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CONCEPTUAL MODELS OF SEA-GOING AUTOMATION APPLICATION DOMAIN AND THEIR COMPUTER AIDED DESIGN

The paper studies a ship engine room automatic and remote control system as a problem-solving environment. The terms 'construct' and 'conceptual model' are introduced. The foundations of the conceptual modeling theory being presented. The results of the knowledge field creating are chown. The instrumental system CONCEPT for the conceptual modeling beung presented.

1. INTRODUCTION

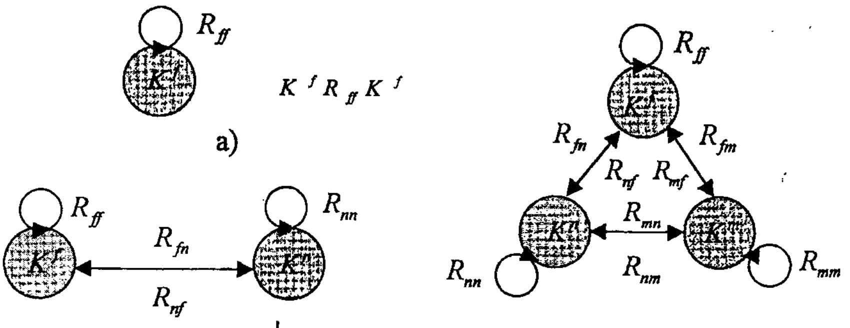
Problem-solving environment [11] 'Design of the sea-going ship automation systems' is ill-structured. It requires using of methods and tools of knowledge engineering (acquisition, presentation, manipulating and argumentation of knowledge) for automation of solving the practical tasks by a designer. In the world practice of the knowledge based systems creation the problem of knowledge acquisition has been accented for the last 10 years. Texts of the documents, books, advertising booklets on the problem-solving environment are one of the sources of knowledge extraction. Knowledge acquisition from texts is the least developing area in knowledge engineering [9]. This is explained, first of all, by the absence of explicit information on the lexical units semantics in them. Thence the problem of knowledge extraction from texts is reasonable to be solved within the man-machine system. Computer automates labour-consuming procedures, but the knowledge engineer makes a decision on the concepts, carrying determined semantic load, and creates more complex information units of problem-solving environment from lexical units. Making explicit decisions and creating come across on bad readiness of knowledge engineer to perform a similar work. 'Transition on object-oriented technologies is connected with overcoming psychological difficulties. The developers and programmers happen to become unaccustomed to traditional ways of thinking.....' [11]. The main problem is in necessity for their developers and programmers to study problem-solving environment and to develop figurative (cognitive) thinking. Unfortunately, this problem is paid a little attention to, with a probable exception, for publications by Gavrilova T.A. and Osipov G.S. [1, 9]. We have offerred and developed the approach to problem-solving environment and synthesis of its description in the form of databases and knowledge-bases using the conceptual models [3 - 5]. This approach is used for developing a knowledge based system for the decision making support of design of automation systems of sea-going ship engine room [5, 6]. The present paper gives theoretical bases of problem-solving environment conceptual modeling and considers instrumental system CONCEPT. It automates both conceptual modeling in computer memories, and analysis of sentences of the professional activity language (LPA) of designers and synthesis of databases and knowledge-bases information units.

2. 'COSNRUCTS' AND CONCEPTUAL MODELS FOR KNOWLEDGE ACQUISITION FROM TEXTS

Understanding of the text on the semantic level implies a revealing of not only linguistical, but also logical relations between language objects. Speaking about the semantic analysis of a text, it's necessary to bear in mind that relation of the text to its semantics begins after we have had a reality model at our disposal. Thereby, the main problem, appearing with an effort of automatic knowledge extraction from the text, is a revealing of the text element properties for a correlation of these elements with the model objects. These properties are presented in the text explicitly (obviously) extremely seldom.

The knowledge engineer, creating a database and a knowledge-base as problem-solving environment models, structures this environment, extracting a final relation set in it. These relations link individual elements of the external world model. Elements on their own, being linked by relations, play in these relations a determined role. Semantics of roles is defined by the relation type. The language of professional activity keeps this structuring. Subjects, phenomena, processes , and events express their own names, inherent to them in language. Relations are expressed also by special names, or purely language syntactical means.

The triad 'thing - property – relation' idea, in terms of which it is possible to describe all the diversity of reality, was proposed by a philosopher A.I.Uemov in 1963 [12]. In 1971- 1979 we have offerred the 'thing (K^1) - property (K^2) - action (K^3)' triad for the analysis of LPA and databases and knowledge-bases synthesis. Then we can introduce the following classification of constructs as the semantic role structures of LPA sentences: one-, two- and threerole. The graphic and mathematical interpreting of all three classes is shown in Fig.1. If f,n,m will take values on set $\{1,2,3\}$, we have a corresponding construct interpretation in the 'thing-property-action' base and corresponding relations (R) classifications. An onerole construct (Fig. 1 a) is a point diagram and its usage for LPA texts will lead only to partial problem-solving and obviously to loss of 'betweenpoint' relations.



$K^f R_{ff} K^f \wedge K^f R_{fn} K^n \wedge K^n R_{nf} K^f \wedge K^n R_{nn} K^n$

b)

$K^f R_{ff} K^f \wedge K^f R_{fn} K^n \wedge K^n R_{nf} K^f \wedge K^n R_{nm} K^m \wedge K^f R_{fm} K^m \wedge K^m R_{mf} K^f \wedge K^n R_{nn} K^n \wedge K^m R_{mn} K^n \wedge K^m R_{mm} K^m$

c)

Fig. 1

A tworole construct (Fig. 1 b) can be obtained from onerole (f) by adding of the second role

(n) and relations (R_{fn}, R_{nf}). Transition from a onerole model to a tworole construct means a transition from point to the single-line diagram and possibilities to take into account betweenpoint relations . Using a tworole construct, in spite of its likely theoretical and practical sufficiency, in certain degrees holds up a knowledge engineering progress development because of weak expressive power of a separate couple of roles. This situation is possible to be corrected, if the tworole paradigm is changed to a threerole one. The threerole construct (Fig. 1 c) can be created from tworole (Fig. 2 b), by adding the third role (m) and relations (R_{fm}, R_{mf} and R_{mn}, R_{nm}), and we move from the single-line diagram to a figured (triangular) one. The knowledge engineer, using such construct, has a possibility 'to see' in LPA texts things, properties and actions simultaneously and in their interrelation.

If we enlarge a main basis by adding 'measures' - K^4, 'values' - K^5, 'states' - K^6 and 'evaluations' - K^7 , we can have more opportunities for building one-, two- and threerole constructs.

3. MULTIROLE SEMANTIC MODELS OF LPA SENTENCES

Above we have considered the construct classification. On the one hand, introduction of quadrangle, pentagon, and polygonal figures complicates a construct by graphic images of relations which cross with each other. On the other hand, with usage of constructs as elements, more complex semantic models of LPA texts can be developed. For instance, in order to get a semantic model shown in Fig.2, we use a usual for the graph theory operation of uniting two of threerole and two of tworole constructs. This model is built for seven roles and allows to extract up to 23 classes of relations. Exactly this model is used as a theoretical foundation for the analysis of LPA sentences of a designer of systems an ship automation, that does not exclude creation of other models. So, operations with constructs do not lead to the creation of new constructs, but synthesize semantic models of LPA sentences.

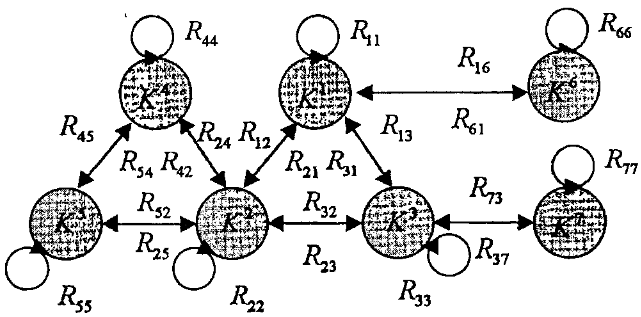


Fig. 2

4. SEMANTIC MODEL TEST

The model shown in Fig. 2, was used for the text analysis of part 15 'Automation' of rules for classification and construction of sea-going ships of Russian Register (as experts say, the texts of these sections in rules of classification societies of other countries mainly coincide), with simultaneous check of model adequacy to LPA sentences, and for the developing of the knowledge field [2] of a problem domain. The knowledge field which we have created includes of about 200 (36,7%) concepts (things and their properties), 87 relations (16%), 120 actions (22%), 28 conditions (5%), 10 events (2%), 20 imperatives (4%), 25 quantifiers (5%), 5 modifiers (1%), 19 modalities (3,5%), 3 evaluations (0,6%) and 23 exotic concepts (4,2%). The results show that things (resources, elements, subjects, devices, etc.), properties (characteristics and physical parameters), actions and relations (almost 80%) carry a main semantic load in the designer LPA. This completely proves the 'thing - property - action' model.

5. DATA- AND KNOWLEDGE-BASES INFORMATION UNITS SYNTHESIS

Above we have considered constructs and the semantic model of LPA sentences. The main purpose of constructs and the semantic model is an extraction of lexical units (dictionaries) of LPA. However, this implies a use of constructs and semantic models, and, at the same time, for the synthesis of data- and knowledge-bases information units. For this purpose the semantic model must be complemented by new concepts. In comparison with lexical (basic) units these new concepts feature that they can be created as derived from them and from other derived units. In this case there should be used corresponding rules of concepts and relations combination. We have proposed the list of derived concepts for the structured presentation of the problem domain 'Design of the sea-going ship automation systems': 'algorithm', 'problem', 'designer', 'operation', 'plan', 'process', 'procedure', 'resource', 'situation', 'structure', 'event', 'purpose', 'element' and 'operator' [3, 4]. So, the list includes 21 concept if basic concepts are taken into account. Obviously the list has a big size. We have offerred to reduce a level of difficulty of a problem-solving environment by introduction of four hierarchical levels [4]. The own declarative and procedural description model was developed on each of them. The example of such a model for systems and processes level of sea-going ship engine room is shown in Fig. 3. The relations indicators on this drawing are possible to find in [3, 7].

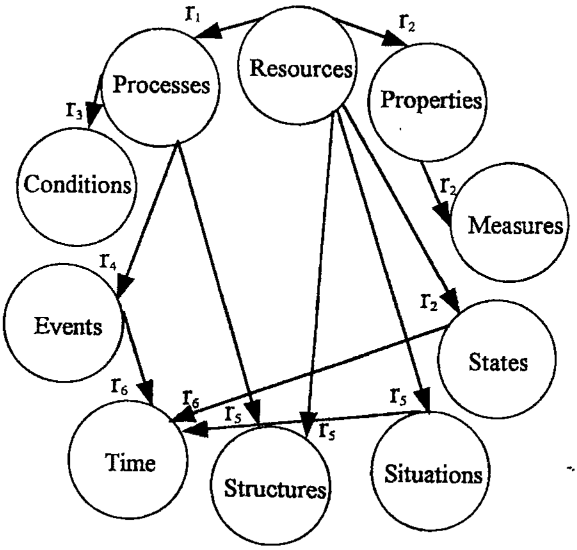


Fig. 3

6. CONCEPTUAL MODELS DEVELOPMENT AND USAGE

It is clear from the above that work with conceptual models requires an entering, saving and manipulating of significant volumes of information. It is labour-consuming and must be executed using modern information technologies. So, in 1976 we have begun a development of systems automating creation and using conceptual models for the transport center [8]. The states and behavior simulation models of transport center and hybrid operation planning model for seaport were created with a usage of a such system. The system ENREL, automating dictionaries and conceptual models development for personal computers, was created in 1998. However, it had limited possibilities, but served as a foundation for instrumental system CONCEPT. This system is realized for IBM PC computers on Visual Basic 5.0 and MS Access 7.0 in the operating system MS Windows 95.

6.1. Instrumental system CONCEPT

The system CONCEPT uses texts, describing problem-solving environment, and creates a database and rule-oriented knowledge-base in an interactive mode. The system raises efficiency of an knowledge engineer work on first three stages of development of a knowledge based systems: identification, conceptualization and formalization. The system does not change data- and knowledge-base management system. Its first version, CONCEPT 1.0, creates a database in Access 7.0 and rule-oriented knowledge-base for EXSYS expert system shell. These two programs were choose as basic for development a knowledge based system for aided design of sea-going ship automation systems. The system CONCEPT functions on stages, when data and knowledge is not yet structured. It does not take place of a knowledge engineer, but it helps him. Ultimate aim of the system development is increasing of efficiency of problem-solving environment structuring by the knowledge engineer. Using such system, he also studies conceptual modeling and uses it as an instrument of analysis of LPA texts and building the data- and knowledge-bases.

6.2. System functions

The system CONCEPT executes the following functions: creates a graphic image of problem-solving environment conceptual models and an equivalent symbolic images in computer memories; saves, edits and displays a graphic image of a conceptual model and its symbolic equivalent; creates and edits textual determinations of concepts and relations, their characteristic descriptions and graphic examples; enters texts and classifies lexical units with the help of the knowledge engineer saving them in the database; enters, saves and analyses texts for the extraction and saving the description of elements, resources, systems, actions and their characteristics, hierarchies and other spatial, temporary structures and processes in the database; enters, saves and analyses texts for the extraction and saving of 'If...then' rules to knowledge-base. The first four functions, which automate the development of a knowledge field and which are a basis for the following two functions have been created and passed laboratory tests.

7. CONCLUSIONS

In this paper there are the results stated which we have obtained in the process of development of knowledge based systems for the computer aided design of sea-going ship automation systems. These results refer to the first three stages in the development of the system: identification, conceptualization and formalizations of data and knowledgebases - the least formalized and difficult for the knowledge engineer. Realization of these stages is offered to be organized on the basis of generation of cognitive images - constructs in the memory of a knowledge engineer. The images are used for creating more complex one - conceptual models, and serve as a structured presentation of problem-solving environment. We have offerred and approved basics of creating conceptual models theory. For automation of creation, education of an knowledge engineer and usage of the conceptual models instrumental system CONCEPT is used.

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