is to develop information technology for the automated selection of social services consumers based on product rules and fuzzy inference methods.

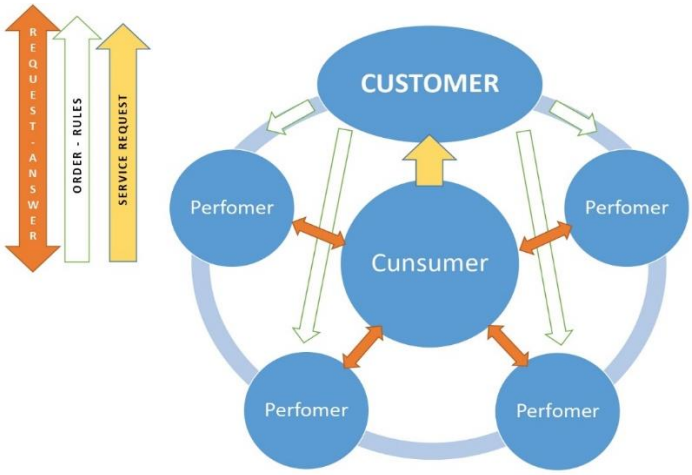
2. Some aspects of social service delivery processes

2.1. Analysis of actors' interaction in social service delivery processes

The article considers the processes of data analysis that take place in the market of social services provided by public organizations to the relevant consumers. This market is characterized by a continuously expanding list of consumer categories, as well as an increasing number of potential consumers of services. For effective interaction, experts from government agencies, local governments, and non-governmental organizations should form a bank of social services based on the monitoring and public surveys conducted. It is also necessary to develop tools to ensure the availability of effective public services for the requestor, taking into account the capabilities of all subjects (actors). There are three main actors in this process:

- Service consumers are individuals who, according to their socio-demographic profile, medical history or other personal characteristics, may be eligible for social service;
- non-governmental organizations, whose employees directly provide social services, draw up a comprehensive and goal-oriented (specific) work plan, monitor the appropriate service market, engage the necessary resources (human and material) and direct them to achieve the goals ("execution of the order");
- Customers are the state, regional public authorities, and territorial communities that provide legislative, organizational and managerial, tax and financial, and other support, i.e. organize the process of service provision, regulate service provision processes in accordance with the law, partially or fully pay for services, provide (control) restrictions, rules for selecting consumers, etc.

The interaction between the main actors of the process is shown in Fig. 1.



Consumer – recipient of the service; **Customer** – authorities, the state;
Perfomer – non-governmental organization.

Figure 1: Scheme of factors interaction in the processes of social services provision

As can be seen from Figure 1, consumers make requests for the relevant services to the main customer, who sends the task to the contractors for consideration. In turn, the processes of service provision are regulated by the customer - the government authority.

At the same time, the following cases may occur, which require additional analysis for effective interaction of the mentioned actors:

1. The number of simultaneous requests for the same type of services may limit the contractor's ability to provide quality, efficiency and effectiveness. In this case, there is a problem of making a decision on filtering out potential service consumers, additional involvement of contractors or modification of the services in order to ensure the continuity of the service provision process.

2. Service consumers do not fully or partially fulfill the criteria established by the customer. Management decisions regarding such consumers can range from rejection - their final elimination from the service provision to adaptation - full or partial involvement by changing certain (rather than principal) criteria that consumers must fulfill.

Given that the considered processes take place primarily in large territorial communities, settlements, and entire regions, such cases can occur frequently, so it is important to develop tools for automated development of possible management solutions for them.

2.2. The problem of consumer choice in the provision of social services

The article considers the problem of selecting consumers who will be provided with services from the list of potential consumers. Management decisions on the selection of consumers take place both in the case when all requests for services cannot be satisfied due to the large number, and also when not all consumers fulfill the criteria established by the customer.

Consider the problem of selection of the consumers to be provided with services from a given list in the following aspects:

- the problem of determining whether a person who is a potential consumer of a social service fullfils the criteria for its provision;
- the problem of ranking service consumers in accordance with the priority of its provision in the case when the number of consumers exceeds the possible scope of service provision.

At first thought, the aforementioned selection problem can be partially formulated as a pattern-matching problem [18]. However, it is important to understand that consumers of different categories can request the same service, which are generally incomparable. Thus, if the total number of potential consumers is large enough, it is not enough to match the sample to decide about the service.It is necessary to develop additional mechanisms for numerical assessment of the potential consumer's characteristics and to bring the scores for various characteristics to a universal scale to further rank or classify them by priority of service provision. It is also worth noting that, in addition to the criteria that consumers must fulfill, the service customer may provide additional conditions for the provision of services, such as the minimum volume of services to be provided to certain categories of consumers, the percentage of services provided to consumers of different categories, etc.

All these arguments and the analysis of the relevant decision-making processes show that when designing an information technology for automated consumer selection, it is necessary to ensure the ability to solve the following tasks: classification [19], comparison with a sample [18], ranking [20], numerical object evaluation [21], etc. However, since the final decision on the consumers' selection for the provision of the relevant service is made by a person ("coordination center") who makes the decision taking into account the existing limitations and rules, the technology of automated consumer selection should have a flexible structure, be scalable and adaptable (it can be an online questionnaire or online selection). At the same time, the selection criteria should be quite clear indicators that are the basis for setting standards for the provision of relevant services and that can be used to predict how well the consumer's data, the services requested and received, fulfill them.

3. Design of information technology components

3.1. Conceptual scheme of data processing in the selection of social service users

The aim of developing an information technology for automated selection of social services consumers is to process data and knowledge to improve the efficiency of decision-making processes in

the social sphere. In this context, efficiency improvement will be understood as the development and application of such universal and unified tools for analyzing socio-demographic portraits of potential service users that would allow the system to be customized to the specifics, rules and limitations provided by the customer. These features include:

- the ability to set several different standard socio-demographic portraits for consumers of the same service;
- ensuring compliance with quotas on the number of consumers with certain specified characteristics, etc.

Given that the initial data, depending on the type of social service, may have a different nature, format, and content, and that knowledge may take the form of product rules, numerical limits, etc., the information technology for automated selection of social service users must be flexible and multifunctional. Data will be processed in several stages. The sequence and number of stages should be determined depending on the characteristics of the input data and the knowledge received from the service customer. The conceptual scheme of data processing is shown in Fig. 2

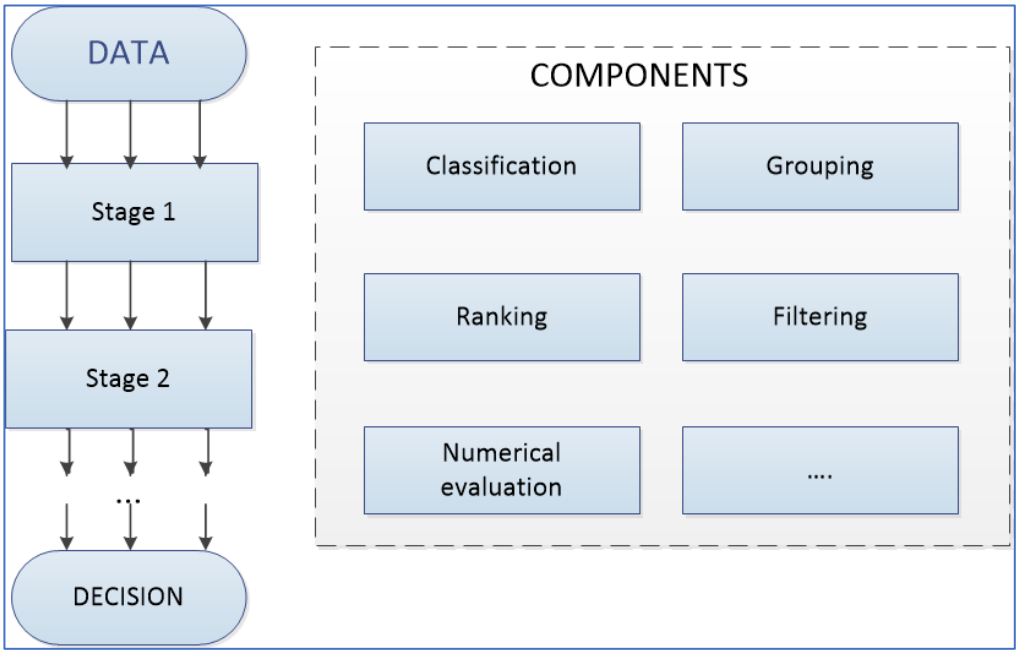


Figure 2: Data processing scheme for the selection of social services consumers

As can be seen from Figure 2, information technology is based on a library of methods and algorithms designed to process data and solve relevant problems (classification, filtering, ranking, etc.). Customizing the data processing process for a particular situation will involve building a sequence of blocks to analyze input data and develop management decision options. Although the blocks are arranged linearly in the diagram, the decision to filter out or select a consumer can be made at any stage of data processing. This approach makes information technology flexible, universal and open to improvement [22]. Thus, the main stage of designing an information technology is the selection, adaptation and development of new models, methods and algorithms relevant to the tasks to be implemented in the relevant blocks.

3.2. Formalization of the problem and development of methods for processing data on social service consumers

The article considers the problem of choosing social service consumers, taking into account their socio-demographic portraits and the rules established by customers, experts, regulations, etc. Let us formalize the problem of choosing services consumers as follows.

Let there be a service *S*, which can be provided in the volume of $NS_{\max}$.

Let the service *S* receive requests from *N* consumers, defined by cs_i. We define the set of consumers by $CS = \{cs_1, cs_2, ..., cs_N\}$. Each consumer of services is characterized by a vector of feature values $X^{(i)} = (x_1^i, x_2^i, ..., x_M^i)$, where *M* is the number of features, x_j^i is the value of the feature with number *j* for consumer cs_i. In the case when $N > NS_{\max}$ it is necessary to select those consumers who will be provided with the service. The selection can be carried out in several stages, taking into account the category of consumers and the set of values of their feaches.

To process data on social services consumers, in addition to the well-known methods of data preprocessing [23], classification methods [19], matching with a sample [18], ranking [20], and numerical evaluation of an object [21], it is proposed to use the following groups of methods.

1. Methods of filtering out consumers from consideration:

1.1. Filtering out consumers for non-compliance with the requirements.

Let's define the criteria for a consumer's eligibility to receive a given service. Let's form the criteria in the state of sets of values for each feature. Let's denote by SI_j - the set of values of the *i*-th feature acceptable for receiving this service. These sets can be specified both by a direct list of their elements and by a system of mathematical relations.

If there are no initial limits for some feature, the corresponding set will be empty.

The method consists in filtering out consumers who do not fulfill the requirements according to the following rule:

$$\forall i = \overline{1,N}: \ if \ \exists j \in \{1,2,...,M\}: SI_j \neq \varnothing \ and \ x_j^i \notin SI_j \ \ then \ CS := CS \setminus \{cs_i\} \quad (1)$$

Let's label $N = |CS|$ and renumber all consumers with numbers from 1 to *N*. We will do the same after each filtering and in the following rules.

1.2. Matching with a sample.

The method is a generalization of the method of filtering out for non-compliance with the requirements (1) and can be used when consumers of different categories can apply for a given service.

For each category of consumers, we define a vector $\overline{SI^k}$, whose elements are the sets of permissible values of the features. That is, $\overline{SI^k} = (SI_1^k, SI_2^k, ..., SI_M^k)$, where SI_j^k is the set of permissible values of the feature number *j* for the category of persons with number *k*, and if the value of the *j*-th feature is not important for the category of consumers *k*, then $SI_j^k = \varnothing$, $k = \overline{1,K}$. Then, the filtering of consumers based on the results of comparison with the sample is carried out according to the following rule:

$$\forall i = \overline{1,N}: \ if \ \bar{\exists} k \in \{1,2,...,K\}: \forall (j = \overline{1,M}, \ SI_j^k \neq \varnothing) \ x_j^i \in SI_j \ \ then \ CS := CS \setminus \{cs_i\} \quad (2)$$

1.3. Filtering by scoring

This method is based on a method similar to the one described in [24]. The method algorithm consists of the following steps.

Step 1. Define a system of functions (3) that assigns a nonnegative integer weight to each value from the set of valid values SI_j^k:

$$\chi_j^k : S_j^k \to ¥ \cup \{0\}, \ k = \overline{1,K}, \ j = \overline{1,M}. \quad (3)$$

For all consumers, do steps 2 and 3.

Step 2. For a consumer, we calculate their score in each category (4):

$$SR_i^k = \begin{cases} \sum\limits_{j=\overline{1,M}: SI_j^k \neq \varnothing} \chi_j^k(x_j^i), \ if \ \bar{\exists} j \in \{1,2,...,M\}, SI_j^k \neq \varnothing : x_j^i \notin SI_j^k, \\ 0, \qquad otherwise, \end{cases}, \ k = \overline{1,K}, \quad (4)$$

Step 3. Calculate the resulting consumer score using (5):

$$SR_i = \max_{k=\overline{1,K}} (SR_i^k) \quad (5)$$

Step 4. Apply one of the Rules to filter out consumers.

Rule 3.1. By threshold*:*

$$\forall i = \overline{1,N}:\ if\ \ SR_i < SR_{\min}\ \ then\ CS := CS \setminus \{cs_i\}, \tag{6}$$

where $SR_{\min}$ is a nonnegative value of the permissible threshold of the resultant score.

Rule 3.2. By the average score:

$$\forall i = \overline{1,N}:\ if\ \ SR_i < SR_{avg}\ \ then\ CS := CS \setminus \{cs_i\}, \tag{7}$$

where SR_{avg} calculates by (8)

$$SR_{avg} = \frac{1}{N}\sum_{i=1}^{N} SR_i\ . \tag{8}$$

2. Methods of consumer selection.

2.1. Selection of consumers by compliance with the requirements.

A method similar to the method of filtering out for non-compliance. The rule for this method is as follows:

$$\forall i = \overline{1,N}:\ if\ \ \forall j = \overline{1,M},\ SI_j \neq \varnothing : x_j^i \in SI_j\ \ then\ W := W \cup \{cs_i\},\ CS := CS \setminus \{cs_i\}, \tag{9}$$

where W is the set of winners, i.e., persons selected to provide services (initially $W = \varnothing$).

2.2 Matching the model.

Let each category of consumers be given an "ideal portrait" of a consumer to whom the service is guaranteed. Similarly to the pattern matching method, we introduce notation. For each category of consumers, we define a vector $\overline{SI^k}$, whose elements are sets of desired values of the features. That is, $\overline{SI^k} = (SI_1^k, SI_2^k, ..., SI_M^k)$, where SI_j^k is the set of desirable values of the feature number *j* for the category of persons with number *k*, and if the value of the *j*-th feature is not important for the category of consumers *k*, then $SI_j^k = \varnothing$, $k = \overline{1,K}$. Let's construct a consumer selection rule in the form (10).

$$\begin{aligned} &\forall i = \overline{1,N}:\ if\ \ \exists k \in \{1,2,...,K\} : \forall (j = \overline{1,M},\ SI_j^k \neq \varnothing)\ x_j^i \in SI_j \\ &\qquad then\ W := W \cup \{cs_i\},\ CS := CS \setminus \{cs_i\}. \end{aligned} \tag{10}$$

Using rule (10), it is possible to divide potential consumers into groups by priority. To do this, it is enough to change the concept of "consumer category" to "consumer priority". After such a division, it is reasonable to conduct further research for each group separately, taking into account the quotas and standards received from the service customer.

2.3 Selection by scoring.

In this method, similarly to method 1.3, we build a rule for selecting consumers whose total score exceeds a given threshold $\overline{SR}$ in the form (11):

$$\forall i = \overline{1,N}:\ if\ \ SR_i \geq \overline{SR}\ \ then\ W := W \cup \{cs_i\},\ \ CS := CS \setminus \{cs_i\}. \tag{11}$$

Similarly to (10), rule (11) can also be used to categorize potential service consumers.

3. Combined scoring method

The method is similar to [25]. We assume that all consumers belong to the same category, and their features are ordered in descending order of importance in making decisions about providing a service to a consumer. Then, similarly to (3), define the system of functions (12).

$$\varphi_j : S_j \to R,\ \ j = \overline{1,M}\ . \tag{12}$$

Let Sum_i is the cumulative value of the sum of score for the consumer cs_i, W is the set of winners, i.e., the persons selected to provide the service (initially $W = \varnothing$).

Let the decision maker, based on other studies and considerations, set two thresholds for the sum:

$\overline{Sum}$ is the smallest value of the sum of scores that is sufficient to provide the service to the consumer;

$\underline{Sum}$ is the highest value of the sum of scores, which is sufficient to decide not to provide the service to the consumer.

Then we will build the algorithm of the method in the form of the next procedure. For each consumer cs_i, we will perform the next steps.

Step 1. Set the initial values of $Sum_i = 0$, $j = 0$.

Step 2. $j := j + 1$, $Sum_i := Sum_i + \varphi_j(x_j^i)$.

Step 3. Check the condition (13):

$$if\ \ Sum_i \geq \overline{Sum}\ then\ W := W \cup \{cs_i\},\ CS := CS \setminus \{cs_i\}. \tag{13}$$

If condition (13) is true, that is, a decision is made to provide the service to this consumer, and the procedure is stopped for him. Otherwise, go to Step 4.

Step 4. Check if condition (14) is true:

$$if\ \ Sum_i \leq \underline{Sum}\ then\ CS := CS \setminus \{cs_i\}. \tag{14}$$

If condition (14) is true, the consumer is filtered out of consideration and the procedure is completed. Otherwise, proceed to step 5.

Step 5. If $j < N$, then go to Step 2, otherwise, conclude that it is impossible to make a decision on this consumer according to this procedure.

4. Fuzzy method of consumer selection

This method is based on the analysis of the socio-demographic portrait of a potential consumer of social service and its comparison with linguistic variables that describe the degree of a person's belonging to the set of consumers *W* selected for the provision of the service.

The algorithm of the method is as follows. At the initial stage, let's fix $\Delta \in (0;1)$ is the threshold of the belonging function for the degree of a person's belonging to the set *W*.

Step 1. Organize the features that are used to evaluate individuals according to their impact on the formation of the socio-demographic portrait of the service consumer and build a hierarchy of features. Note that the *L*-th level of the hierarchy includes features that satisfy condition (15):

$$I_L = \left\{ X_j \mid r_j = \max_{\substack{t=\overline{1,M} \\ K_t \notin I_j, \forall l \in \{1,2,\ldots,L-1\}}} (r_t),\ j = \overline{1,M} \right\}. \tag{15}$$

where r_j is the rank of the feature X_j is predefined by the service customer.

Step 2. Based on the data obtained from the expert surveys, build a fuzzy knowledge base for the features of the first level of the hierarchy from the rules of the formula (16):

$$if\ \ x_1 \in A_{11}^{\tau_1},\ and\ x_2 \in A_{12}^{\tau_1},\ \ldots,\ and\ x_{T_1} \in A_{1T_1}^{\tau_1},\ then\ y \in C^{\tau_1}, \tag{16}$$

where τ_1 is the number of rules in the fuzzy knowledge base for the features of the first level of the hierarchy; T_1 is the number of features at the level I_1; x_i is input variables; *A* is belonging functions; functions $C^s : [0,1] \to [0,1]$, $s = \overline{1,\tau_1}$.

Step 3. For each consumer, find the degrees of truth of the corresponding functions: $A_j^s(x_j^i)$, $s = \overline{1,\tau_1}$, $j = \overline{1,T_1}$.

Perform the procedure of logical data output and composition of fuzzy sets [26].

$$\alpha_{si} = A_{11}^s(x_1^i) \wedge A_{12}^s(x_2^i) \wedge \mathrm{L}\ \wedge A_{1T_1}^s(x_{T_1}^i),\ s = \overline{1,\tau_1}, \tag{17}$$

$$C^{si}(y) := \alpha_{si} \wedge C^s(y),\ s = \overline{1,\tau_1},. \tag{18}$$

$$\mu_C^i(y) = C^{1i}(y) \vee C^{2i}(y) \vee \mathrm{L}\ \vee C^{\tau_1 i}(y),. \tag{19}$$

Calculate the values of the interval limits according to the following rules:

$$a_1^i = \min_{y\in[0,1]}\left\{y|\ \mu_C(y)=\mu_C(0),\ \forall\varepsilon>0\quad \mu_C(y+\varepsilon)<\mu_C(0)\right\}. \tag{20}$$

$$b_1^i = \max_{y\in[0,1]}\left\{y|\ \mu_C(y)=\mu_C(1),\ \forall\varepsilon>0\quad \mu_C(y-\varepsilon)<\mu_C(1)\right\}. \tag{21}$$

As a result of the calculations for each object, the interval of scores $\left(a_1^i, b_1^i\right)$ is obtained.

Step 4. Exclude from consideration persons for which $b_1^i < \Delta$. If all persons are excluded, the algorithm stops working.

Step 5. Repeat steps 2-4 for the features of the next hierarchy levels. When switching between iterations, match the evaluation intervals according to predefined rules.

After completing the iterations, for each person remaining in the consideration, determine the resulting belonging function of the fuzzy set, which characterizes the degree of its belonging to the set *W* according to the following rule:

$$\mathrm{C}^{\mathrm{si}}(y) := \begin{cases} C^s\left(a^i\right),\ if\ y\in\left[0,a^i\right], C^s(y)>\mathrm{C}^{\mathrm{s}}(y+\varepsilon), \varepsilon>0, \\ C^s\left(b^i\right),\ if\ y\in\left[b^i,1\right], C^s(y)>C^s(y-\varepsilon), \varepsilon>0, \\ C^s(y),\ otherwise. \end{cases} \tag{22}$$

$$\mu_C^i(y) = C^{1i}(y)\vee C^{2i}(y)\vee \mathrm{L}\ \vee C^{\tau_L i}(y). \tag{23}$$

Next, defuzzify the fuzzy sets using the formula:

$$\overline{\mu}_i = \frac{\int_0^1 y\mu_C^i(y)dy}{\int_0^1 \mu_C^i(y)dy}. \tag{24}$$

Then, for individuals with $\overline{\mu}_i \geq \Delta$, conclude that $cs_i \overset{\overline{\mu}_i}{\in} W$; for individuals with $\overline{\mu}_i < \Delta$, conclude that $cs_i \notin W$. That is,

$$\mu(O_i) = \begin{cases} \overline{\mu}_i,\ for\ person\ who\ are\ still\ in\ processing, \\ 0,\ \ for\ person\ who\ are\ filtering. \end{cases}. \tag{25}$$

To build the fuzzy knowledge base (16), it is proposed to use the following algorithm:

Let there be a set of features $\{X_1, X_2, ..., X_T\}$ that form the socio-demographic portrait of a person.

Step 1. Constructing linguistic variables for each feature from the set of features.

Step 2. Constructing the linguistic variable "Degree of belonging to the set of consumers". It is proposed to use the fuzzy subsets C_1 = "High degree of belonging to the set of consumers", C_2 ="Low degree of belonging to the set of consumers". Build membership functions for such fuzzy sets as follows:

$$\mu_{C_1}(u) = \begin{cases} 0, & if\quad 0\leq u\leq a, \\ 2\left(\dfrac{u-a}{1-a}\right)^2, & if\ a<u\leq\dfrac{a+1}{2}, \\ 1-2\left(\dfrac{1-u}{1-a}\right)^2, & if\ \dfrac{a+1}{2}<u\leq 1. \end{cases} \tag{26}$$

$$\mu_{C_2}(u) = \mu_{C_1}(1-u). \tag{27}$$

where *a* is a fixed parameter, $a\in(0,1)$.

Step 3. Interviewing experts by including potential rules of the fuzzy knowledge base in the expert questionnaire.

Step 4. Calculating the total rank of the rules that the experts marked as correct, and then including those rules in the fuzzy knowledge base whose total rank exceeds a fixed value.

In accordance with the algorithm described above, the rules for matching the intervals of scores obtained at different levels of the feature hierarchy play an important role.

Suppose that for the upper level of the feature hierarchy with rank η_1, an interval of scores (a_1, b_1) was obtained for the next level with rank η_2 – (a_2, b_2). Then the limits of the agreed interval (a, b) can be calculated according to one of the next heuristics (28)-(30):

$$b := \max(b_1, b_2),\ a := \max(a_1, a_2)\ .. \tag{28}$$

$$b := b_1 - (b_1 - b_2)\frac{\eta_2}{\eta_1},\ \ a := a_1 - (a_1 - a_2)\frac{\eta_2}{\eta_1}. \tag{29}$$

$$a := \min(a_1, a_2),\ \ b := \max(b_1, b_2)\ .. \tag{30}$$

4. Experimental results and evaluations

To demonstrate the results of using the developed methods and approaches, let us consider a simplified case. Let's assume that consumers can be provided with the social service "Psychological counseling for internally displaced persons", which is provided to people who were forced to leave their homes and move to safer areas due to the fighting in Ukraine.

To analyze the service, the customer selected the features of the socio-demographic portrait of such persons and built the corresponding linguistic variables (Table 1).

Table 1

Features of a socio-demographic portrait and their linguistic variables

Characteristic (Name of the linguistic variable)	Sets of valid values of the characteristic	Terms
Where did they come from	Localities of Ukraine	From a dangerous neighborhood, From a conditionally safe area, From a safe area
Duration of stay in safety	Time period	Long-term, short-term
Feeling of safety	Stable, unstable, partial, absent	Yes, No
Contacting a psychologist	For the first time, systematic	Yes, No
Contacts with family members	Living with relatives, complete loss of contacts, partial communication	Yes, No
Take out children	Number of children	Number
Brought pets with them	Number of pets	Number

The membership functions of the terms of the linguistic variables were specified in the table as shown in Table 2.

Table 2

The membership function of the terms of the linguistic variable "Sense of safety"

Terms	Value			
	None	Unstable	Partial	Stable
Yes	0	0,3	0,5	1
No	1	0,7	0,2	0

In accordance with the customer's settings, the processing of input data for the selection of service consumers should take place in two stages, as shown in Figure 3.

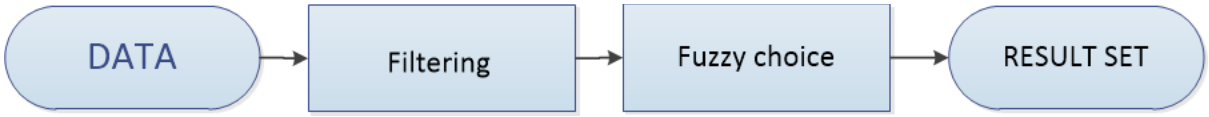


Figure 3: Data processing scheme for the service "Psychological counseling for internally displaced persons"

Thus, in accordance with Table 2 and Fig. 3, at the first stage, the sets of features of potential consumers are analyzed and those that do not fulfill the specified requirements are filtered out, that is, the values of the features go beyond the sets of acceptable values. At the second stage, a fuzzy selection method is used to build a fuzzy set of social service consumers.

5. Conclusions

In this paper, the methods and algorithms that underlie the information technology of automated selection of social services consumers are analyzed and developed. The specifics of the processing and analysis of potential clients' personal data during the selection of social services consumers were analyzed. The proposed conceptual scheme of data processing provides a flexible and scalable structure. These properties make the developed information technology more universal and comfortable for editing.

Several groups of methods for analyzing data on potential customers have been developed: customer filtering methods, customer selection methods, and a combined scoring method. All the developed methods allow taking into account the requirements and limitations of social services customers and forming a set of consumers to whom these services will be provided.

Screening methods allow for the initial stages of data analysis to exclude from consideration those individuals who do not fulfill the initial requirements for receiving the service in question.

In turn, consumer selection methods should be applied at the next stages to rank potential consumers or form the resulting set of consumers.

The developed fuzzy method of consumer selection for each potential consumer allows to calculate their degree of belonging to the resulting set based on the results of the socio-demographic portrait analysis.

The choice of methods and the construction of the data analysis sequence depends on the specifics of the social service and the limitations received from the customers of such services [27, 28].

6. References

[1] H. Zhosan Development of digitalization in Ukraine. Ekonomichnyy analiz, 30(1 (2)), 2020, pp. 44-52.
[2] J. E. Teixeira, A. T. C. Tavares-Lehmann, Industry 4.0 in the European union: Policies and national strategies. Technological Forecasting and Social Change, 180 (2022) 121664.
[3] P. Marinič, P. Pecina, Industry 5.0 in Vocational Education. In INTED2023 Proceedings, 2022, pp. 3805-3811.
[4] D. G. BrooKaynak, S. M. Sait Rethinking engineering education at the age of industry 5.0. Journal of Industrial Information Integration 25 (2022) 100311.
[5] State services online, 2023. URL: https://diia.gov.ua/
[6] Electronic healthcare system in Ukraine, 2023. URL: https://ehealth.gov.ua/
[7] M. Lupei, M. Shlahta, O. Mitsa, Y. Horoshko, H. Tsybko, V. Gorbachuk, Development of an Interactive Map Within the Implementation of Actual State and Public Directions. In 2022 12th International Conference on Advanced Computer Information Technologies (ACIT), (2022). 384-387. IEEE.
[8] U. Brinkmann, H. Heiland, M. Seeliger, Corporate public spheres between refeudalization and revitalization. Theory, Culture & Society, 39(4), (2022), 75-90.

[9] Gu Bingmei, Liu Jiaguo, Ji Qiang. The effect of social sphere digitalization on green total factor productivity in China: Evidence from a dynamic spatial Durbin model. Journal of Environmental Management, 2022, 320: 115946.
[10] O. Mulesa, I. Myronyuk, O. Kachmar, F. Jakab and O. Yatsyna, "Decision-Making Modeling in Educational Process Organization Under the Conditions of Crisis Situations Forecasting," 2022 20th International Conference on Emerging eLearning Technologies and Applications (ICETA), 2022, pp. 460-465, doi: 10.1109/ICETA57911.2022.9974909.
[11] S. Dolgikh, O. Mulesa, "Covid-19 epidemiological factor analysis: Identifying principal factors with machine," CEUR Workshop Proceedings, vol. 2833, pp.114–123, 2021
[12] I. Yoo, C. G. Yi, Economic innovation caused by digital transformation and impact on social systems. Sustainability 14(5) (2022) 2600.
[13] X. Chen, Machine learning approach for a circular economy with waste recycling in smart cities. Energy Reports 8 (2022) 3127-3140.
[14] S. Giglio, B. Kelly, D. Xiu, Factor models, machine learning, and asset pricing. Annual Review of Financial Economics 14 (2022) 337-368.
[15] F.Salami, A. Bozorgi-Amiri, G. M. Hassan, R. Tavakkoli-Moghaddam, A. Datta, Designing a clinical decision support system for Alzheimer's diagnosis on OASIS-3 data set. Biomedical Signal Processing and Control 74 (2022) 103527.
[16] S. K. Khare, V. Bajaj, A hybrid decision support system for automatic detection of Schizophrenia using EEG signals. Computers in Biology and Medicine, 141 (2022) 105028.
[17] O. I. Borodkina, A.V. Starshinova, E. B. Arkhipova, Social investment: Problems and development strategies. Terra Economicus, 20(2) (2022) 6-31.
[18] W. Zheng, X. Tian, B. Yang, S. Liu, Y. Ding, J. Tian, L. Yin, A few shot classification methods based on multiscale relational networks. Applied Sciences 12(8) (2022) 4059.
[19] L. Guan, R. Tibshirani, Prediction and outlier detection in classification problems. Journal of the Royal Statistical Society. Series B, Statistical Methodology, 84(2) (2022) 524.
[20] G. Sun, M. Wang, X. Li, Centroid coordinate ranking of Pythagorean fuzzy numbers and its application in group decision making. Cognitive Computation 14(2) (2022) 602-623.
[21] H.C. Liu, H. Shi, Z. Li, C. Y. Duan, An integrated behavior decision-making approach for large group quality function deployment. Information Sciences 582 (2022) 334-348.
[22] O. Mulesa, O. Kachmar, I. Myronyuk, P. Horvat, T. Radivilova and Y. Kykyna, Designing Semi-Automated Decision-Making Expert Systems for Healthcare Tasks, 2022 IEEE 17th International Conference on Computer Sciences and Information Technologies (CSIT), 2022, pp. 235-238, doi: 10.1109/CSIT56902.2022.10000448
[23] T. A. Alghamdi, N. Javaid, A survey of preprocessing methods used for analysis of big data originated from smart grids. IEEE Access 10 (2022) 29149-29171.
[24] O. Mulesa, Methods of considering the subjective character of input data in voting. Eastern-European Journal of Enterprise Technologies, 1.3 (2015): 20-25.
[25] O. Mulesa, O. Yatsyna, O. Melnyk, I. Myronyuk, I. Povkhan, A. Batyuk. Prediction of the Occurrence of Threatening Conditions in Individuals as a Problem of Assigning an Object to a Class. In: 2022 IEEE 17th International Conference on Computer Sciences and Information Technologies (CSIT). IEEE, 2022. p. 332-335.
[26] S. Batubara, Analisis perbandingan metode fuzzy mamdani dan fuzzy sugeno untuk penentuan kualitas cor beton instan. IT Journal Research and Development 2(1) (2017) 1-11.
[27] Hnatiienko, H., Kiktev, N., Babenko, N., Desiatko, A., Myrutenko, L. Prioritizing Cybersecurity Measures with Decision Support Methods Using Incomplete Data. Selected Papers of the XXI International Scientific and Practical Conference "Information Technologies and Security" (ITS 2021), Kyiv, Ukraine, December 9, 2021. CEUR Workshop Proceedings, 2021, 3241, pp. 169–180.
[28] Palko, D.; Babenko, T.; Bigdan, A.; Kiktev, N.; Hutsol, T.; Kuboń, M.; Hnatiienko, H.; Tabor, S.; Gorbovy, O.; Borusiewicz, A. Cyber Security Risk Modeling in Distributed Information Systems. Applied Sciences (Switzerland) 2023, 13, 2393. https://doi.org/10.3390/app13042393