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An Approach to Managing Regional Socio-Economic Systems Based on Situational Precedent Models and Ontologies

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Abstract: Management efficiency improvement for regional socio-economic systems is a relevant task for the modern economy development and advancement. The main difficulty in solving this issue lies in the high degree of uncertainty in the operating conditions of these systems, arisen due to the need to ensure the interaction of a large number of its constituent elements in the absence of the information amount. In this regard, using traditional analytical and probabilistic-statistical management methods becomes difficult and determines the advisability of seeking and developing new approaches to solve the specified problem. To work with various types information coming from several sources, a fuzzy ontological model, where the relationships between concepts will be described using terms of fuzzy sets is proposed to be used. This model allows using the developed procedure to obtain a set of fuzzy situational features describing the current situation arisen in the regional socio-economic system. The resulting description is the input for the procedure of constructing a fuzzy situational-precedent model based on accumulated fuzzy situational precedents, being used in the implementation of an intelligent method for controlling the systems under consideration. An example for developed methods, procedures and algorithms implemented in the form of application software is given.

1 INTRODUCTION

At present, an important issue of the society development in conditions of a high level uncertainty and instability for both management and organizational processes that have a direct impact on the current state of the economy is the need for continuous improvement of regional socio-economic systems (RSES) considering the current situation and existing restrictions in order to summarize the accumulated positive experience in various areas of public life (Dolgih, Trubin, Trubina, Semenihina and Filimonova, 2023). At the same time, in the modern world there is a prevailing tendency to involve in economic activity an increasing number of interacting entities and resources, united by a complex structure of economic relations and social connections, which leads to a significant complication of these systems structures (Kulapov and Zhuravlev, 2024.). In practice, however, information about the functioning and states of the RSES can be presented in various modalities, resulting in situations where important characteristics of the systems under consideration can be described exclusively in the linguistic form. At the same time, the high degree of uncertainty in the functioning of the RSES, characterized by an insufficient amount of information in a poorly formalized and poorly structured form, which may contain distorted or contradictory data, also imposes restrictions on the possibility of applying existing methods and approaches to their management. (Arthur, 2021). These circumstances determine the appropriateness of using ontological modeling to describe a subject area, which will allow forming a formal representation of a data scheme based on the selection of its objects, facts and relationships between them, and will provide broader capabilities than classical databases or an object-oriented approach. However, for the considered RSESs in most cases it is difficult to establish univocal connections between the concepts of ontology, in this

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connection terms of fuzzy sets being proposed to be used to describe them (Rybina and Slinkov, 2023).

At the same time, the efficiency of the RSES functioning can be influenced by various internal and external factors of uncertainty that are difficult to assess or predict, which significantly complicates their management and planning. In this regard, a fuzzy situational approach can be used to solve this problem, which involves representing the process under consideration in the form of individual states (situations) and control transitions connecting them. (Glukhova L.V., Sherstobitova, Kodzokov and Nagorov, 2023). The specified approach allows forming optimal strategies for transferring the object under consideration from a certain initial situation to a target one, as well as obtaining an idea of intermediate situations, which is especially important under the influence of uncertainty factors.

Thus, taking into account the information presented in the linguistic form using fuzzy ontological models to expand the capabilities of fuzzy situational management of the RSES employing a precedent approach under conditions of uncertainty is a relevant and practically significant task.

2 MATERIALS AND METHODS

The need to take into account the listed specific features of regional socio-economic systems determines the feasibility of solving the following problems aimed at increasing the efficiency of their management:

- providing the ability to store and work with information presented in linguistic form using fuzzy ontological models in which the relationships between individual concepts are described using fuzzy sets;
- organization of the accounting and use of accumulated experience in managing regional socio-economic systems in various situations in which they were in the past, which can be accomplished through the formation of a precedent base;
- creation of conditions for organizing a flexible structure for decision-making depending on the current situation in the process of functioning for the systems under consideration in the form of a global fuzzy situational-precedent model.

Thus, the paper deals with a new scientific problem related to the development of a new approach to managing regional socio-economic systems based on the use of fuzzy ontological and situational-precedent models.

2.1 General structure for the developed approach to the management of regional socio-economic systems

To solve the identified scientific problem, it is proposed to use the developed approach aimed at ensuring situational management of regional socio-economic systems using fuzzy ontological models and accumulated situational precedents.

The choice of ontologies for describing and storing information about the subject area under consideration is due to the fact that they are one of the main areas of artificial intelligence development and represent an effective tool for describing a certain area of knowledge using a set of concepts and categories, as well as information about their properties and relationships. The works (Misnik, 2022) and (Arp, Smith, and Spear, 2015) provide a formalized description of ontologies, their essence and purpose, according to which, in general, these models represent a set of the following elements Ontology= $< N,F,V,A >$, where N – concepts, F – characteristics of an individual concept , V – relationships between concepts, A – axioms. Thus, ontology allows creating a model of a subject area using a formal language that provides the ability to perform logical inference and describing any information expressed in natural language. The transition to fuzziness in the considered models allows describing the relationships between concepts in the form of fuzzy sets for cases where such relationships cannot be unequivocally established, which increases the descriptive ability of the model and, as a consequence, the effectiveness of its application.

As noted earlier, fuzzy models implementing a situational approach can be used to manage the RSES under uncertainty conditions, fuzzy cognitive maps and fuzzy situational networks being the most widespread among them.

Fuzzy cognitive maps represent the RSES as a set of concepts united by cause-and-effect relationships, and are mainly used for analysis and decomposition in order to identify the characteristics of an object and external environmental factors that have the greatest impact on the functioning process (Zakharova, Podvesovskii and Isaev,2020.), as well as to determine the control effects on these factors to transfer the object to the desired state [Fomchenkova and Fomchenkov, 2021.]. However, fuzzy cognitive maps display only general relationships between the parameters of an object and do not provide an idea of its intermediate states when implementing a control decision, which significantly complicates the processes of predicting the obtained result and adjusting control in the event of deviations from the chosen strategy.

Fuzzy situational networks represent weighted directed graphs and, unlike fuzzy cognitive maps, their application is focused on searching for the closest reference situation among the network nodes for the current fuzzy situation with the subsequent determination of the sequence for control decisions that allow the object to be transferred to a certain specified target situation when the selected optimality criterion is met. The disadvantage of this model type is the need to involve a large amount of expert information to form the structure and parameters of the network, which is often associated with significant expenditure of time and resources, as well as an increased risk of incorrect operation of the model due to the high degree of subjectivity for the data used in construction.

In this regard, to solve the scientific problem stated, it is proposed to use not classical situational networks, but their variety - fuzzy situational-precedent models (FSPM) (Sokolov, Chernovalova and Prokimnov, 2024.). The main advantage of these models is that they provide the ability to consider previous experience of managing an object when determining the structure and parameters of the model in order to reduce the amount of expert information used, as well as considering the ambiguity of control transitions under similar initial conditions due to the influence of unaccounted uncertainty factors.

The general scheme of the approach aimed at increasing the efficiency of RSES management based on the joint use of the considered tools is presented in the figure 1.

As can be seen from figure 1, the approach under consideration can be represented as the following sequence of basic steps.

Step 1. Formation of a description for the current situation $S = \{s_1, \ldots, s_z, \ldots, s_Z\}$, where S – the current situation developed under the RSES management, s_z – description for a particular situation characteristic in linguistic form; m – number of characteristic (z = 1,…, Z). The external environment, its internal elements and the connections between these elements can be identified as the sources of the characteristics under consideration. The characteristics themselves represent specific values of indicators describing the specified sources. They are often assessed by experts and presented in linguistic form, for example, «average level of education», «high level of social tension», «low level of innovation potential», «favorable state and political environment», «low inflation growth», etc.

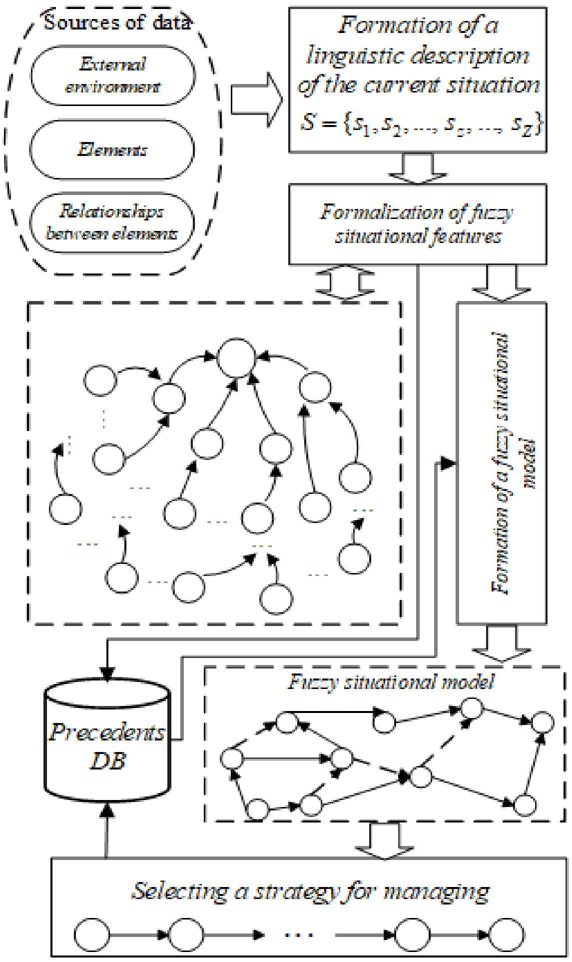

Figure 1: The structure of the proposed approach to managing the regional socio-economic system.

Step 2. Obtaining a set of fuzzy situational features using the considered modification of the procedure described in the work (Avdeenko and Makarova, 2017). The implementation of this procedure involves the use of a fuzzy ontological model formed in advance. It contains all the necessary information about the RSES, which can be presented in various forms, including linguistic. In the process of executing the specified procedure, each individual characteristic $\{s_m\}$ is compared with the concepts of the ontology in order to establish a correspondence and subsequently calculate its value. The result of this procedure is a set $\tilde{X} = \{\tilde{x}_i\}$, which elements have fuzzy values.

Step 3. Formation of a global fuzzy situational precedent model. To implement this step, an intelligent method is used, described in the work (Sokolov, Chernovalova and Prokimnov, 2024), according to which, with the help of a pre-collected database of situational precedents, their fuzzification occurs with the aim to identify groups of similar fuzzy situations among them using a fuzzy clustering algorithm. In accordance with the obtained results, the fuzzy situations are combined and a global FSPM is constructed. If necessary, the situational feature space is supplemented with the help of synthetic generation.

Step 4. Application of FSPM to find a rational management strategy for RSES. Using the selected method for identifying the degree of proximity to existing fuzzy situational precedents, the current fuzzy situation is determined, after which the target situation is established and sets of possible transitions between them are formed. For each obtained set, the total predicted values of the efficiency indicator of the RSES management are calculated, and then a rational strategy is selected according to the pre-set management criteria.

Thus, the proposed approach is aimed at combining the advantages of fuzzy ontological and fuzzy situational precedent models with the aim to increase the validity and efficiency of managing regional socio-economic systems. Let each stated type of the models be considered.

2.2 Construction and application of a fuzzy ontological model

There are various approaches to constructing ontologies, among which the most famous are the Cyc method, the Uschold and King method, the Gruninger and Fox methodologies, *Methontology*, *DOGMA-MESS*, *DILIGENT*, *NeOn*, and etc., (Suárez-Figueroa, Gómez-Pérez, Motta and Gangemi, 2012; Salatino, Thanapalasingam, Mannocci, Birukou, Osborne and Motta, 2020), but to solve the problem it is more appropriate to use the approach described in (Arp, Smith and Spear, 2015). However, the presence of a high degree of uncertainty in the operating conditions of regional socio-economic systems, characterized by the lack of sufficient information necessary for constructing an ontological model, leads to situations in which the connections between concepts can only be described using fuzzy sets. In this regard, it is advisable to use the structure of the ontological knowledge model to support decision-making on the management of these objects, described in (Dli, Chernovalova, Sokolov and Morgunova, 2023). The general view of this ontology structure is shown in figure 2.

In figure 2 $w^{\alpha}_{\beta\delta}$ - concepts of the subject area, α – ontology branch number (α =1,…, A), β – the ontology hierarchy level (β=1,…, B), δ – concept number (δ=1,…, Δ), $\tilde{\rho}^{\alpha}_{\beta\delta}$ – fizzy weight of the connection between concept δ at the level of hierarchy β of some «branch» after the top-level concept α and its parents.

The construction of fuzzy ontological models with the structure shown in figure 2 allows considering all available information about a socio-economic object, which can be presented in various forms, including linguistic, which is especially important when analyzing and evaluating various current states in which the specified object may be located. Since information technologies cannot directly work with information presented in linguistic form, it is proposed to transform it into fuzzy sets using the approach described in (Dli, Chernovalova, Sokolov and Morgunova, 2023).

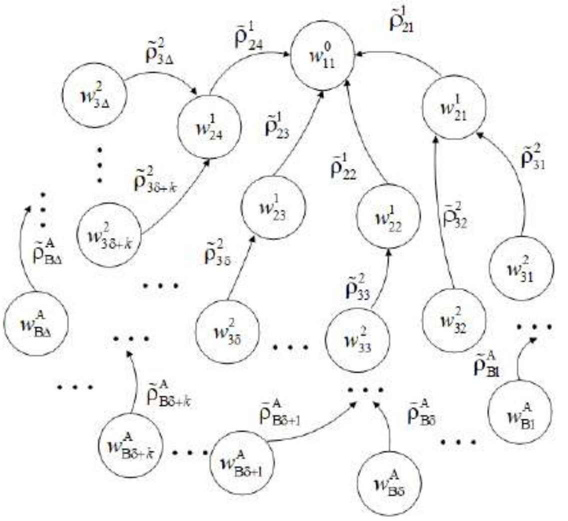

Figure 2: Example of fuzzy ontology structure.

Let the input to the system be some current situation, described in linguistic form $S = \{s_1, \ldots, s_z, \ldots, s_Z\}$.

The formation of sets for fuzzy sets describing the characteristics of the current situation, using the structure of the fuzzy ontological model shown in figure 2, is carried out in the form of operations with fuzzy numbers and involves the following.

Step 1. Comparison for the characteristics of the current situation with the ontology concepts. In the formed fuzzy ontological model concepts are identified being most semantically similar to the meanings of each individual characteristic of the situation under consideration.

Step 2. Establishing between the selected concepts and the corresponding characteristics of the current situation for a fuzzy degree of conformity $\tilde{v}^{s_z}_{w^{\alpha}_{\beta\delta}}$, which will be determined by experts due to the complexity of the assessment.

Step 3. Formation of an empty set for fuzzy situational features $\tilde{X}$, describing the current situation, which number of elements $\{\tilde{x}_n\}$ corresponds to the number of terminal concepts for a fuzzy ontological model.

Step 4. Filling the vector with obtained values. In case when the description of the current situation, according to its characteristics $\{s_m\}$ corresponds to the δ-th terminal concept on some branch of the ontology with a fuzzy degree of conformity $\tilde{v}^{s_z}_{w^{\alpha}_{\beta\delta}}$, then $\tilde{x}_n = \tilde{v}^{s_z}_{w^{\alpha}_{\beta\delta}}$. Otherwise:

$$\tilde{x}_n = \tilde{v}^{s_z}_{w^{\alpha}_{\beta\delta}} \underset{\delta=1,\ldots,\Delta}{\tilde{\otimes}} \tilde{\rho}^{\alpha}_{\beta\delta},$$

where $\tilde{\otimes}$ – operation of fuzzy numbers multiplication.

In this case, when no matches were obtained for individual terminal concepts of the ontology, they remain empty (filled with zeros).

The result of this procedure is a set containing the characteristics of the current situation that appears during the functioning of the RSES, described in the form of fuzzy sets, which will be used to construct a situational model.

2.3 Description for the application of a situational approach

Fuzzy situational networks, which belong to the group of models «situation-control strategy-action», are weighted directed graphs, the vertices of which are some reference fuzzy situations described using a set of fuzzy situational features $\tilde{X} = \{\tilde{x}_n\}$ and reflecting some fixed states of the control object and the external environment of its functioning [Borisov and Avramenko, 2021.]. The arcs of the graph define control transitions, which are associated with control decisions $\tilde{R}$, allowing the transfer of an object between fuzzy situations, and assessment of the costs required to implement management decisions $\tilde{\alpha}$.

To build and use the considered FSPM the following sequence of steps are necessary to be performed.

Step 1. A set of fuzzy precedents of the following type is formed:

$$\tilde{Q}_l = \left\langle \tilde{X}^{\text{н}}_l, \tilde{R}_l, \tilde{X}^{\text{к}}_l, \tilde{\alpha}_l \right\rangle,$$

where $\tilde{Q}_l$ – l-the fuzzy set precedent, l=1, …, L; $\tilde{X}^{\text{н}}_l$ – vector of characteristics for a complex object describing the initial fuzzy situation; $\tilde{R}_l$ – a fuzzy control solution allowing the RSES to be transferred from the initial situation to the final one, which characteristics are determined by the vector $\tilde{X}^{\text{к}}_l$; $\tilde{\alpha}_l$ – vector of fuzzy costs estimates for implementing a control decision $\tilde{R}_l$.

Each element of the set for fuzzy situational features $\tilde{X}$, including the characteristics of a complex object and the external environment of its functioning, is a fuzzy number with a given membership function $\mu(\tilde{x})$:

$$\tilde{X}_m = \{\tilde{x}^m_1, \tilde{x}^m_2, ..., \tilde{x}^m_n, ..., \tilde{x}^m_N\},$$
$$\tilde{x}^m_n = \mu^m_n(x)/x,\ n = 1, \ldots, N,$$

where $\tilde{X}_m$ – m-th fuzzy set of situational features, m – fuzzy set number (m = 1 ,…, M); $\tilde{x}_i$ – i-th fuzzy situational feature; n – number of fuzzy feature (n=1,…, N) ; $\mu^m_n(x)$ - membership function.

Step 2. Grouping of fuzzy situations with similar characteristics of the RSES using one of the known algorithms for fuzzy clustering (Savita, Kumar and Siwch, 2024). The similarity of situations can be determined based on the calculation of a pseudo-metric distance, for example, the fuzzy Hamming distance, followed by its comparison with a given threshold value:

$$\tilde{X}_m \cong \tilde{X}_k : d_{Hemming}(\tilde{X}_m, \tilde{X}_k) \le d_{\text{кр}},$$
$$d_{Hemming}(\tilde{X}_m, \tilde{X}_k) = \frac{1}{N}\sum_{n=1}^{N}\left|\mu_m(x^m_n) - \mu_k(x^k_n)\right|,$$

where $d_{Hemming}(\tilde{X}_m, \tilde{X}_k)$ - fuzzy Hamming distance between situations $\tilde{X}_m$ and $\tilde{X}_n$; $d_{\text{кр}}$ – distance threshold.

Step 3. Combining similar fuzzy situations. For this purpose, it is proposed to use the following expression:

$$Merge(\tilde{X}_m, \tilde{X}_k) =$$
$$= \left\{\frac{1}{2}\cdot\max\left\{\mu_m(x^m_n)/x^m_n,\ \mu_k(x^k_n)/x^k_n\right\}, n = 1, ..., N\right\}.$$

Step 4. FSPM application. To perform this, first, the network node closest to the current situation is determined, the target situation, to which the RSES must be transferred, is set, and a set of paths from the current situation to the target one is formed $\left\{Path_{\tilde{X}_{\text{Н}},\ldots,\tilde{X}_{\text{К}}}\right\}$.

From the formed set, a path is selected, which corresponds to a sequence of control decisions, allowing achieving optimal indicators for efficiency management from the point of view of the given criterion:

$$\min\left(\left\{Path_{\tilde{X}_{\text{Н}},\ldots,\tilde{X}_{\text{К}}}\right\}\right) \rightarrow Path_{opt}.$$

For example, «minimization of resource costs», «maximization of net profit», etc. can be considered as criteria for management efficiency.

It was noted earlier that when managing the RSES, cases may arise when with similar initial situations and identical control decisions the object may move into different final situations due to the influence of unaccounted uncertainty factors. Having a sufficient amount of precedent information, the possibility of transition from a certain situation $\tilde{X}_m$ into a situation $\tilde{X}_n$ under the influence of a control decision $\tilde{R}_{\tilde{X}_m,\tilde{X}_n}$ can be calculated statistically according to the expression:

$$B(\tilde{R}_{\tilde{X}_m,\tilde{X}_n}) = \frac{\sum(Path_{\tilde{X}_m,\tilde{X}_n})}{\sum(Path_{\tilde{X}_m,\tilde{X}_{n+j}})},$$

where $\sum(Path_{\tilde{X}_m,\tilde{X}_n})$ – number of transitions (direct paths) from situation $\tilde{X}_m$ to $\tilde{X}_n$ under the influence of the control decision $\tilde{R}_{\tilde{X}_m,\tilde{X}_n}$; $\sum(Path_{\tilde{X}_m,\tilde{X}_{n+j}})$ – the total number of transitions from situation $\tilde{X}_m$ under the influence of the control decision $\tilde{R}_{\tilde{X}_m,\tilde{X}_n}$; j – some random number.

In practice, considering the uncertainty in the statistical data obtained, it is advisable to move to a fuzzy interpretation of the possibility for transition:

$$\tilde{B}(\tilde{R}_{\tilde{X}_m,\tilde{X}_n}) = \mu_{B(\tilde{R}_{\tilde{X}_m,\tilde{X}_n})}(B)/B.$$

Thus, based on the quantitative description of the current situation obtained using the fuzzy ontological model, the application of the considered intelligent method allows formulating well-founded rational strategies for managing the RSES ensuring an increase in the efficiency of their functioning, which becomes possible due to a more complete description of the subject area, taking into account all the specific features of the specified systems and the flexibility of the developed tools.

3 RESULTS AND DISCUSSION

As a result, a block diagram of the algorithm was developed that implements the proposed approach to managing regional socio-economic systems using fuzzy ontological and situational-precedent models to form an optimal strategy for managing these systems. As a result, a block diagram of the algorithm was developed that implements the proposed approach to managing regional socio-economic systems using fuzzy ontological and situational-precedent models to form an optimal strategy for managing these systems (figures 3 and 4).

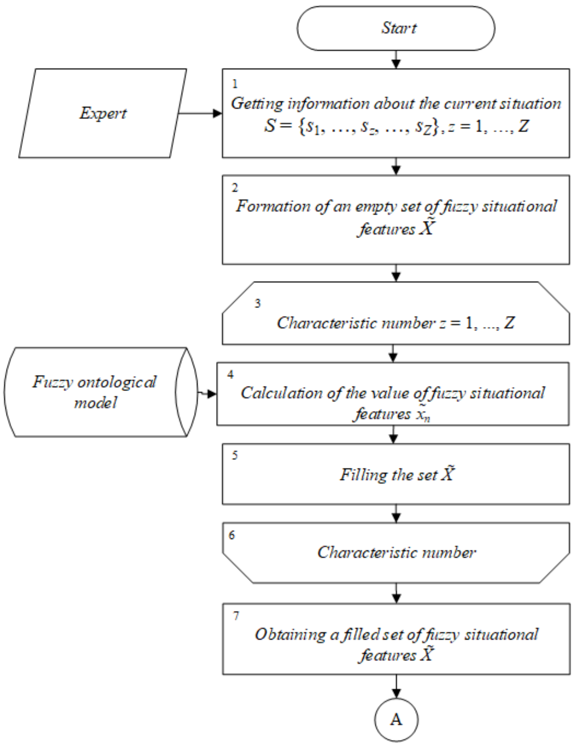

Figure 3: Block diagram for the algorithm of implementing the proposed approach.

At the initial stage of the algorithm (figure 3), a description of the current situation is formed in linguistic form by taking into account expert opinion, reflecting the state of the external environment, elements of the RSES and their interrelations between them. Next, using a fuzzy ontological model, fuzzy sets $\tilde{x}_i$ are formed which are then transferred to the

FSPM construction block (figure 4), where at the beginning a complete set of known situations is formed, which includes both the initial and final situations of each precedent $\tilde{Q}_l$ from the set of fuzzy precedents:

$$\left\{ \tilde{X}_l^{\text{н}}, \tilde{X}_l^{\text{к}} \right\}, l = 1, ..., L .$$

The formed set is passed to the fuzzy clustering module to determine groups of similar situations. Next, the situations that form individual clusters and the corresponding control decisions are combined. The situations combined within clusters represent the vertices of the network structure for the FSPM, and the combined decisions form the control transitions between them.

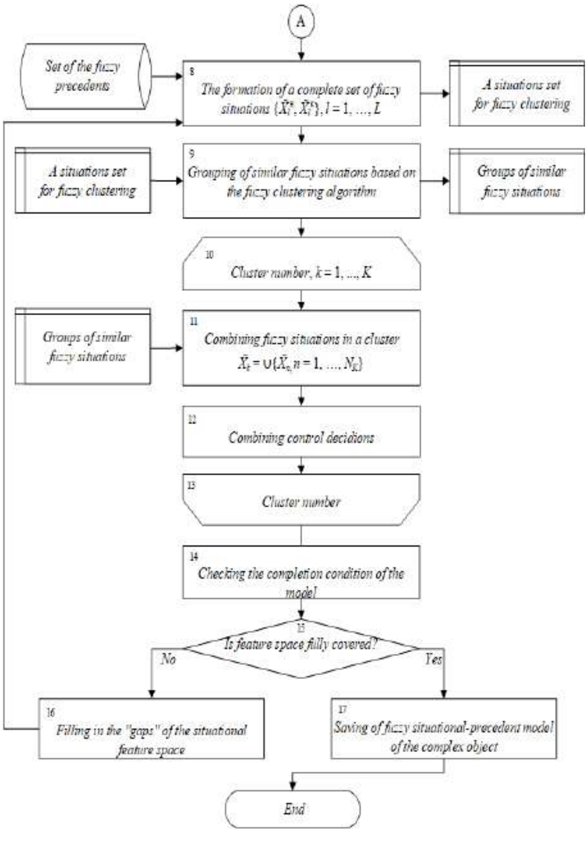

Figure 4: Block diagram of the algorithm for implementing the proposed approach (continuation).

The model having been formed, a check is made to ensure that the situational feature space is uniformly filled with the generated fuzzy situations. In the case of «gaps» presence, the set of fuzzy precedents is supplemented with additional elements obtained using simulation modeling, expert data or extrapolation of the feature space near known situations, after which the process of adjusting the network structure is initialized.

The constructed FSPM is saved for subsequent use to manage the RSES, after which the algorithm completes its work.

The proposed approach to managing the RSES based on fuzzy ontological and fuzzy situational-precedent models was implemented in the form of a software application, which algorithmic support is implemented in *Python 3.12.1*. The choice of this language is determined by the fact that it allows creating understandable, interpreted code with dynamic typification of variables. In addition, this language is developed according to the paradigm of object-oriented programming, based on the concepts of class and instance, and has a large number of third-party extensions and open source libraries, which allows it to be used to solve a wide range of problems.

The development of the ontological model of the subject area was carried out using the open source editor *Protégé* version 5.6.5., which is a multifunctional environment for creating ontologies in the *OWL 2* (*Ontology Web Language*). In addition, the editor in question is a cross-platform *Java*-application, and its architecture is convenient to use when developing intelligent systems based on ontologies of various complexity. Further use of the developed ontology structure in the creation of the application under consideration was carried out using the *Owlready2* library for the *Python* programming language, which allows the use of modified versions of *HermiT* or *Pellet*. However, since *HermiT* and *Pellet* are written in *Java*, a *Java* virtual machine was also installed in *Owlready2* to perform reasoning.

The developed software application was used to monitor and manage the functioning of such a regional socio-economic system as the Smolensk region information technology cluster. Figure 5 shows a fragment of the ontology for the subject area under consideration, developed using the *Protégé* ontology editor.

As can be seen from figure 5, the presented fragment of ontology can be classified as a formal taxonomy. In this case, transitivity is strictly observed when implementing the «class-subclass» relationship, and the description of instances, properties and axioms is omitted in order to ensure the speed of the proposed application. The top-level concepts in this fragment are «Projects», «Participants» and «Indicators». The first concept reflects the part of the ontology that describes the projects implemented by the IT cluster of the Smolensk region, the second – the participants of this cluster, and the third – the main indicators for assessing the efficiency of the functioning for all its directions. Then this ontological model was used and refined using the *Owlready2* library.

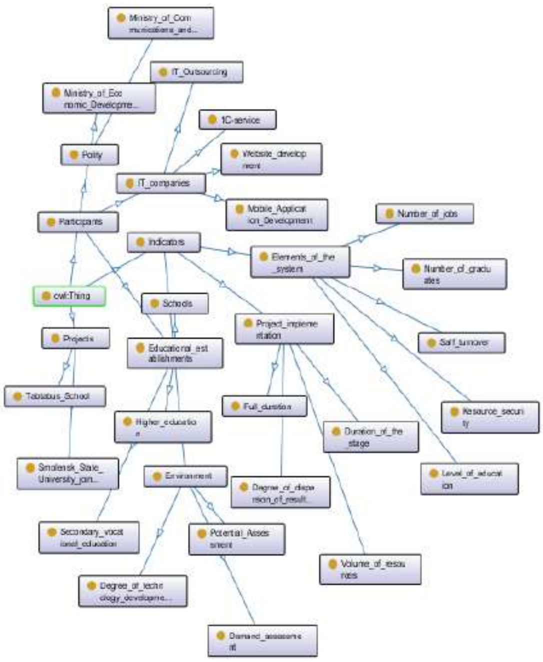

Figure 5: A fragment of the developed ontology.

Using the proposed approach, a fuzzy situational-precedent model was formed, its graphical representation is shown in figure 6.

Figure 6 shows the following situations included in the FSPM:

- $\tilde{X}_1$ – normal functioning of IT cluster;
- $\tilde{X}_2$ – IT cluster functioning in the conditions of high degree of uncertainty;
- $\tilde{X}_3$ – successful implementation of the project stage;
- $\tilde{X}_4$ –conducting additional analysis and making adjustments to the process of implementing IT cluster projects;
- $\tilde{X}_5$ – growing demand for IT specialists involved in websites development;
- $\tilde{X}_6$ – increasing in the number of universities places for the training programs related to the websites development;
- $\tilde{X}_7$ – attracting third party developers;
- $\tilde{X}_8$ – obtaining tacit knowledge in the IT field;
- $\tilde{X}_9$ – searching for and attracting new investors;
- $\tilde{X}_{10}$ – subsidizing part of the projects cost;
- $\tilde{X}_{11}$ – completing the IT project and its commercialization

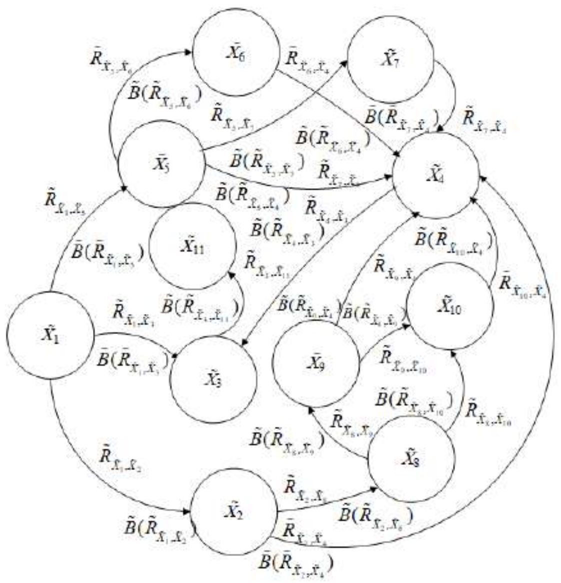

Figure 6: Built global FSPM.

Transitions between situations are carried out using fuzzy control decisions with a certain degree of probability. When managing the RSES under consideration a situation occurred in which an increased need for IT specialists involved in web development was identified. «Minimization of IT project due date» was established as the criterion for management efficiency. As a result of the application operation a management strategy was recommended based on the formed FSPM, which includes changing the following states $\tilde{X}_5 \rightarrow \tilde{X}_7 \rightarrow \tilde{X}_4 \rightarrow \tilde{X}_3 \rightarrow \tilde{X}_{11}$. This solution 87% corresponds to the solution proposed by the experts who were invited for this purpose. However, it took experts several days to do this, and the developed application allowed receiving an answer in a few minutes, which determines the effectiveness of its practical application.

4 CONCLUSION

Thus, a relative scientific problem related to improving the management of regional socio-economic systems in the process of their functioning was solved based on the proposed approach, the main novelty of which lies in combining the advantages of fuzzy ontological and fuzzy situational-precedent modeling.

The use of fuzzy ontology structures discussed in the paper allows forming a complete and detailed description of a subject area in the form of a knowledge base, which is then used to form a set of fuzzy situational features. This set is necessary to initiate the implementation for the second part of the developed approach, associated with the formation of global fuzzy situational-precedent models and with their help finding a rational strategy for managing the specified systems.

All proposed intelligent methods, processes and algorithms were implemented in the form of a software application, which was subsequently used to manage the functioning of the IT cluster for the Smolensk region.

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