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Key Elements of a Specialized Complex for Solving Modeling Problems

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Abstract—*Making effective decisions in any field of science, technology, industry, human life, first of all, is determined by the availability of necessary and reliable information. Such information can be obtained both as a result of experiments in real conditions and on the basis of simulation. As a result of real experiments, the information obtained may already be outdated or belated for making appropriate decisions. Therefore, modeling becomes an important tool in the process of learning and making the necessary decisions. In order for the modeling process to be most effective, it is important to take into account all its aspects. In this regard, it is relevant to create specialized complexes for solving modeling problems. Disclosure of this issue is the main point in this study.*

Keywords—modeling; solution; specialized complex; control action; situational center; multi-agent; implementation environment; exposure environment

1. Introduction

Modeling is one of the elements of knowledge of the surrounding world. Modeling is used in various fields of science, technology, industry to justify and make the necessary decisions. These solutions can be aimed at developing new technologies, overcoming unforeseen situations, fighting epidemics, analyzing various subject areas that are in the process of being studied and researched [1]-[3]. This is due to the fact that the modeling process allows us to consider and analyze various situations that may arise in real life [1], [4]-[6]. At the same time, such a process does not affect the surrounding world and does not harm its existence. In the process of modeling, we can get a lot of different information, which is an additional source for making appropriate decisions.

Additional information obtained during the modeling process needs to be properly captured, processed and stored. This makes it appropriate to talk about the creation of some specialized complex that allows you to carry out the modeling process and process additional information. The structure of such a complex is largely determined by the subject area of the problem that needs to be solved in the modeling process. However, it is also possible to identify individual elements of such a complex, which determine its direction and essence from the point of view of modeling.

An important point of modeling is also the use of various methods and models, which are determined by the subject area of the study [7]-[11]. But here you can also use different models that have found appropriate application in any applications and areas of research [12]-[19]. This extension of the toolkit for the implementation of modeling is based on the fact that we can get additional information that also needs to be processed. Then a specialized complex for modeling should be able to work with various types of tools that can be used in this process of cognition.

Thus, in this study, some issues of the functioning of a specialized complex for organizing the modeling process, its main elements are considered.

2. Brief Literature Review on the Research Topic

Modeling, development of appropriate systems and models is a key topic for many research and applied works. In these papers, both general modeling issues and specific models for various special cases are considered.

In [20], a general methodology for creating a model for solving one specific problem is considered. The authors are exploring the possibility of creating a general model for the contact force for complex contact surfaces. To do this, the authors develop a reverse research strategy to create a model of the contact force between complex geometric shapes [20]. For these purposes, the GA-SQP estimation method is used, which allows obtaining unknown dynamic parameters of the model.

The research work [21] analyzes and develops the architecture of the corresponding software for modeling in complex optical systems. The article describes a physical model and primary calculation algorithms developed and implemented in a software package for modeling interference in complex optical systems [21]. In particular, a model of a highly monochromatic laser beam interacting with various optical elements was proposed in this work [21].

In [22], a model for the optimization analysis of specialized tourist settlements is presented. For these purposes, the methods of neural networks and system dynamics are used. The article also discusses the optimization analysis of the agglomeration of specialized tourist villages. It is shown that the analysis method proposed in the article is most suitable for calculating the agglomeration of tourist professional villages in mountainous areas and can satisfy the needs of the development of professional tourist villages in mountainous areas [22].

In [23], various models for understanding processes in complex physics are generalized. To do this, the authors use various graph networks (GNS). The authors also consider a machine learning framework and model implementation that can learn to model a wide range of complex physical domains, including fluids, solids, and deformable materials interacting with each other [23]. This allows one to generalize simultaneous predictions with thousands of particles during training to different initial conditions [23].

J. Li in his work presented a critical review of the process of modeling spatial forecasting in environmental sciences [24]. At the same time, the paper notes that the accuracy of forecasts is crucial, since they form the basis for the rational use and conservation of the environment. The study by J. Li evaluates the process of spatial predictive modeling and identifies nine main components for spatial predictive modeling [24]. Each of these nine components is then analyzed and recommendations are provided for selecting and applying the appropriate components and developing accurate predictive models [24].

I. Ahmad, M. Kano and S. Hasebe explore the issues of size and analysis of uncertainties in the process of industrial simulation [25]. At the same time, the authors note that reliable and efficient modeling of industrial processes is vital for the implementation of stable and economical design, operation and control of technological processes [25]. Therefore, the authors consider various aspects of uncertainty in process modeling. The review presented in the paper is intended to provide modelers with a platform to identify sources of uncertainty and effectively model their impact on decision making [25].

In [26], a review of approaches is given, which considers the modeling of process-structure-property relationships in the additive production of metals. A set of methods based on physics and data is presented, as well as examples of their application for understanding relationships in psp ratios (in any of the bonds) in widely used methods of additive modeling of metals [26]. The review also contains a discussion of the advantages and disadvantages of using each type of model, as well as a vision of the future role of both physical and data models in the additive modeling of metals [26].

G. Guizzardi and H. A. Proper explore the issues of understanding the value of domain modeling [27]. The authors emphasize the importance of considering the subject area in the process of developing a model and its subsequent implementation. The article also explored the factors that can be used to determine the value of a simulation.

Thus, we can say that the modeling process is considered for application in different areas and applications. In this case, the concept of "complex" is often used to implement the integrity of the modeling process. Also an important aspect is the consideration of the subject area where the appropriate modeling process is applied and considered.

3. Situational Center as a Specialized Modeling Complex

Integration into one model, specified for the θ elements of the environment model and the specialized set of situational center (SC) indicate a close connection between the design goals and the goals of the decisions made in the subject area.

The set of local goals z_j ensures the fulfillment of the global goal $\Re_J$ for the actions of the decision maker – J (see Fig.1).

In principle, several sets of local objectives can provide a global objective $\Re_J$. For the phased development of the SC, the overall objective can be 'forgotten' at an intermediate stage $\Re_J$ and simpler local objectives can be provided. In general, the structure of links between local goals z_j is arbitrary. The following cases can be considered as extreme situations:

the case where the fulfillment of any goal is linked to the fulfillment of each of the others, with all goals belonging to the same condition (no hierarchy);

the case of complete independence of the goals, i.e. each of them is achieved independently.

In addition, the simplest and simultaneously *the most basic types* of connections between goals are only three: sequential, parallel and cyclical [7].

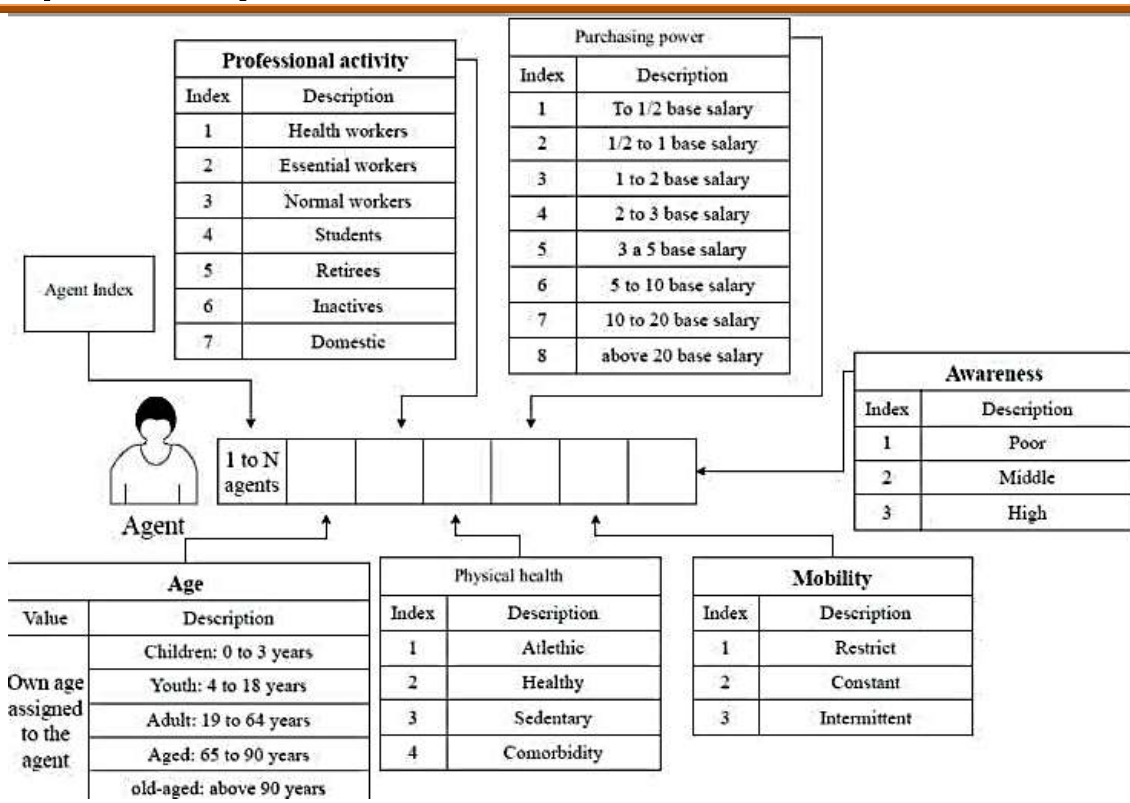

Figure 1: Classification of the attributes according to their respective aspects

For a local goal tree, the connections between them will be a combination of elementary types of connections. Often the performance of one local objective can make it difficult or even impossible to perform the other one. Such goals (two or more) are called antagonistic. In our design, it will not be possible to get rid of some degree of antagonism of the local goals. The problem is multi-criteria and most acute for goals of the same hierarchical level.

The model developed θ depicts the relationship between the situation of the natural environment and SC at a fixed moment or interval in time, which has a significant impact on SC's performance of its functions to achieve the intended objectives (see Fig. 2).

In addition to the natural environment, the SC is also surrounded by the environment of technical and organizational means, the resources of which are managed by the decision making person for the prevention or elimination of the consequences of an emergency. In this case, in addition to the natural environment, the emergency development tools, the model θ should be extended to take into account the presence of organizational and technical tools and generalized situations in the environment, which display quantitative and qualitative parameters X. Qualitative parameters represent any decision or action that is proposed by the decision maker and have three main characteristics: the purpose of the action; the description of the action; the means of its execution. All these characteristics can be obtained from the answers of specialists and experts who can competently answer the following three questions: "Why?" or "What should be the result? - The answer will describe the goal (purpose of the action); "What to do?" - the answer will describe the action; "How to do?" - the answer will characterise the means of doing (skill and opportunity).

The basis for constructing a 'tree' or question system to identify knowledge of an emergency and actions to respond to or prevent an emergency is the following elementary, short questions: "What?", "Why?", "How?". The questions should follow standards . The answers to these questions provide the knowledge base that is displayed in the objectives of the development of the SC functional set and the decision-making requirements that the SC proposes to the decision maker.

4. **Elements of the "Agent - Control - Environment" Complex for Creating a Multi-Agent Space of the**

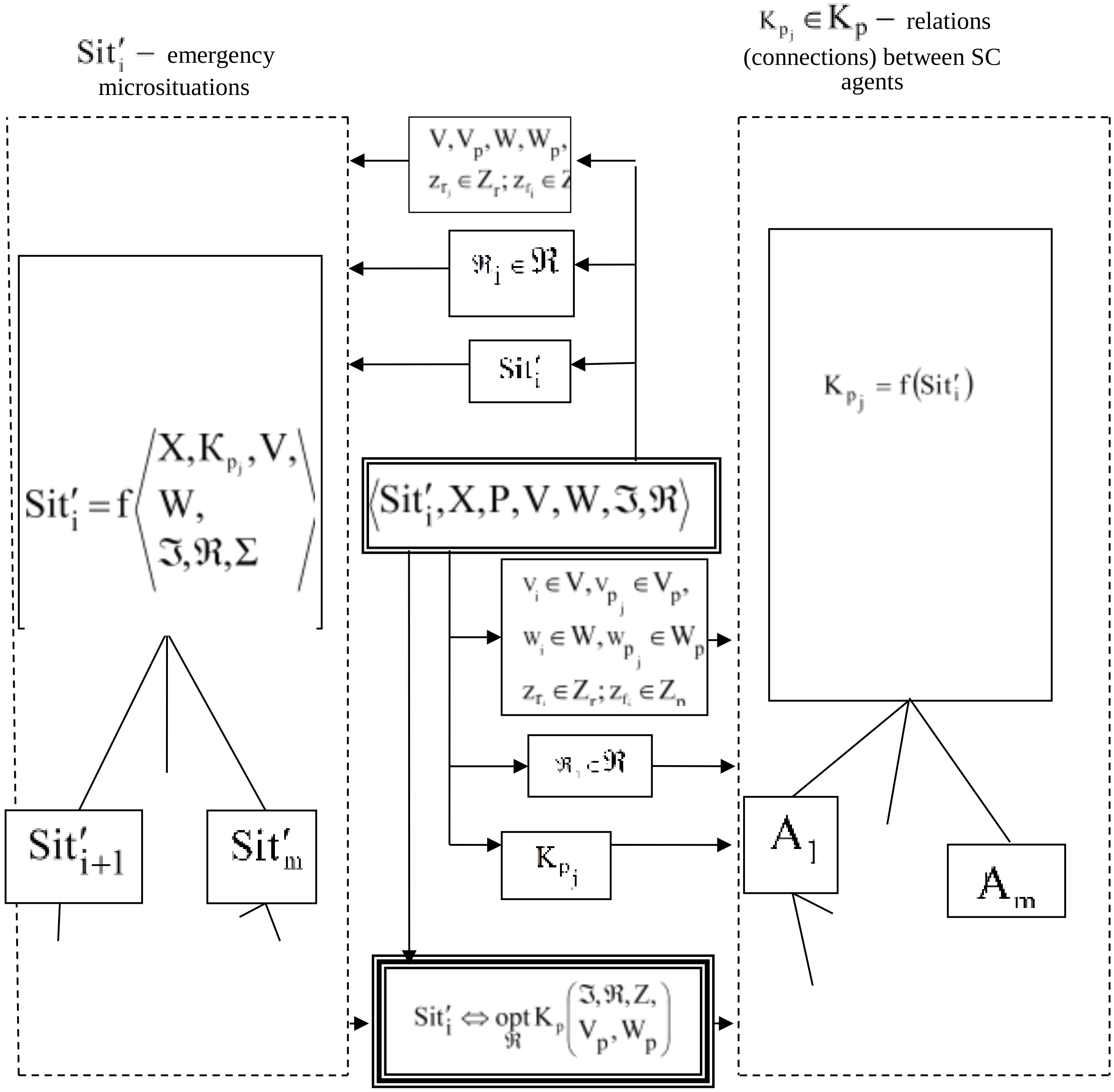

Figure 2: Scheme of interaction between the environment and model for identifying the development tool language

Control Object

In our work, we will use the notion of generalized situation structure $Sit\{Sit'_i\}$ $(i = \overline{1,n})$, which consists of a set of micro-situations $\{Sit'_i\}$ and is formed by concepts – elements of the environment (Fig. 2). Let us supplement a part of the situation Sit with a pair of $\langle e_i, K_e \rangle$, which we will call a linguistic (qualitative, semantic unit) of the central concept e, around which the microsituation is based. Set $K_e = \{Ot_i, Pvt_k\}$ is the context of the microsituation for the linguistic, central concept e. The set $K_e = \{k_{e_i}\}$ $i = \overline{1,m}$ has a relation Ot_i of the central concept e with the other secondary concepts Pvt_k involved in this microsituation. The relation Ot_i is some dependence of the central concept on the secondary concepts. For a given microsituation, a concept that is central in another microsituation can be a secondary concept.

5. THE TASK OF FINDING PRECEDENTS FOR THE KNOWLEDGE BASE SC

For the text $TextExp$, obtained from the expert, it is necessary to identify, from the set of candidates to the central concepts $cPvt$, the concepts that will be related to the set of microsituations $\{Sit'_i\}$ by precedents.

Steps of constructing a set of microsituation precedents (benchmarks):

Description of the current situation of the subject field in the form of a narrative text.

Identification of concepts from available categories from the resulting description.

Finding relations between the given concepts.

Constructing the description in the language of representation of microsituations.

Concepts Pvt for the category $eKat$ in question are obtained as a result of the function of concept identification ERp.

$$ERp(TextExp) \to Pvt_i,$$

where Pvt_i are the revealed concepts, $i = \overline{1,n}$.

Thus we have

$$Sit' \Rightarrow \{cuP, Ot\},$$

where $Sit' -$ is the micro-situation, which corresponds to the set of concepts cuP, which are entities, and the set of concepts Ot expressing the relation between other concepts.

1. Step. Identify from the set of candidates cuP a set of central concepts or antecedents $cPvt$ (nouns that are subjects in sentences $TextExp$).

$$ERp1(cuP) \to cPvt_i,$$

where $ERp1$ is a function for identifying candidates for central concepts $cPvt$.

2. Step. Identification of context or relations.

$$OtA = cuP/cPvt.$$

for the obtained candidates for the central concepts $cPvt$. The task is to identify a subset of relations (associations) $Ot \subset OtA$.

The elements of the set of relations $\{Ot\}$ are the main, active and supplementary relations. Each element of a set of relations $OtP_l \in Ot$ will be associated with a certain central concept $cPvt_i \in cPvt$.

3. Step. A set of microsituations $Sit'_i = \left\langle cPvt_i, Ot_{cPvt_i} \right\rangle$ - precedents, n which the elements of the sets Ot_{cPvt_i} are the elements of the set Ot. At this stage, microsituations are not yet complete because secondary notions have not yet been assigned to the elements of the set Ot.

4. Step. Search for secondary concepts. Any elements of the set of candidates cuP, can be used as secondary concepts, irrespective of whether they are included in the set of central concepts $cPvt$, set of relations Ot, or in none of them. In most cases, secondary concepts are derived from additions to verb forms, which have been previously identified. In general, secondary concepts are those to which the associations refer.

The decisive rule is represented as follows:

The decisive rule is represented as follows:

$$pravResh = \underset{i}{\wedge} Prizn_i,$$

where $Prizn_i$ is the individual attribute.

When calculating the value of the decisive rule $pravResh$, each of the attributes is assigned a value of true if the attribute is present in the concept and false otherwise.

Denote the textual description of the situation obtained from the expert as $TextExp$. A concept of the subject domain from the primary textual representation $etExp$, and a concept expressed in terms of available categories $eKat-e$. The process of identifying concepts Pvt from the text $TextExp$ is a function which maps the text onto a set of concepts:

$$ERp(TextExp) \to Pvt_i,$$

where ERp – is the function for identifying the concept; Pvt_i are the identified concepts, $i = \overline{1,n}$

For a microsituation Sit' we have two candidate sets: cuP is a set of concepts that are entities and Ot is a set of concepts expressing relations between other concepts. The first step is to identify from the set of candidates cuP the set of central concepts $cPvt$. First of all, these are nouns, which are subjects in the sentences from which they have been derived. The central concepts are then searched among the remaining elements of the candidate set cuP.

Highlighting the context. The next step is to isolate the relationships of the resulting candidate central concepts. To do this, first the elements of the set of central concepts cuP cE are removed from the set of candidates cuP, resulting in a set of relations and secondary concepts $cuA = cuP / cPvt$. The task is to identify a subset of relations (associations) $Ot \subset cuA$.

Using the list of types of active and supplementary relations, we obtain elements of the set of relations Ot. Each element of the set of relations $OtP_l \in Ot$ will be connected with a certain central concept $cPvt_i \in cPvt$, forming a set of microsituations $Sit'_i = \left\langle cPvt_i, Ot_{cPvt_i} \right\rangle$, in which elements of the sets Ot_{cPvt_i} are elements of the set Ot. At this stage, the resulting microsituations are not yet complete because the elements of the set Ot have not yet been assigned to secondary notions.

Searching for minor notions. As secondary notions any elements of the set of candidates cuP can act as secondary ones irrespective of the fact whether they are included in the set of central notions $cPvt$, in the set of relations Ot or in none of them. In most cases, secondary concepts are derived from additions to verb forms that have been singled out earlier. In general, secondary concepts are those to which the associations refer.

The decisive rule is represented as follows:

$$pravResh = \underset{i}{\wedge} Prizn_i,$$

where $Prizn_i$ is the individual feature.

When calculating the value of the decisive rule $pravResh$, each of the features $Prizn_i$ is assigned a value of true if the feature is present in the concept and false otherwise.

6. Conclusion

Considering the importance of the modeling process, the paper considers some issues of implementing a certain specialized complex to solve the corresponding ones. Particular attention is paid to the key elements of such a specialized complex. For these purposes, by a specialized complex we mean a situational center that is able to adapt as a result of receiving new information.

We also consider the elements of the "agent - control - environment" complex for creating a multi-agent space of the control object. An important point is the specification of the task of searching for precedents for the SC knowledge base. Thus, the paper proposes an adaptive principle of decision support in emergency situations, using a generalized, knowledge-generating generalized database and knowledge.

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