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DEVELOPMENT OF EDUCATIONAL ONTOLOGY FOR C-PROGRAMMING

Sergey Sosnovsky, Tatiana Gavrilova

Abstract: *Development of educational ontologies is a step towards creation of sharable and reusable adaptive educational systems. Ontology as a conceptual courseware structure may work as a mind tool for effective teaching and as a visual navigation interface to the learning objects. The paper discusses an approach to the practical ontology development and presents the designed ontology for teaching/learning C programming.*

Keywords: *Ontology Design, Knowledge, Educational Ontology, C Programming, Ontology Visualization.*

ACM Classification Keywords*: K.3.2 Computer and Information Science Education; D.2.11 Software Architectures: Languages (e.g., description, interconnection, definition)*

Introduction

The intensity of modern technology development makes exceptional demands of the process of education. The speed of the knowledge deterioration increases steadily. According to the experts' reports the "half-value period" of a modern specialist is from 3 to 5 years. The number and the diversity of students grow up. Programs for life-long and distance education appear. Students differ in the learning goals, background, cultural aspects, which increase not only the volume of knowledge but also the ways, how it is taught. Different subjective views on the same knowledge for different groups of students may exist.

In these conditions a teacher as the main knowledge provider in the framework of modern education is overloaded. It becomes impossible for him/her alone to preserve the high quality of the knowledge taught. The solution is now obvious, knowledge should be created in the reusable and sharable form, in a way that once developed it could be used by anyone as a whole or partially.

Even greater need in making knowledge shareable and reusable is declared in the field of educational systems development. The knowledge base of a modern computer-based educational system should support the import and export of the knowledge in a standard format using standard protocols. Even for the domains where knowledge is pretty stable, like C Programming, such a perspective lead to the exceptional opportunity of using different systems from different developers in a common framework. The first step in this way is making the process of engineering of educational knowledge ontology-based.

The term of ontology emerged and became popular (even fashionable) during the last one and half decades. Though very yang it is yet a quite mature area of research. Ontological engineering inherits the practical and theoretical results of knowledge engineering, which has about forty yeas of history. According to one of the definitions "ontology is a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base" [Swartout et al., 1997]. It "defines the basic terms and relations comprising the vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary" [Neches et al., 1991].

In this paper we present the stepwise approach to ontology engineering and describe the experience of ontology developing for C-Programming. Developed knowledge structure is not just the hierarchy of the C language standard. It represents the application ontology designed for the purpose of education and accumulates the authors' experience of teaching several C-based programming courses. Next section gives details of the proposed algorithm for ontology development as well as a set of recommendations, which may be helpful in building a "beautiful ontology". Then in the section 3 we describe our domain, the motivation for the work presented here and, finally, the developed educational ontology for C programming. The summary and future work discussion conclude the paper in the section 4.

Stepwise Ontology Design

Generalizing our experience in developing different teaching ontologies for e-learning in the field of artificial intelligence and neurolinguistics [Gavrilova et al., 2004(a); Gavrilova, Voinov, 1998; Gavrilova et al., 1999; Gavrilova, 2003; Gavrilova, 2004(b)] we propose a 5-step algorithm that may be helpful for visual ontology design.

We put stress on visual representation as a powerful mind tool [Jonassen, 1996] in structuring process. Visual form influences both analyzing and synthesizing procedures in ontology development process.

Concise Algorithm for Ontology Design:

1. Glossary development: gather all the information relevant to described domain, select and verbalize all essential objects and concepts.
2. Laddering: define main levels of abstraction and define type of ontology (taxonomy, partonomy, genealogy, etc.). Reveal hierarchies among these concepts and represent them visually on defined levels.
3. Disintegration: try to detail "big" concepts into a set of "smaller" ones via top-down strategy.
4. Categorization: group similar concepts and create meta-concepts to generalize the groups via bottom-up structuring strategy.
5. Refinement: update the visual structure and exclude excessiveness, synonymy, and contradictions. Try to create beautiful ontology.

Some Precepts to Create Beautiful Ontology:

Conceptual balance (Harmony). It is a challenge to formulate the idea of well-balanced tree, but some tips may be helpful:

- One-level concepts should be linked with a "parent" concept by one type of relationship (is-a, has part, etc).
- The depth of the branches should be more or less equal (±2 nodes).
- The general outlay should be symmetrical.
- Try to avoid cross-links.

Clarity:

- Minimal number of concepts is the best tip according Ockham's razor principle proposed by William of Ockham in the fourteenth century: "Pluralitas non est ponenda sine neccesitate", which translates as "entities should not be multiplied unnecessarily". The maximal number of branches and the number of levels should follow Miller's number (7±2) [Miller, 1956].
- The type of relationship should be understandable if the name of relationship is missing.

C programming Ontology

Domain Description

During a number of years, we have been teaching C-based programming courses to undergraduate students of the School of Information Sciences at the University of Pittsburgh and artificial intelligence disciplines in Saint-Petersburg State Polytechnic University. Several adaptive computer-based systems have been developed for serving such learning activities as parameterized quizzes, interactive examples and social navigation [Brusilovsky et al., 2004(a); Brusilovsky et al., 2004(b); Brusilovsky et al., 2004(c)].

The natural development of such tools is an evolvement towards the distributed web-based architecture where applications share the common students' profiles (student model) and the ontology of the domain (domain model). Some progress in this direction has been made [Brusilovsky, 2004]. Ontology of the domain as a framework for common knowledge base would allow our applications to "speak the same language". Moreover applications from side developers can share our knowledge base and become the part of the architecture.

Another motivation to build the ontology of C programming is connected with the attempts to create more meaningful and effective teaching strategies as there is no predefined way to teach C. Different textbooks and different instructors (even when using the same textbook) may introduce C concepts, combine them into lectures and explain them one on the basis of another in very different orders. One teacher may believe that it is better to teach “while” before “if-else”, when another thinks visa versa. Not only the order of teaching concepts, but also the emphasis instructors' place on the different parts of the course and didactic paradigms they use could be different. Students may be required to learn first the structure of C program in details, or may be given “Hello World” example and immediately asked to code the similar program; the programming patterns for some courses (like algorithm design or data structures) might have much higher importance then for the introductory C course, etc.

The advantage of the ontology is that it attempts to unify different views on the domain. Selected parts of the ontology could be used for different sections of the course. The order, in which a teacher presents the material, is up to him/her while the basic hierarchical link structure is not violated.

Development of Educational C Ontology

We used the algorithm described above to create the ontology for teaching/learning C programming. Figure 1 demonstrates four top levels of the developed ontology. Lower levels trivially expand the hierarchy therefore we have hidden them. The main type of relationships is “has part”. That is why this is partonomy.

Naturally, the upper level central node is the C programming; second level represents the abstract meta-concepts, which combine more concrete entities. The major difficulties were to compose and to name these intermediate concepts. Figure 1 presents the fourth “release” of the design drafts.

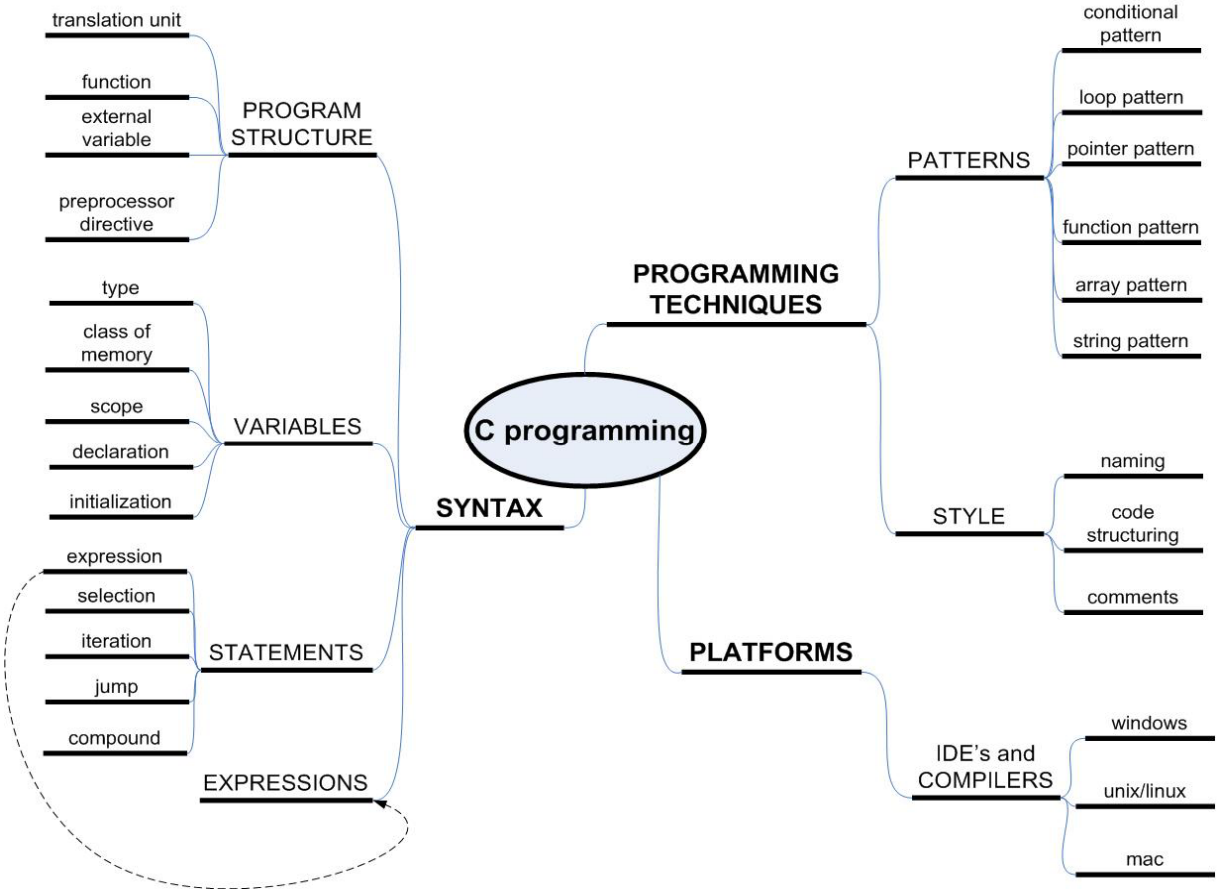

Figure 1. Top Levels of the Educaional Ontology of C Programming.

The concepts of the third level are the main parts of the material that students study. They combine very separate areas of C programming knowledge, where an emphasis needs to be placed. The entities of the third level in their turn are subdivided into programming topics as sub-concepts. These topics for some branches are already concrete enough to be the theme of the lecture or the section in a syllabus. However, as we mentioned before, this level is far from being the last one.

As we told already, the purpose of this ontology is use in education; therefore it attempts to reflect not simply the standard of the language, but all necessary knowledge that students need to learn, including helpful programming techniques and compiler usage. It does not mean that we necessary provide a system, which teaches students for example to work with compilers. However, this branch in the ontology let us to use it, say, for navigating them in entering the online compiler tutorials.

The association link between expression sub kind of statements and expressions as a section of the third level though adds some irregularity to our ontology, is needed because of the educational purpose. In C standard expression statement is a kind of statement. That is why expression is a sub concept of statements. However, from the point of view of teaching/learning C, expressions are totally different area then any other.

The expressive power of the ontology allows us to encode different relations between concepts (by concepts we mean here entities in the hierarchy, but not the knowledge elements of the lowest level). Besides the link topology representing the whole-part hierarchical relationships, the order of concepts in a group represent the interconnection between them and preferred sequence of their study, though the last one is rather a recommendation then a directive.

As the main source for knowledge elicitation on the stage of glossary development we used [Kernighan, Ritchie, 1988].

Summary and Future Work

The paper has proposed the stepwise algorithm for ontology development and implementation of this algorithm for creation of the educational ontology for C programming. Created ontology does not simply replicate the hierarchical structure of the C language standard, but reflects the authors' vision on what is important in studying C and accumulates their experience of teaching C-related programming courses. Following three subsections discuss the directions of the future research.

Ontology-based Common Domain Model

The developed ontology is going to be used for several computer-based educational systems as a domain knowledge representation model. The C programming as a domain for adaptive educational systems is "lucky" to be formal enough for its concepts possess grammatical structure. This is especially true for the sub kinds of the SYNTAX meta-concept (see figure 1). Traditionally, the extraction of grammatically meaningful structures from textual content and the determination of concepts on that basis is a task for the special class of programs called parsers. In our case, we have developed the parsing component with the help of the well-known UNIX utilities: lex and yacc. This component processed source code of a C program and generates a list of concepts used in the program [Sosnovsky et al., 2004]. This tool will help us to automatically index the content of our adaptive systems in terms of the concepts of the developed ontology. This leads us to the exceptional opportunities of implementing mutual adaptation across different educational application. As a result, the possible set of instructional strategies increases, since on every step instructional treatments from more applications are available.

Ontology Visualization

As we already mentioned above the ontology is not just a technical instrument but a powerful mind tool also. Ontology visualization and creation of a student interface for an educational system is one of the authors' primary goals. The hierarchical structure of the ontology makes it natural to create a navigable hypermedia interface on its basis. In 1995 Gaines and Shaw created the WebMap – system integrating concept maps (which can be to some extend considered as an ontology visualization technique) with WWW, making a first step in this direction [Gaines,

Shaw, 1995]. It seems very natural to use hypermedia as an implementation framework for ontology; hence we can use different methods of hypermedia adaptation, which are well developed now [Brusilovsky, 2001].

Ontology Evaluation

One more direction of future research is the evaluation of the developed ontology, from both perspectives: as a knowledge base framework and as an interface framework. From the first point of view, we can evaluate its structural consistency as a domain knowledge representation mechanism. Also, the quality of defined concepts as assessment units might be evaluated.

From the second point of view, the quality of ontology-based interface is to be evaluated on the subjective and objective levels. Subjective evaluation could be done on the basis of questionnaires filled by students at the end of the course. To evaluate it objectively we are going to perform the statistical analysis of logs of students' work with the system to find: first, how does work with the system correlates with course performance, second, how reasonable student use the interface, i.e. do they follow our hints and suggestions, and third, if they do, how do they benefit from it, how reasonably the system adapt its behavior to the specific student.

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DEVELOPMENT OF PROCEDURES OF RECOGNITION OF OBJECTS WITH USAGE MULTISENSOR ONTOLOGY CONTROLLED INSTRUMENTAL COMPLEX

Alexander Palagin, Victor Peretyatko

***Abstract**: the ontological approach to structuring knowledge and the description of data domain of knowledge is considered. It is described tool ontology-controlled complex for research and developments of sensor systems. Some approaches to solution most frequently meeting tasks are considered for creation of the recognition procedures.*

***Keywords**: the tool complex, methods of recognition, ontology.*

***ACM Classification Keywords**: I.4.8 Scene Analysis – Object recognition; I.2.9 Robotics – Sensors*

Introduction

One of the ambitious purposes of the world civilization is construction of the knowledge-oriented society. In computer science, a main priority direction thus is intellectualization of computer resources and technologies, in particular creation knowledge-oriented ontology controlled intelligence systems for various assignments. Information technologies on their basis are composing components of all high technologies. Except for usage in spheres of socioeconomic activity (the most difficult) spheres of research and development activity which result are objects of new knowledge, engineering, high technologies are rather important. The majority of these applications of intelligent systems is related to the problem solving, recognition (identifications), the diversification of their settings and implementation which are extremely various. The present material is devoted to usage of the

instrumental ontology-controlled complex for development of sensor systems, and in particular new (and refinement of already known) methods of recognition.

Productivity

Productivity is the most important parameter for the tasks related to recognition of signals data acquisition from external sources and their processing. The logical approach to the execution of these conditions is creation of tool complexes. Instrumental complex (IC) should unite in itself the block of interaction with an environment, the block of digital signal processing, and the block of interaction with the user. (Fig. 1)

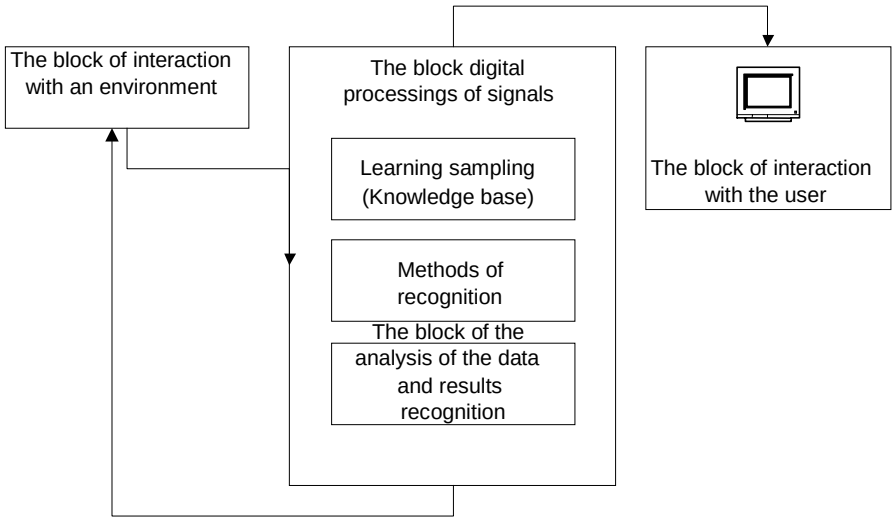


Fig. 1 Block-scheme of the tool complex.

The block of digital signal processing (DSP) contains the ontological component. Recently ontology's designing and knowledge processing become the object of steadfast notice of contributors of the various domains mainly ones operating in the knowledge engineering area. Among others, it is possible to mark such important directions of their interests:

- Knowledge management. To this directions such sections may be relevant as (intelligent) search, an automatic information accumulation from various sources (channels of news operating RSS), extract of knowledge from texts (Text mining) or sets of others - unstructured documents (text, databases, HTML, XML, etc.). The result of such analysis should become the generated document, which briefly formulates the major positions of the document, or groups of documents.
- Attempt to create advanced (system like ontology for WEB) [1]. Two key standards, which subsequently were used as a basis of the project named Semantic Web are completed. It is possible, that we are on a threshold of significant events' variations comparable with those, which have brought the Internet, World Wide Web and HTML. The given development - attempt to correct an ancient disadvantage of the Internet - its weak structure ability. New standards are Resource Definition Framework (RDF) and Web Ontology Language (OWL). They are the part of Semantic Web project and the main idea consists in making the information transmitted on the Network more clear, having provided possibility of identification, sorting and processing. Till now Web has been mainly oriented to operation of the person, but Web of the following generation, by opinion of developers of the project will be designed on the computer processing of the formation [1]. As a basis of the future WEB is assumed to be not only to search and read, but also to understand a contents of the Internet - information, and to reach it not through the creation of programs of the artificial intelligence,

simulating activity of the person, but through usage of resources of expression of semantics of the data and their links [2].

- Ontologies designing on the basis of available program systems which are reduced to filling special forms by the description of this or that data domain. Such developments are carried on more often in the research (educational) projects, for example [7].

Ontology

Ontology (O) as the formal description of the defined data domain can be represented as:

$$O = \{X, R, F\},$$

Where:

O - a finite set concepts (terms, quantum's of knowledge);

R - a finite set of the relations between concepts;

F - set of functions of interpretations of concepts and/or relations.

The set X is frequently bunched as subsets $X = \{X1, X2, \ldots Xq\}$, $q=1,2, \ldots, Q$ on subsumption to tags, making tree-like network structure. In a case $R \subset \varnothing$, $F \subset \varnothing$, ontology $O = \{X\}$ represents the usual dictionary - glossary.

Relation R - are served for association concepts in orderly structure (semantic model of a field of knowledge). Link is always unidirectional - one of the concepts is a grandparent, and another - the descendant. Link can define the ratio between quantity of grandparents and descendants 1:1, 1:N, N:1, N:M. Link can be hierarchical i.e. if A it is coupled with B, and B - with C and so on.

For effective scientific operation in this or that field of knowledge - it is necessary to fulfill the following standard procedures: to structure knowledge which concern both to a researched theme, and to adjacent areas, to study existing methods of researches, putting forward hypotheses and trying to check them on concrete examples to develop new methods.

Usually, the contributor fulfils all this, drawing up all logical chains as speak, in mind. In this case, designed in process of research operations ontology can help him in solution of a lot of the important tasks essentially. It is correctly and full constructed model of the field of knowledge can become the power factor for research and development designing operations. Even preliminary constructed variants of ontology give more complete "imbedding" in a theme researches (general domain). The description of objects and links connecting them will allow presenting more precisely processes, which occur in this or that system (a fragment of the system).

Ontology in the application to methods of recognition fulfils such functions:

- Formalistic - structuring of knowledges;
- Information- retrieval - carries out relevant navigation;
- Creative- generation of applications;
- Transforming- perfecting of the base methods of recognition;
- Extension- support of extended model computer ontology.

Computer Ontology

In [7] computer ontology is described which have been created on Lotus Notes platform (though at the given stage editors of ontology are developed, such as OntoEdit, OILed, Protege which give a graphic interface and create an output file according to standards of representation for Semantic Web). The program fulfilled on Lotus-Domino platform, is non-relational database which has the defined advantages: the convenient system of replication, the power 128 bit system of encoding, a built-in system of navigation, broadcasting of contents of base - programs in Web, etc.

The system is suitable for filling by the information from arbitrary fields of knowledges. In process of creation, the area of methods of recognition, which can be used, for construction of sensor systems has been selected.

The program will consist of the following blocks:

Categories - the description of categories which concern to a given theme,
Applications – examples of usages (demonstrations) of operations of different kind,
Navigation - relevant navigation by category (both through headers, and internal content),
Glossary – description of general scientific terms of ontology,
The library - storage of necessary files,
Diary - clone of an organizer. Allows to plan the operations and to bring various arbitrary records,
Help for the user.

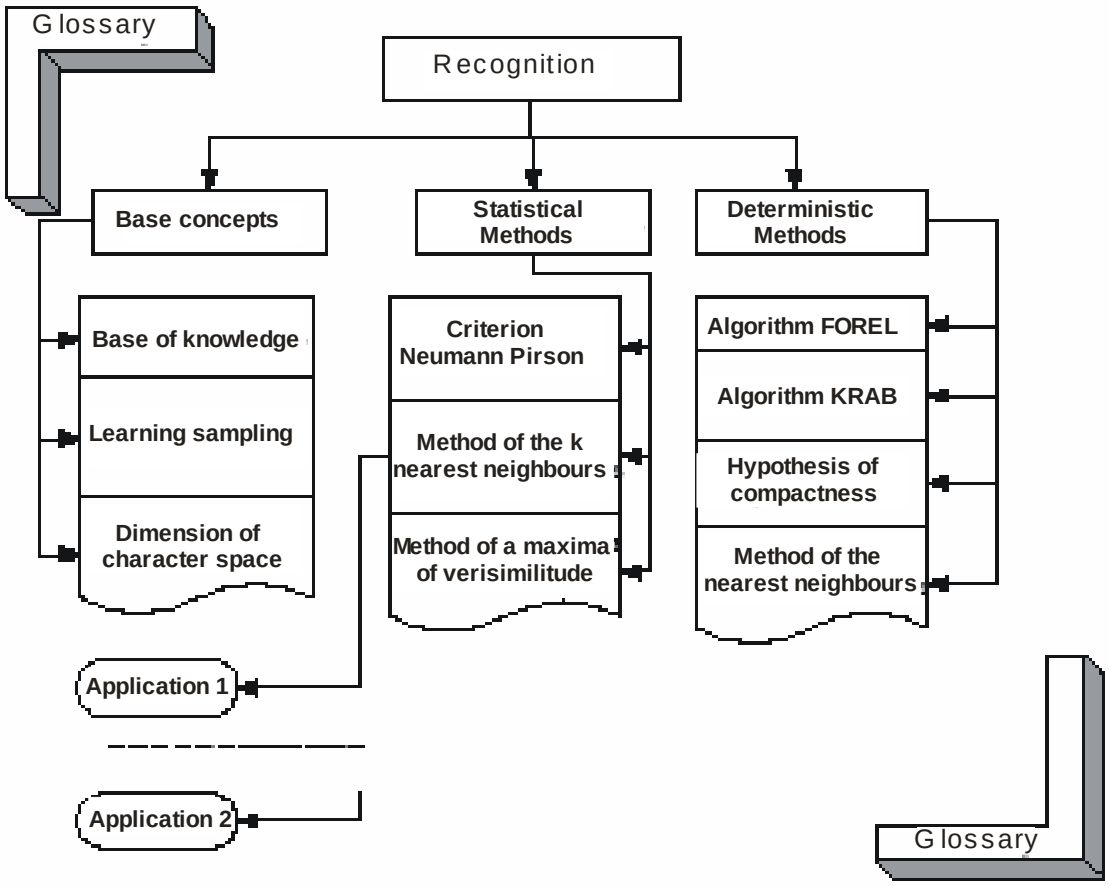


Fig. 2 Scheme ontology

Ontology represents an outline (see fig. 2). The theme ontology "Recognition" has three main categories: base concepts, statistical methods and deterministic methods. Inside these subsections also are concepts - quantum's of knowledge. It is necessary to mark that each of concepts can be referred to more than one subsection. For example, some methods of recognition are simultaneously statistical and deterministic ones. It is possible to connect the derived object of the application in which practical application of some concept is described in parent concepts to each quantum of knowledge. Besides, from anyone concept the reference to arbitrary others concepts, units of the application or a glossary can be created.

For each of concepts, (for each quantum of knowledge) it is underlined:

- Theme;
- The type of the message (definition, an explanation, an example, etc.)
- Category (in a case with methods of recognition - the class of a methods);
- Keywords;
- Weight coefficient of concept (on a five-point scale);
- The language of the message (Russian, English);
- Source.

More detailed description of ontological components of the complex is resulted in [7].

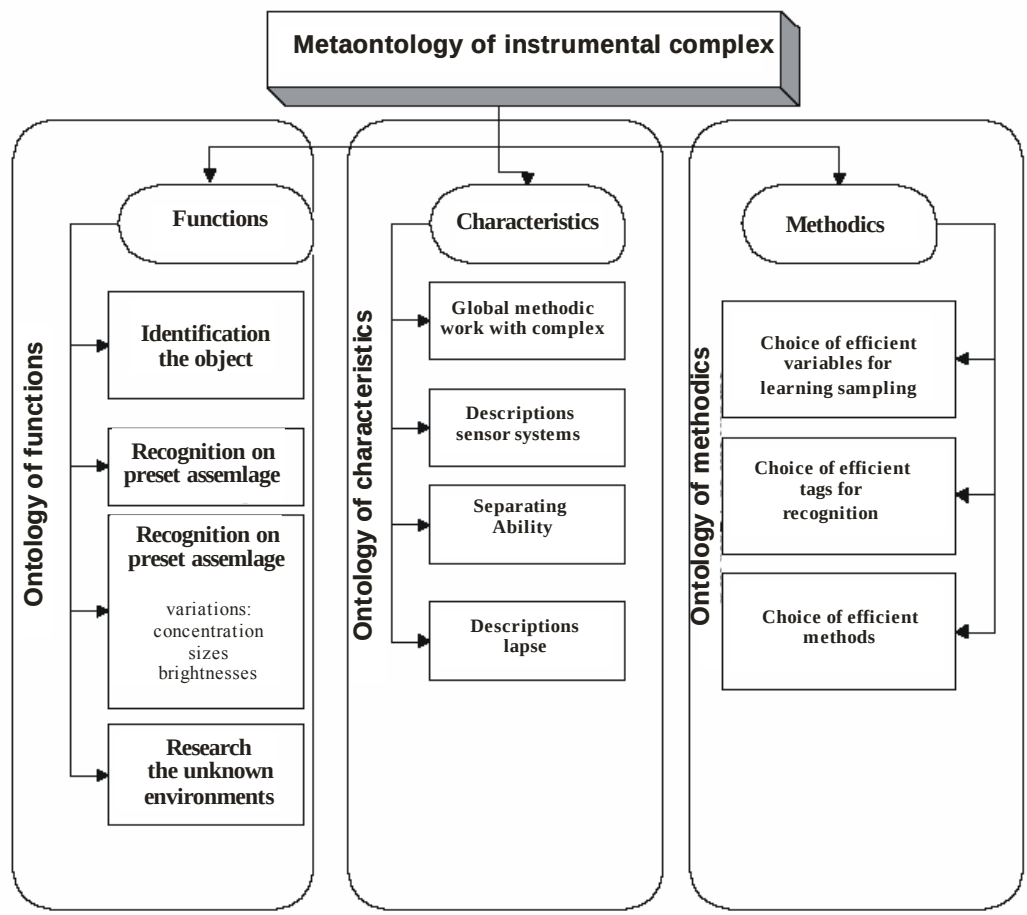


Fig. 3 Functional diagram instrumental complex

The modern level of development of the methods of a multivariate statistical analysis allows to carry out classification of objects on a wide and objective basis, in view of all essential structural - typological tags and characters of object allocation in the preset system of tags.

At logical level IC should contain such descriptions:

- Common procedures of operation with the complex for various conditions;
- Sets of characteristics of the block of interaction with an environment (a set of sensor controls, procedures of operation with them, errors, separating ability for various sorts of defined objects);
- A method (or several methods) of recognition;
- Procedures of choice of effective variables, for samplings;
- Procedures of choice (automatic or hand-held) of effective methods for operation with each concrete object or group of objects (fig. 3)

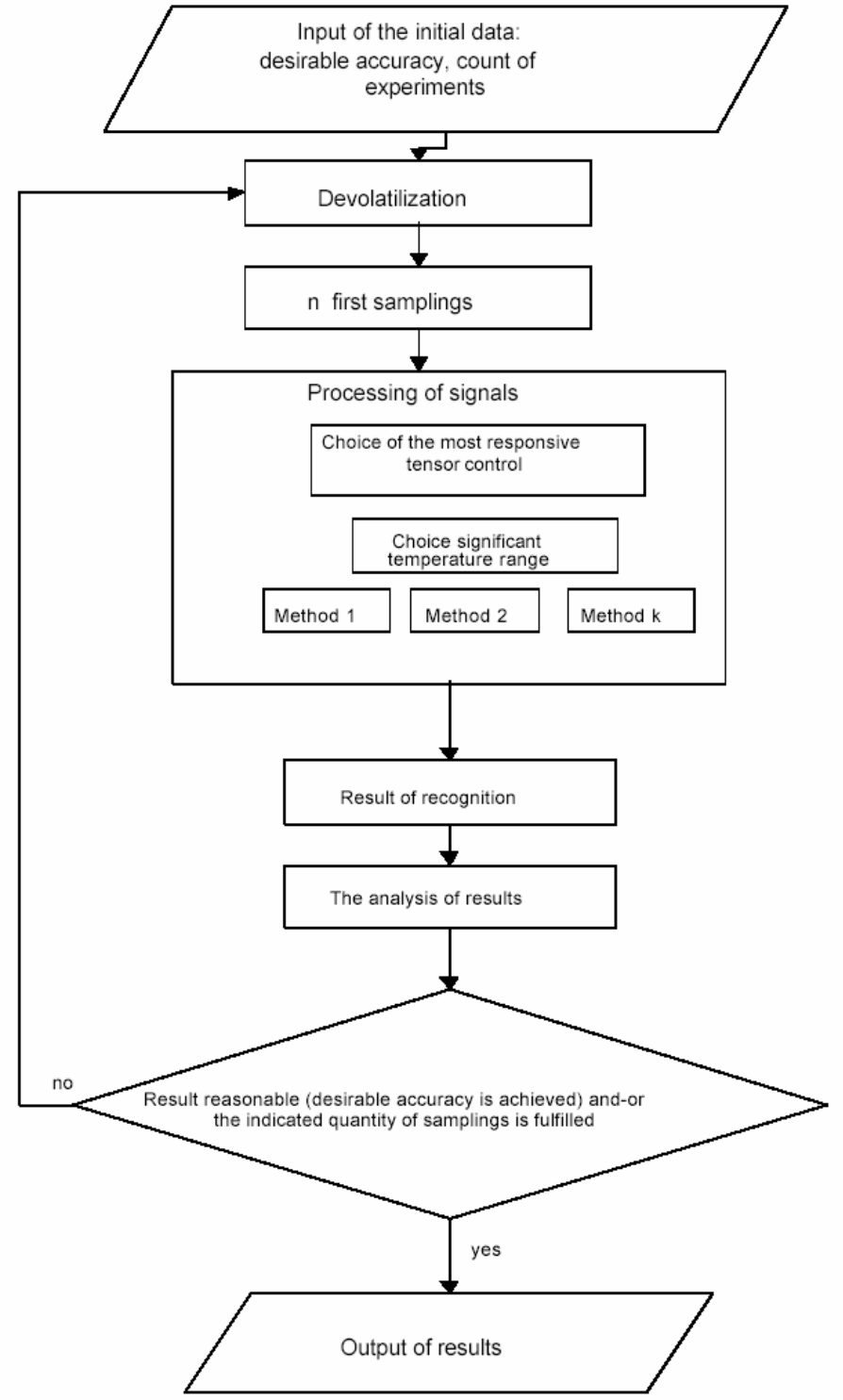


Fig. 4 Procedure of sampling

This tool complex is intended, in particular, for research of the gaseous environments, and coupled to a set of the sensor controls included in the projected instrument (system). Sampling procedure consists in removal of metrics from sensor controls at heating. The scheme of the procedure of removal of the data with the subsequent processing is represented on fig. 4.

Classification of Multivariate Objects

There are many methods of classification of multivariate objects with the help of a computer. Methods of the first group are connected with task of "recognition", identifications of objects and have received the name of methods of pattern recognition. The sense of recognition consists in that any object showed to the computer with the least probability of an error has been referred to one of beforehand-generated classes. Here to the computer all over again show a taught sequence of objects (about each it is known to what class or "image" ' it belongs), and then, "having trained", the computer should recognize to what classes from the investigated collection the proposed object is belonging.

More common approach to the classification includes not only reference of objects to one of classes, but also simultaneous creation of "images", the number of which can be beforehand unknown. At absence of a taught sequence such classification is made on the basis of tendency to collect in one group somewhat similar objects moreover so that objects from different groups (classes) were whenever not similar. Such methods have received the name of methods of automatic classification.

Now tens and hundreds of the various algorithms realizing multivariate classification automatically are developed. They are based on various hypotheses about character of allocation of objects in multivariate space of tags, on various mathematical procedures. Browses of these methods widely represented in the literature.

Various requirements are characteristic for various types and procedures of recognition of the objects to the measured data. In general, *choice given* (variables for recognition) is the most challenge in all chain of the operations coupled to recognition. Thus, it is possible to speak about two types of choice:

- About choice of the measured data: the most sensitive for these objects a range, periodicity, etc., that is those aspects which are defined *by a procedure of samplings* (and, accordingly, can be modified at this stage);
- About choice of variables – tags for *recognition.*

The Requirement of Independence

The requirement of independence of tags is typical of the majority of methods of recognition. The requirement is logically proved: if the data are dependent, the information contained in one tag, already is presented at the learning sampling, and in other measured variables the method of recognition can "tangle" its repetitions only. For example, for method Bayes (posterior probability) this requirement is extremely strict and mandatory. For other methods, this rule can be neglected. To such ones the methods based on clusterizations, "cognizance" objects (a method to the nearest units, a method of measurement standards) are concerned.

However, the independence of tags can be frequently guaranteed by the very sensor subsystem. For support of independence of tags pertinently takes advantage the check of correlation tags.

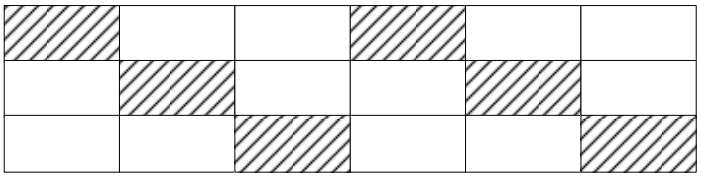
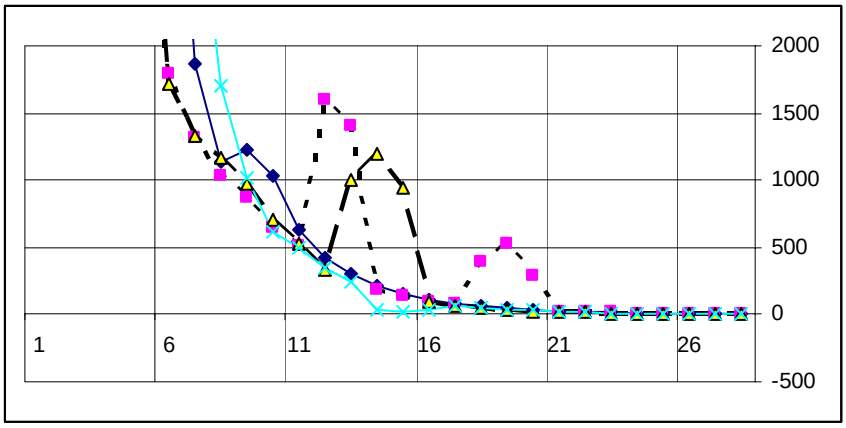


Fig. 5 Scheme of division of an interval of sampling on 6 parts, for definition of minimum correlation

For example, for obtaining an independent data set from 3 samplings the same process (object) it is possible to divide the data into intervals, and to check up on correlation each of intervals. Then the most correlated intervals are deleted from learning sampling (fig. 5.). Thus, it is possible to investigate, for definition of optimal quantity of parts. It is possible also, for the analysis of a digital data to make the various sorts of the intermediate

conversions, for more visual data representation, and, more convenient extract of the information from these data. For example, at presence of a plenty of the schedules constructed in one range, it is possible to construct a matrix in which to point that quantity of schedules which passes through each of coordinate squares. This information (fig. 6) can be used for development and modification of existing methods of recognition. In particular, it carries the information on potential possibilities of definition of measured objects on various intervals of a scale of argument.



4	1	0	0	0
4	2	0	0	0
4	4	1	0	0
0	4	4	4	4

Fig. 6 Schedules of the data, and a matrix of quantities

Conclusion

Considered tool ontology- controlled complex is the tool for creation and learning of procedures of identification of objects. Some approaches are resulted in creation of new procedures of the analysis and direct recognition.

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ANALOGOUS REASONING AND CASE-BASED REASONING FOR INTELLIGENT DECISION SUPPORT SYSTEMS

Alexander Eremeev, Pavel Varshavsky

***Abstract**: Methods of analogous reasoning and case-based reasoning for intelligent decision support systems are considered. Special attention is drawn to methods based on a structural analogy that take the context into account. This work was supported by RFBR (projects 02-07-90042, 05-07-90232).*

***ACM Classification Keywords**: I.2.6 [Artificial intelligence]: Learning – analogies; I.2.4 [Artificial intelligence]: Knowledge Representation Formalisms and Methods – semantic networks.*

1. Introduction

Investigation of mechanisms that are involved in the analogous reasoning process is an important problem for specialists in artificial intelligence (AI). The analogy can be used in various applications of AI and for solving various problems, e.g., for generation of hypotheses about an unknown subject domain or for generalizing experience in the form of an abstract scheme. AI experts model analogous reasoning by computers in order to develop more flexible models of search for solutions and learning. The great interest in this problem is caused by the necessity of modeling human reasoning (common sense reasoning) in AI systems and, in particular, in intelligent decision support systems (IDSS).

In this paper, we consider approaches and methods of search for solutions based on structural analogy and cases, which are oriented to use in real-time (RT IDSS). These systems are usually characterized by strict constraints on the duration of the search for the solution. One should note that, when involving models of analogous reasoning in IDSS, it is necessary to take into account a number of the following requirements to systems of this kind [1]:

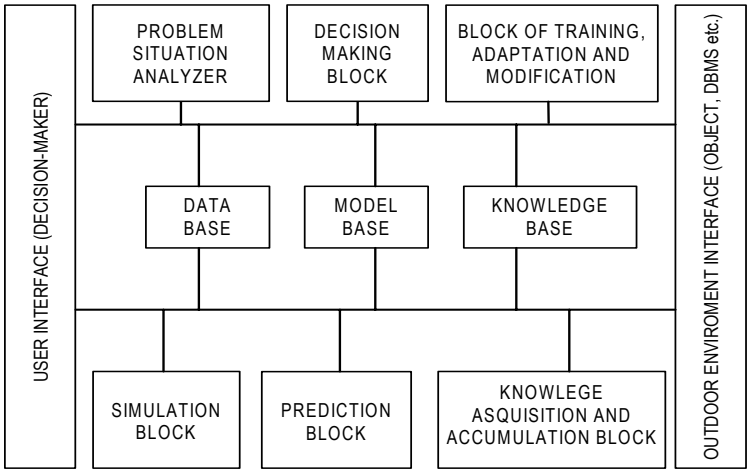

Fig. 1 Base RT IDSS structure

- The necessity of obtaining a solution under time constraints defined by real controlled process;
- The necessity of taking into account time in describing the problem situation and in the course of the search for a solution;
- The impossibility of obtaining all objective information related to a decision and, in accordance with this, the use of subjective expert information;

- Multiple variants of a search, the necessity to apply methods of plausible (fuzzy) search for solutions with active participation of a decision making person (DMP);
- Nondeterminism, the possibility of correction and introduction of additional information in the knowledge base of the system.

The generalized structure of a RT IDSS [2] is given in Fig. 1.

The search for an analogy-based and case-based solution may be applied in units of analysis of the problem situation, search for solutions, learning, adaptation and modification, modeling, and forecasting. The use of the respective methods in IDSS broadens the possibilities of IDSS and increases the efficiency of making decisions in various problem (abnormal) situations.

Special attention in this paper will be paid to the most efficient inference methods on the basis of structural analogy that take into account the context and rest on the structure mapping theory.

2. Analogous Reasoning

Questions about the nature of analogies, a formal definition, justification of reasoning by analogy, etc., arose in the time of epicureans and stoics. The attempts to answer these questions, starting from the first attempts of Leibniz to formalize this notion up to our time, have not received a final answer [3-4].

In encyclopedia the word analogy (analogia, Greek: correspondence, similarity, likeness, closeness) is defined as the similarity of objects (phenomena, processes) with respect to some properties. Reasoning by analogy is the transfer of knowledge obtained from an object to a less studied one, which is similar to the latter with respect to some essential properties or attributes. Thus, analogous reasoning can be defined as a method that allows one to understand a situation when compared with another one [4-6]. In other words, an analogy is an inference method that allows one to detect likeness between several given objects due to transfer of facts and knowledge valid for both objects, to other objects and to determine a means of problem solution or to forecast unknown properties. It is this type of inference that is used by a human in the first stages of solving a new problem.

Notwithstanding the fact that the method of analogy is intuitively clear to everyone and is actively used by humans in everyday life, the notion of analogy does not allow for complete formal definition and, hence one cannot uniquely describe the mechanism of reasoning by analogy. At the present time, there are a great number of various models, schemes, and methods that describe mechanisms of analogous reasoning [3-13].

Analysis of the literature has shown that one can distinguish various types of analogies [4-6]. Depending on the nature of information transferred from an object of an analogy to the other one, the analogy of properties and that of relations can be distinguished.

The analogy of properties considers two single objects or a pair of sets (classes) of homogeneous objects, and the transferred attributes are properties of these objects, for example, an analogy between illness symptoms of two persons or an analogy in the structure of the surfaces of Earth and Mars, etc.

The analogy of relations considers pairs of objects, where the objects can be absolutely different and the transferred attributes are properties of these relations. For example, using the analogy of relations, bionics studies processes in nature in order to use the obtained knowledge in modern technology.

According to plausibility degrees one can distinguish three types of analogies: strict scientific analogies, nonstrict scientific analogies, and nonscientific analogies.

A strict scientific analogy is applied to scientific studies and mathematical proofs. For example, the formulation of the attributes of the similarity of triangles is based on a strict analogy, which results in a deductive inference, i.e., which deduces a valid conclusion.

Unlike the strict analogy, a nonstrict scientific analogy results only in plausible (probable) reasoning. If the probability of a false statement is taken equal to 0 and that of the true statement is taken equal to 1, then the probability of inference by a nonstrict analogy lies in the interval from 0 to 1. To increase this probability, one need to satisfy a number of requirements to the method of reasoning by analogy, otherwise, a nonstrict analogy may become nonscientific.

The probability of conclusions by a nonscientific analogy is not high and often is close to 0. A nonscientific analogy is often used deliberately to perplex the opponent. Sometimes, a nonscientific analogy is used

unintentionally, by someone not knowing the rules of analogies or having no factual knowledge concerning the objects and their properties that underlie the inference. For example, nonscientific analogies underlie superstitions.

3. Case-based Reasoning

Case-based reasoning, like analogous reasoning, is based on an analogy; however, there are certain differences in their realizations [5-8]. In most encyclopedias precedent (from Latin, precedentis) is defined as a case that took place before and is an example or justification for subsequent events of this kind. To create a precedent means to give grounds for similar cases in the future, and to establish a precedent is to find a similar case in the past.

As the practice shows, when a new problem situation arises, it is reasonable to use this method of case-based reasoning without drawing an analogy. This is caused by the fact that humans operate with these reasoning schemes at the first stages, when they encounter a new unknown problem.

Case-based reasoning is an approach that allows one to solve a new problem using or adapting a solution of a similar well-known problem. As a rule, case-based reasoning methods include four main stages that form a CBR-cycle, the structure of which is represented in Fig. 2 [8].

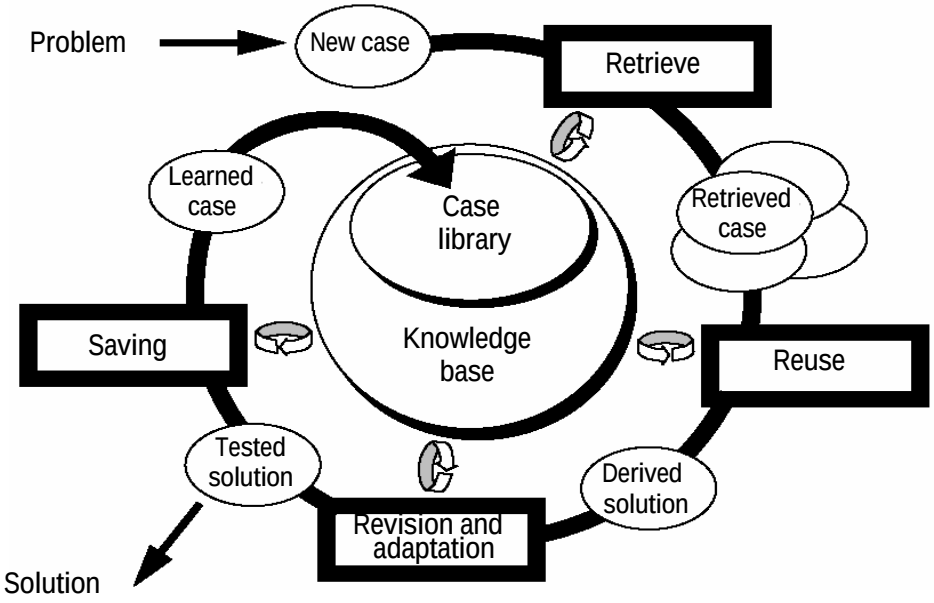

Fig. 2 The structure of CBR-cycle

The main stages are as follows:

- Retrieving the closest (most similar) precedent (or precedents) for the situation from the library of precedents;
- Using the retrieved case (precedent) for solving the current problem;
- If necessary, reconsidering and adaptation of the obtained result in accordance with the current problem;
- Saving the newly made solution as part of a new case.

It is necessary to take into account that a solution on the basis of precedents may not attain the goal for the current situation, e.g., in the absence of a similar (analogous) case in the case library. This problem can be solved if one presupposes in the CBR-cycle the possibility to update the case library in the reasoning process (inference) [5]. A more powerful (in detecting new facts or new information) method of search for a solution on the basis of analogy is a means of updating case libraries. We also note that the elements of case-based reasoning may be used successfully in analogy-based reasoning methods [7]; i.e., these methods successfully complement each other and their integration in IDSS is very promising.

In what follows, we consider in detail the methods of search for a solution on the basis of structural analogy, which allows one to take into account the context and are based on the structure mapping theory. We use semantic networks (SNs) as a model of knowledge representation.

4. Knowledge Representation in the Form of a Semantic Network for Analogous Reasoning

The choice of an SN for knowledge representation is due to an important advantage, which distinguishes it from other models, such as natural representation of structural information and fairly simple renewal in a relatively homogenous environment. The latter property is very important for RT IDSSs oriented to open and dynamical subject domains.

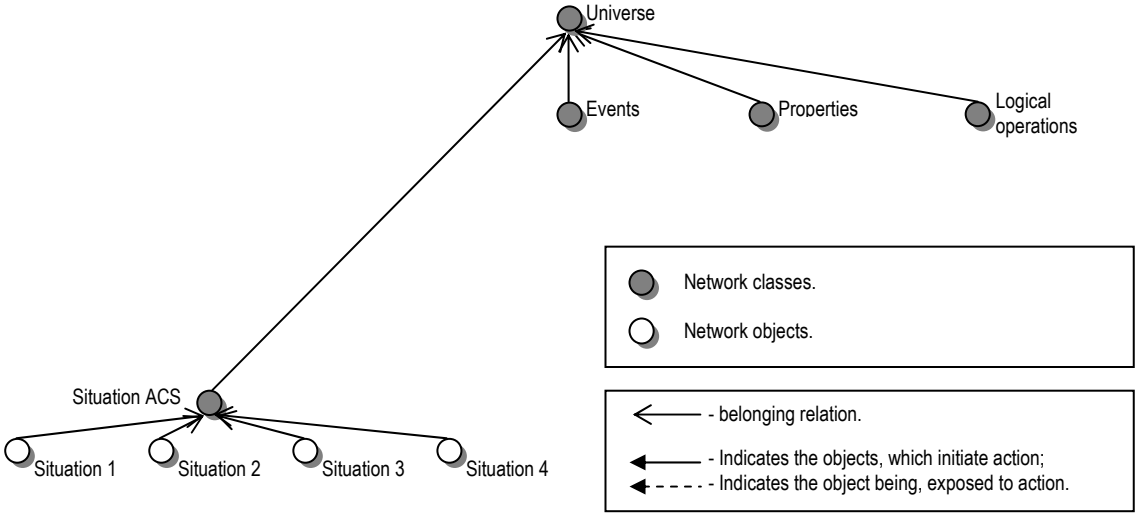

Fig. 3 (a) A fragment of the semantic network that represents the metalevel

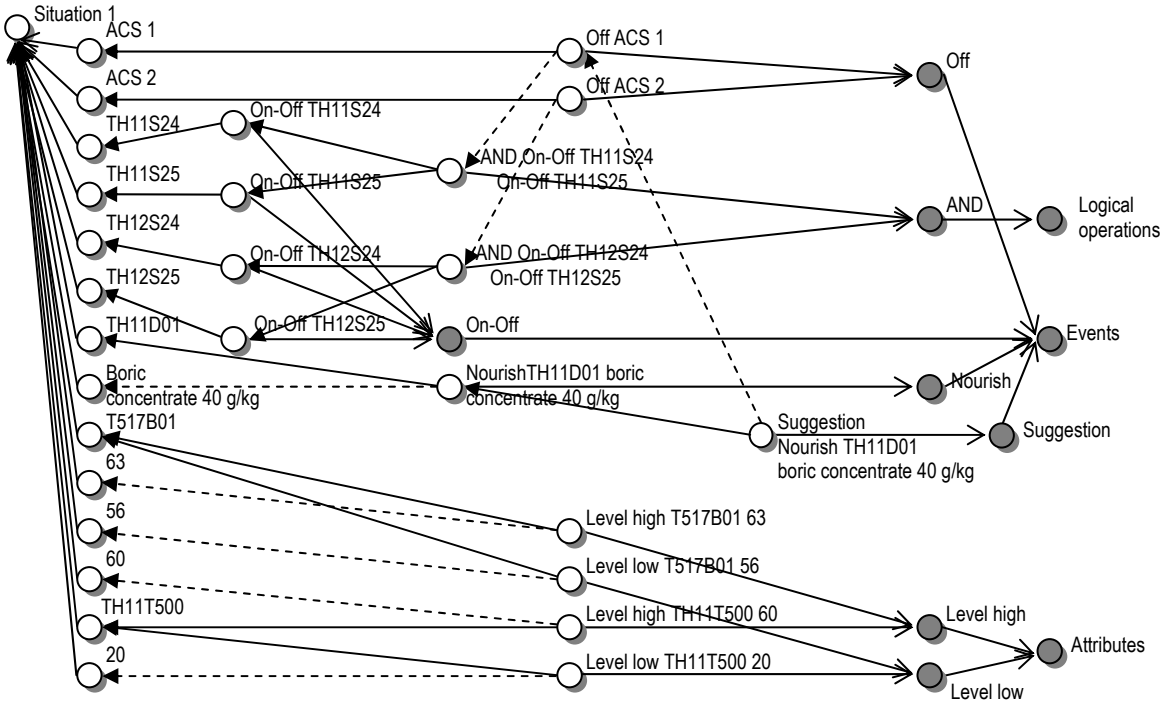

Fig. 3 (b) A fragment of the semantic network that represents the Situation 1 that was formed in the course of ACS functioning

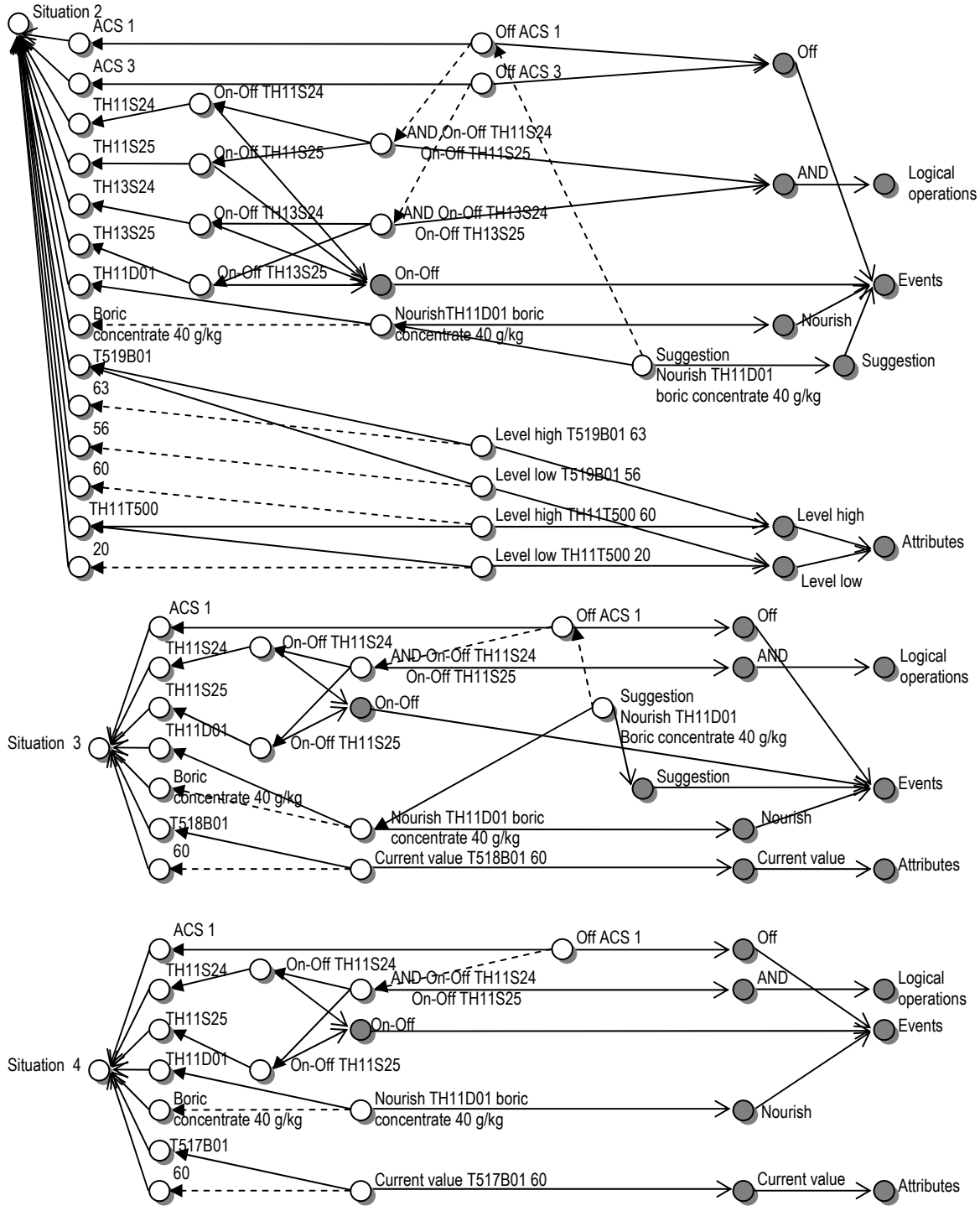

Fig. 3 (c) A fragment of the semantic network that represents the situations (Situation 2, Situation 3, Situation 4) that were formed in the course of ACS functioning

A semantic network is a graph <V,E> with labelled vertices and arcs, where V and E are sets of vertices and arcs, respectively. The vertices can represent objects (concepts, events, actions, etc.) of the subject domain, and the arcs represent the relation between them.

We consider the structure of the SN in more detail using an example from power engineering -operation control of nuclear power unit (Fig. 3).

We give a semantic interpretation of the information given in the SN for Situation 1 (Fig. 3b):

- It is recommended to inject TH11D01 with boric concentrate 40 g/kg caused by switching off ACS 1 (automatic cooling system) due to closing the gates TH11S24 and TH11S25;
- ACS is switched off due to the closed gates TH12S24 and TH12S25;
- The upper setting T517B01 (pressure in the container of ACS 1) is equal to 63;
- The lower setting T517B01 (pressure in the container of ACS 1) is equal to 56;
- The upper setting TH11T500 (temperature in the frame of ACS 1) is equal to 60;
- The lower setting TH11T500 (temperature in the frame of ACS 1) is equal to 20.

5. Search for a Solution on the Basis of Structural Analogy Taking into Account the Context

In [9] it was proposed to consider an analogy as a quadruple A = <O, C, R, P>, where O and R are the source object and the receiver object and C is the intersection object, i.e., the object that structurally intersects the object source and object receiver, which has a larger cardinality of the set of properties as compared with these objects. In other words, the analogy between the source object and receiver object is considered in the context of the intersection, and P is the property for definition of the original context. The structure of this analogy is represented in Fig. 4.

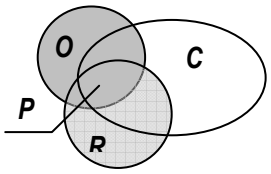

Fig. 4 Structure of analogy using the context

Using the described structure of the analogy, the authors of [9] propose an algorithm for the problem solution that is based on an analogy of the properties. An SN with information about the subject domain, a receiver R, and the property for defining the original context P provide input data for this algorithm.

The algorithm for the problem solution on the basis of an analogy taking into account the context consists of the following steps.

Step 1. Determine all objects of the SN, except for receiver R, that have property P. If there are no objects of this kind, then the search for a solution fails (without finding an analogy), otherwise, go to step 2.

Step 2. For the objects found in step 1, determine all possible intersections of C with R taking into account P. If there are no intersections of C, the first search for a solution fails, otherwise, go to step 3.

Step 3. From the objects extracted in step 1, determine all possible sources O for analogies with the receiver R and the intersection C taking into account P. In the case of success (possible analogies for R are defined), go to step 4, otherwise, the search for a solution fails.

Step 4. From the analogies extracted in step 3, choose the most appropriate (taking into account the requirements of the DMP). In the case of success, go to step 5; otherwise, the search for a solution fails.

Step 5. The analogies obtained in step 4 (which could be previously compared with each other taking into account the context) are given to the DMP, which means successful termination of the algorithm.

Having obtained analogies, the DMP may then make the final choice of the best ones. On the basis of these facts, the facts (properties) that hold for the source O are transferred to the receiver R.

Consider a modified algorithm for a problem solution that uses the structural analogy based on the modified structure of an analogy and the algorithm for the search of minimal intersections [5, 6]. The modification consists

in the fact that P is considered not as a unique property, but as a set of properties that determine the original context of the analogy.

As compared with the base variant, one of the main advantages of this modified algorithm is the possibility of realizing the search for a solution on the basis of an analogy without refining the original context, since in the result of the search for the minimal intersection, one can easily distinguish all possible contexts for the analogy. For example, if it is necessary to find analogues for Situation 4 (Fig. 3c), then, for the base algorithm, one should indicate property P to determine the original context (e.g., the property "Switch off ACS") since in the result analogues will be obtained in all possible contexts. Another important advantage of the modified algorithm is the possibility of a more detailed refinement of the original context for the determination of analogies; i.e., as P, one can choose several properties (e.g., "Switch off ACS" and "Switch off-Close TH11S24"). This is especially important in the work with a complex object, when one should operate with large amount of information, since the more detailed the original context, the faster the search for a solution on the basis of analogies will be realized and the more qualitative the solution obtained will be. Moreover, in the modified algorithm there is a possibility to construct an analogy taking into account the context between well-known objects, the source and the receiver.

Thus, in the execution of the modified algorithm the procedure of searching for minimal intersections is used. In turn, the minimal intersections determine the context for the analogy. At the second stage, depending on the fact whether an object source and a property or a set of properties are given, or there is no refinement of the original context from objects that are contained in the set of generators of minimal intersections, analogies are formed. In the case of successful termination of the search for a solution on the basis of analogies, new facts for the receiver object will be obtained.

6. Search for Solution on the Basis of an Analogy Based on the Structure Mapping Theory

Structure mapping theory (SMT) allows one to formalize the set of implicit constraints, which are used by the human who operates notions such as analogy and similarity [10]. This theory uses the fact that an analogy is a mapping of knowledge of one domain (base) in another domain (target) based on the system of relations between objects of the base domain, as well as the target domain. The main principle of SMT is that of a systematic character, which reflects the fact that humans (DMP) prefer to deal with a system of connected relations, not just with a set of facts or relations.

According to SMT, the inference process on the basis of analogies consists of the following stages.

1) Definition of potential analogies. Having the target situation (target), define another situation (base) that is analogous or similar to it.

2) Mapping and inference. Construct a mapping that consists of matches between the base and the target. This mapping can contain additional knowledge (facts) about the base that can be transferred to the target. These pieces of knowledge are called candidates of conclusions formed by an analogy.

3) Estimate the match "quality." Estimate the correspondence found using structural criteria such as the number of similarities and differences, the degree of structural correspondence, and the quantity and type of new knowledge synthesized by analogy from the conclusion candidates. We stress that the estimate of the "quality" of matching in SMT is based only on structural criteria that distinguish analogies from other types of inference.

Besides analogies, other types of likeness based on structurally compatible mapping can be represented in SMT. In the case of an analogy, only structures of relations are mapped, while the properties of objects that do not play role in the structure of relations are ignored. In strict likeness both the structures of relations and the properties of objects are mapped. In purely external matching, object properties are mapped (e.g., as in the metaphor "The road is like a silver band"), and in abstract mapping the entities in the base domain are not objects, but some variables.

Consider the structure mapping engine (SME) which is based on SMT [11-12]. This mechanism is suited for modeling inference by an analogy providing the match of an estimate independent of the subject domain. The input data for the SME algorithm are structural representations of the base and target domains.

Algorithm SME consists of the following steps:

Step 1. Constructing local mappings. Determine the matches (mapping hypotheses) between separate elements in the base and target domains by means of the following rules:

(1) If two relations have the same name, then create a mapping hypothesis.

(2) For the mapping hypothesis between relations, test the arguments: if they are objects or functions, then create for them local mapping hypotheses. Determine the plausibility estimates for these local hypotheses using the following rules:

(a) increase the plausibility degree for the correspondence if the base and the target relations have the same names;

(b) increase the plausibility degree for the correspondence if it is known that the base relation has the parent relation.

Rule (a) prefers the identity of relations, and (b) reflects the principle of the systematic character of relations.

Step 2. Construction of global mappings. Form mapping systems that use compatible pairs of objects (Emaps). Unite them in systems of relation with compatible mapping of objects. With each global mapping of this kind (Gmap), relate the set of conclusion candidates.

Step 3. Construct conclusion candidates. For each mapping Gmap, construct a set of the facts (possibly empty) that occur in the base domain, which does not occur originally in the target domain.

Step 4. Estimate of global matches. The global matches receive a structural estimate that is formed taking into account the plausibility of local correspondence. Terminate.

Thus, as a result, the most systematic consistent mapping structure Gmap that includes the following components arises: matches is set of paired mappings between base and target domains; conclusion candidates is the set of new facts that presumably are contained in the target domain; structure estimate is a numeric equivalent of the match quality based on the structural properties of Gmap.

The main advantages of SME that are especially important for RT IDSS are the polynomiality of the considered SME-algorithm and the simplicity of importing the conclusion candidates in the target domain. Note that this mechanism is used in a number of research systems (in the domain of plausible inference on the basis of analogies), in particular, in the systems ACME, LISA, IAM, Sapper, CyclePad, PHINEAS [12].

7. Conclusion

Methods of the search for a solution on the basis of a structural analogy and cases were considered from the aspect of their applications in modern IDSS, in particular, for a solution of problems of real-time diagnostics and forecasting. Methods based on analogies of properties and relations were described. An example of an algorithm for the search of a solution on the basis of an analogy of properties that takes into account the context was proposed. A more efficient algorithm, in the sense of the solution quality, is proposed. It uses a modified structure of an analogy that is capable of taking into account not one property (as in the base algorithm), but a set of properties. These properties determine the original context of the analogy and transfer from the source to the receiver only those facts that are relevant in the context of the constructed analogy.

We stress once again that analogous reasoning can be used both for solution of well-formalized problems and for the problems of search forecast (as is done, e.g., in the JSM-method of automated hypothesis generation [13]). In other words, analogous reasoning is an approximate inference rule based on heuristic mechanisms. Therefore,

any solutions obtained with the use of it should be amplified by reliable methods of reasoning if their use is planned for making important decisions or actions.

The presented method was applied in realization of a prototype of a RT IDSS on the basis of nonclassical logics for monitoring and control of complex objects like power units.

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DIALOG BASED ON GRAPHICAL STATIC SCENES MANAGED BY AN ONTOLOGY

Valeriya Gribova

Abstract. *A new method to implementation of dialog based on graphical static scenes using an ontology-based approach to user interface development is proposed. The main idea of the approach is to form necessary to the user interface development and implementation information using ontologies and then based on this high-level specification to generate the user interface.*

Keywords*: Ontology, interface model, user interface development*

ACM Classification Keywords*: I.2.2 Artificial intelligence: automatic programming*

Introduction

The user interface is an integral part of most software systems. Experts note that complexity and functionality of software systems are increasing every year; at the same time the number of users with a wide range of expertise and, accordingly, requirements to software is rapidly growing. The competition at the software market is increasing, too. All these factors demand a tool capable of realizing dialog between the user and software in accordance with his or her requirements, which are subject to changes during the software life cycle.

Modern tools for user interface development – Interface Builders, User Interface Management Systems, Model-Based Interface Development Environment – are, on the one hand, only oriented to implementation of the GUI (Graphical User Interface) based on using different interface elements – menus, windows, buttons, lists, etc. On the other hand, they do not support design of all user interface components.

To solve the problems mentioned above a new ontology-based approach to user interface development is proposed. The main idea of the approach is to form information necessary for the user interface development and implementation using ontologies and then, based on this information, to generate the user interface. For implementation of different types of dialog (verbal and graphical), ontologies of the graphical user interface and of graphical static scenes on a plane have been developed. They manage design of the presentation component of the user interface and allow us to implement various types of the dialog.

The aim of the present study is to describe implementation methods of various types of the dialog - verbal and graphical - within the limits of the ontology-based approach to user interface development.

The Basic Conception of the Ontology-based Approach

Rapid software progress demands that the cost of interface development need to be decreased, and its maintenance need to be simplified, which is even more important. According to experts, for example, [1] software maintenance exceeds the cost of its development in 3 or 4 times. These requirements in full measure relate to user interface development. The user interface has an additional requirement, namely, adaptability for users with a wide range of expertise.

Taking into account the requirements mentioned above, a new approach to user interface development based on ontologies is suggested [2]. The approach is a modification of the model-based approach to user interface development [3].

The main ideas of the ontology-based approach are as follows: aggregation of uniform information in components of an interface model, formation of information for every component on the basis of the appropriate ontology model and automated the code generation according to this information.

The interface model consists of a domain model, a presentation model, an application program model, a model of a dialog scenario and a relation model.

The domain model determines domain terms, their properties and relations between them. In this system of concepts, output and input data of the application program and information on the intellectual support of the user are expressed.

The presentation model determines a visual component of the interface. It provides support for various types of the dialog.

The application program model determines variables, types of their values shared by the interface and the application program, protocols for communication between the application program and the interface, addresses of servers and methods of message transfer.

The model of a dialog scenario determines abstract terms used to describe the response to events (sets of actions, executed when an event is occurs, sources of events, modes of transfer between windows, methods of the window sample selection and so on).

The relation model determines relations between components of the interface model.

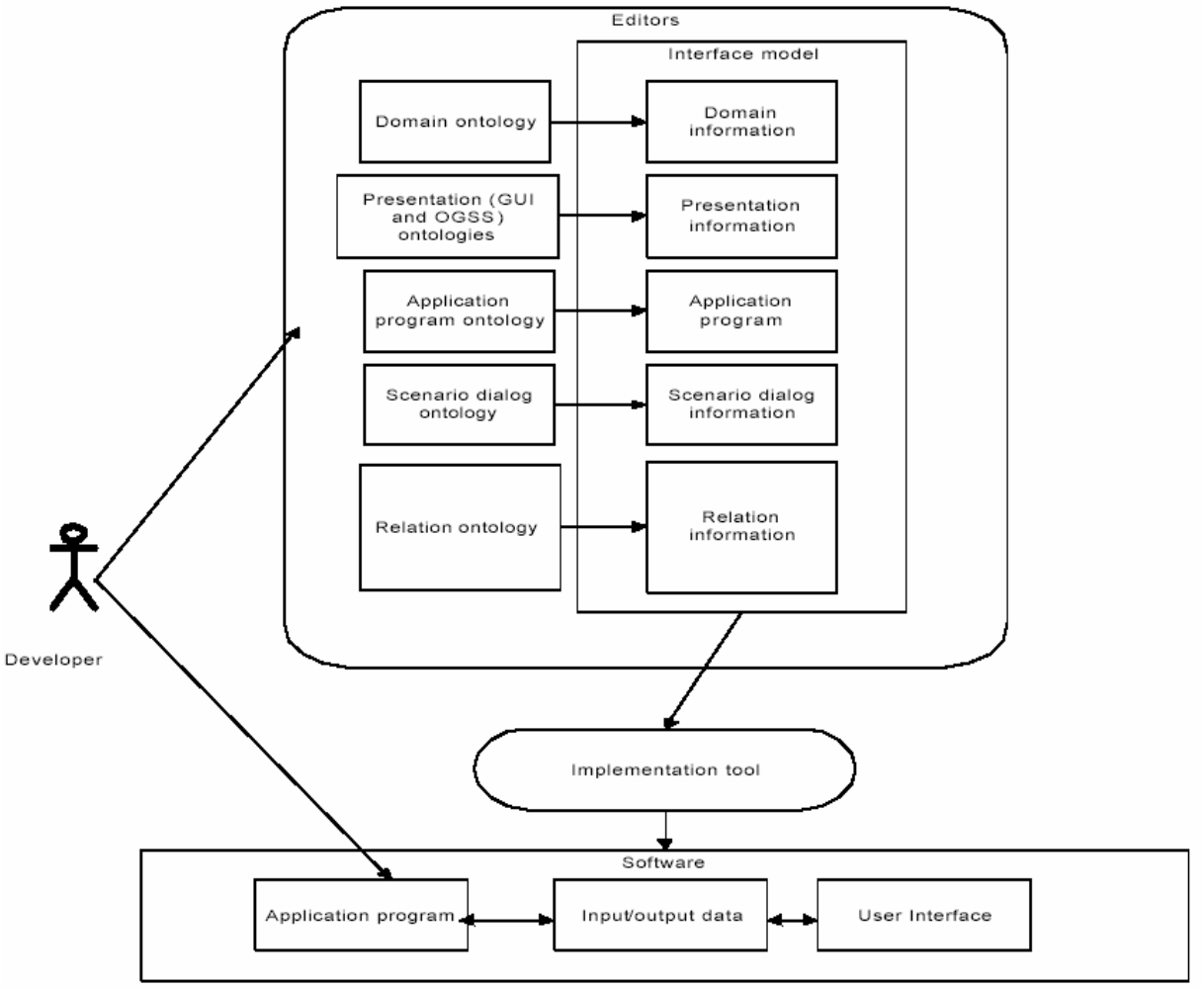


Fig. 1. The basic architecture of the user interface development tool based on ontologies

Fig. 1 shows the basic architecture of the user interface development tool based on ontologies. We show only the basic one because (the architecture) as a whole involves additional components such as design critics, advisors, automated design tools, etc. These components are not included in the basic architecture.

An Approach to Implementation of Various Dialog Types

When the user interface is developed, it is necessary that information representing input and output data of an application program be presented in accordance to user requirements and in forms accepted in the domain for which the software is developed.

In this case time various representation forms of information and types of dialog, for example, verbal and graphical, are often required in the framework of the same interface. Fig. 2 shows how the information can be presented to users in various forms. According to our conception, an ontology model for creating and managing every component of the model interface is suggested.

In this way, the interface developer creates domain information. It is a verbal description of domain terms, their properties and relations with other terms. This domain information can be presented in the interface verbally or graphically in various forms depending on user's requirements to representation of information, expertise of users and on their preferences.

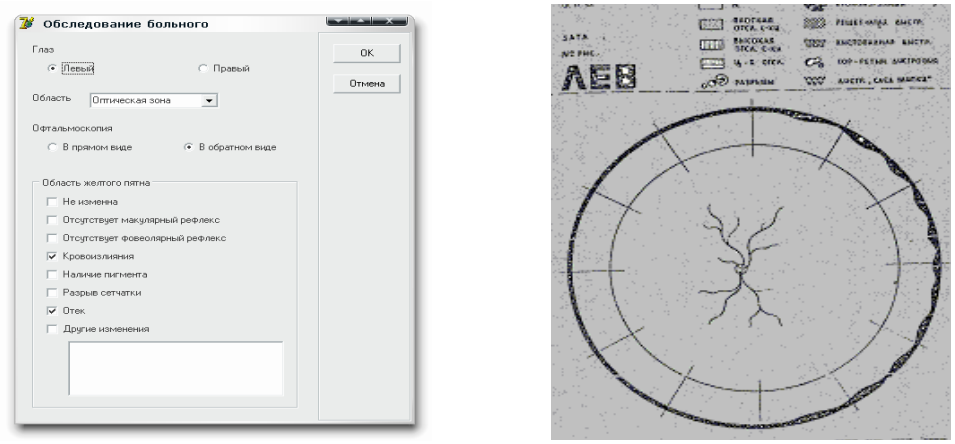


Fig. 2 Representation the same information in various forms

The presentation model is responsible for representation of a domain model. The former is the basis for visual representation of the interface.

To combine various dialog types in the framework of the same interface two ontologies are suggested, the ontology of the graphical user interface (OGUI) and the ontology of graphical static scenes on a plane (OGSS).

The OGUI is intended for presentation of information in the verbal form using interface elements – windows, menus, lists, buttons, etc. The OGUI describes interface elements, their properties and relation to one another. Interface elements permit the user to choose and install values, to start operation and also to move within the program. At present, the OGUI in the OIL language is available in the Internet [4]. The process of design information in the verbal form consists in correlating domain fragments with interface elements and specifying properties of interface elements (dimension, color, location and so on).

The design process in the form of graphical scenes is accomplished by the OGSS. For this purpose terms of the domain are associated with graphical images and their properties peculiar for a particular interface are specified. The generation of graphical scenes, their interpretation (input data for an application program) and automated construction of graphical scenes (output data of a application program are accomplished by the OGSS. Thus, the OGSS is the managing structure for organization of dialog based on graphical scenes.

To provide flexibility and simplify modification of the user interface the correlation between input and output data and term values is established on the basis of the domain model, as the output and input data are independent of the dialog type.

The Ontology of Graphical Static Scenes on a Plane

To implement dialog based on graphical scenes a domain independent the OGSS has been developed. A graphical static scene S on a plane is defined as: S = <B, F, P>, where B is the base graphic representation, F - filler, P - primitive. Fig. 3 shows the OGSS model in the URL language [5].

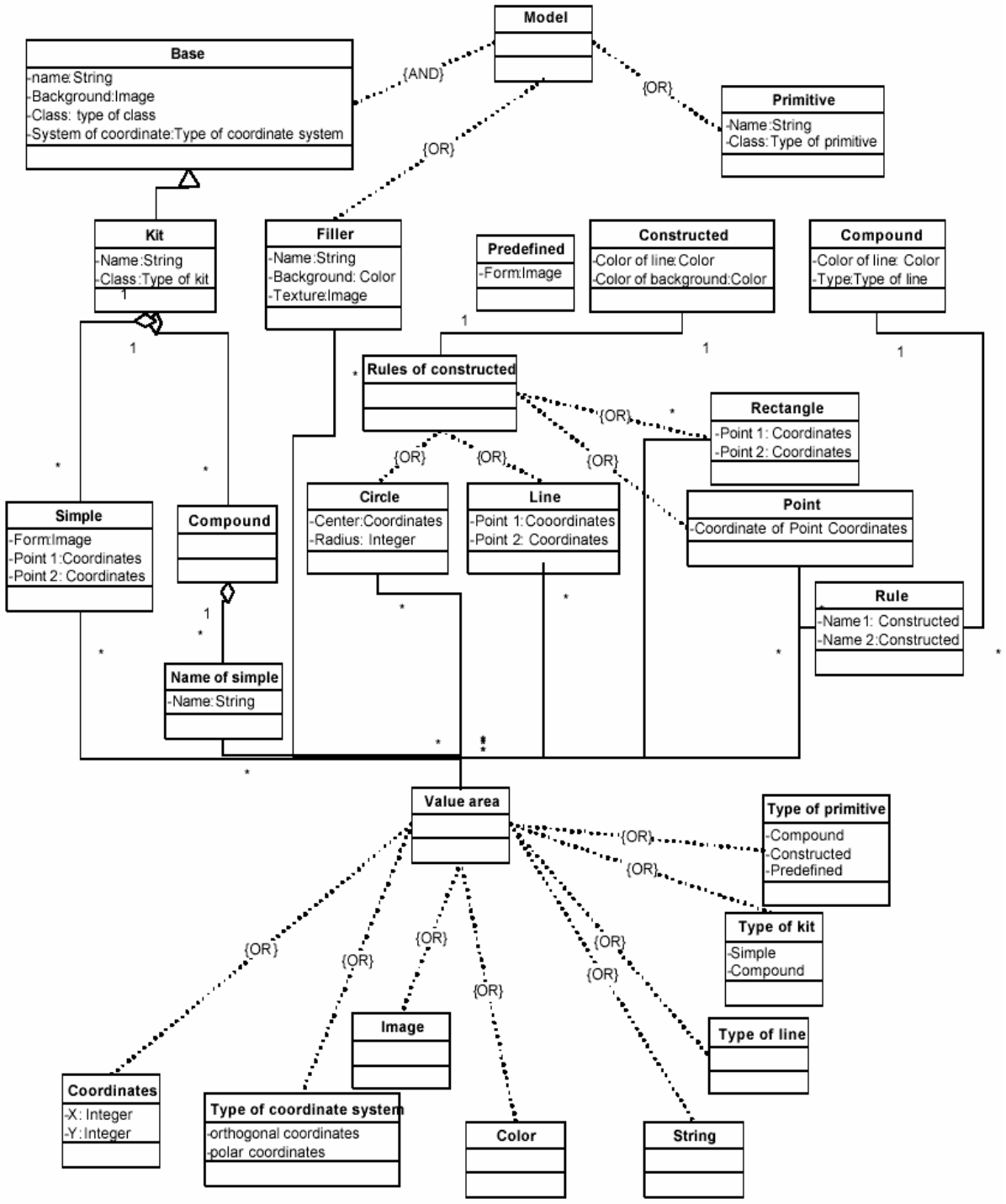


Fig. 3. The model of the ontology of graphical static scenes on a plane

The base graphic representation B, further for brevity named the base, is any graphic figure, scheme, sketch, etc., being a basis for drawing various images on it. The base B consists of the following elements: B = (NmB, ImB, Db, Db′), where NmB is the base name, ImB is the base image, Db is the description of the main elements of the base, and Db′ is the alternative description of the base elements.

The description of the main elements of the base is Db={(b1,nb1), (b2,nb2),…,(bn,nbn)}. Here b1,…,bn are simple elements of the base image, such as B=b1∪b2∪…∪bn, i.e. merging simple elements forms the base image; nb1,…,nbn - names of simple elements. The alternative description of elements of the base is Db′={(b′1,nb′1), (b′2,nb′2),…,(b′f,nb′f)}. Here b′1,b′2,…,b′f are compound elements of the base image, nb′1,…,nb′f are names of compound elements of the base image. Each compound element is some merging of simple elements of the base image, i.e.

b′1=bi1 ∪bi2∪…∪ bik, where 1≤k≤n, bi1,bi2,…,bik, are simple elements of the base image;

b′2=bj1 ∪bj2∪…∪ bjh, where 1≤h≤n, bj1,bj2,…,bjk are simple elements of the base image;

b′f=bv1 ∪bv2∪…∪ bvd, where 1≤d≤n, bv1,bv2,…,bvk are simple elements of the base image.

The filler determines possible color and texture options for elements of the base image. A set of possible fillers can be defined for the base F={f1,f2,…,fn}. The filler is defined as fi=<Nfi, Col, Tex>, where Nfi is the name of the filler, Col is the color of the filler, Tex is the texture of the filler.

The primitive determines possible images applied on the base image. A set of possible primitives can be defined for the base: P=p1,p2,…,pn. The primitive pi is defined as: pi=<Npi, Tp, Dp(Tp)>, where Npi is the name of the primitive, Tp is the type of the primitive, Dp(Tp) is the description of the primitive. The type of any primitive can be defined as Tr is predefined, Tb is constructed, Tc is compound.

By the predefined primitive is meant a primitive whose image is known. The description Dp(Tr) of the predefined primitive is Dp(Tr)= < Ip>, where Ip is the image of the primitive.

The constructed primitive it defined by a form, a color of a line and a background. Hence it has the following description: Dp(Tb)=< F, R(F), Cl, Cb>, where F is the form of the primitive, R(F) is the rule for construction of the primitive of a specified form, Cl is the color of the line, Cb is the color of the background. The following forms of a primitive are defined: a circle, a point, a line and a rectangle. For each form, it is necessary to define rules of its construction. The rule of a circle construction is defined by the circle center coordinates and radius: R(circle) =<(x,y), r>; the point is defined by the coordinates: R(point) =<(x,y) >; the line is defined by coordinates of two points: R(line) =<(x1,y1), (x2,y2)>; a rectangle is defined by coordinates of two points, its top left and lower right vertexes: R(rectangle) =<(x1,y1), (x2,y2)>.

The compound primitive is a set of constructed primitives, connected by themselves by lines of a certain color and type: Dp(Tc)=< {(Npi, Npj), (Npj Npk),…, (Npn Npv)}, Cl, Lt>. To describe the compound primitive it is necessary to determine a set of pairs of constructed primitive names (Npi, Npj), that must be connected by lines of a certain color Cl and type Lt.

The Design Process of Dialog in the Form of Graphical Static Scenes

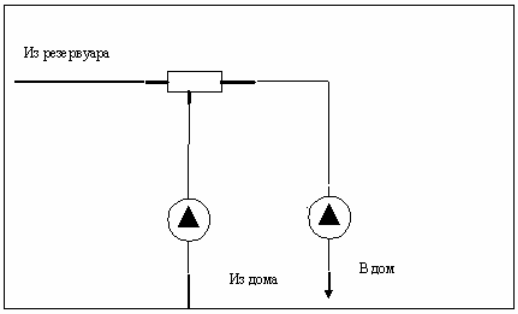
The design process of dialog in the form of graphical static scenes is carried out in two phases.

At the first phase, it is necessary for the interface developer to correlate elements the OGSS with the information, specific for a certain domain. In this way, the developer defines a base, i.e. its image, name (a term of the domain), as well as names and images of base components. Further, with the same editor the developer determines fillers and/or primitives by specifying their possible properties.

At the second phase the developer forms the design of the interface, namely, specifies location of the base, primitives, fillers and additional elements of the graphical user interface determined by the OGUI.

The input data dialog of the user with the applied program consists in composing the graphic static scenes. Fig. 4 shows examples of graphical static scenes. According to the specification of the OGSS for a certain domain, the interface recognizes a graphic scene and transfers values of the output data to the applied program in the format

assigned by the developer. Then the interface generates graphical scenes based on computation results of the applied program in conformity with the same description.



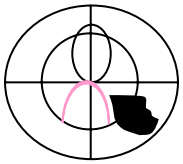


Fig. 4 Examples of graphical static scenes for heat supply and medicine domains.

Discussion

Development of the user interface combining various types of dialog (verbal and graphical) is a topical problem. No less important, as noted above, is the problem of reducing the cost of development and simplifying maintenance of the user interface. In the paper, we have considered how the proposed technology of development allows the specified problems to be solved.

First, the interface is automatically generated based on the declarative description of its model.

Second, information for each component of the model is formed on the basis of the ontology model offered to the developer.

Third, the interface developer can generate various types of dialogues according to requirements of users (verbal and/or graphical on the basis of the OGUI and the OGSS.

Fourth, information transmitted to the applied program and back (the input/output data) does not depend on the form of its representation to the user and is formed based on the domain model. Thus, modification of the dialog does not require any modification of other interface components.

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A WEB-SYSTEM FOR COMPUTER EXPERIMENTS IN THE FIELD OF PROGRAM TRANSFORMATIONS

Margarita Knyazeva, Alexander Kleshchev

Abstract: *The paper presents basic notions and scientific achievements in the field of program transformations, describes usage of these achievements both in the professional activity (when developing optimizing and unparallelizing compilers) and in the higher education. It also analyzes main problems in this area. The concept of control of program transformation information is introduced in the form of specialized knowledge bank on computer program transformations to support the scientific research, education and professional activity in the field. The tasks that are solved by the knowledge bank are formulated. The paper is intended for experts in the artificial intelligence, optimizing compilation, postgraduates and senior students of corresponding specialties; it may be also interesting for university lecturers and instructors.*

Keywords: *Knowledge bank; Ontology; Knowledge base; Ontology editor; Database editor; Knowledge processing; Program transformations; Optimizing compilation*

ACM Classification Keywords*: I.2.5 Artificial intelligence: programming languages and software*

Introduction

The science, higher education and professional activity are closely linked in knowledge-intensive domains. Scientific achievements – the foundation of higher education content – are used in the professional activity and contribute to its progress. Higher education institutions train specialists both for science and professional activity. The more university graduates are aware of the latest scientific breakthroughs, the more they are in demand both in science and professional activity which is a validation and utility criterion of scientific knowledge in the last resort. It also formulates tasks to be solved by science. Finally, it sets up requirements for the training level of university graduates; the most important of which is a skill to apply obtained knowledge in practice. Progress in such domains is usually based upon ideas that help to solve problems in all the three areas – science, education and professional activity. One of the science-intensive domains where those areas are interlinked is computer program transformation.

At present the task of increasing processing power is still of current interest. The modern development of computer science is connected with new parallel architectures. With processors getting more powerful, the requirements to them are growing. The relevant software is necessary for achieving high efficiency of parallel machines. Computer architecture getting more complicated, the programming languages are also becoming more complicated. That leads to poor quality both of source programs and target ones. Therefore, to keep the gain obtained at the expense of the possibilities of new computer architectures it is necessary to optimize source programs and improve programming language compilers. A lot of problems connected with systems of program transformations still remain unsolved (for example, problems of taking context into account and choosing an order (strategy) of using transformations as any transformation used in wrong environment and at an inappropriate step may result in the deterioration of program instead of its improvement). Intensive scientific research on program transformations is to facilitate progress in high-technology professional activity – developing optimizing and unparallelizing compilers. Universities must train up-to-date specialists to ensure both scientific and professional activities in this field.

The main achievements in the three spheres linked with program transformations, major problems impeding progress in the filed and possible solutions are considered in the present paper.

Hereinafter classical transformations, restructuring transformations and transformations for parallel machines are regarded as program transformations. Classical transformations are those developed for sequential machines but also useful for parallel ones. Restructuring transformations are transformations that increase the degree of parallelism in the program at the expense of changes in the program structure. Transformations for parallel machines follow exclusively from the parallelism of the machine architecture [Evstigneev, 1996].

Some basic notions and scientific achievements in the field of program transformations are considered in the following part.

This paper was made according to the program of fundamental scientific research of the Department of Power Engineering, Mechanical Engineering, Mechanics, Control Processes, the Russian Academy of Sciences, within the framework of the project “Synthesis of intellectual systems of control over knowledge bases and databases”; according to the program of the Far Eastern Branch of the Russian Academy of Sciences (the project code is 05-III-ZH-01-008).

Modern State on Program Transformations

The necessity of program optimization was first realized almost together with the creation of the first translators of programming languages. The practice showed that raised level of a source programming language told negatively on object program efficiency obtained as a result of translating. In this connection at the end of 1950s the task to increase efficiency with the help of transformations during the process of translating was taken on. This task will be called *program optimizing transformation task.* Transformations that increase the program efficiency are called *optimizing transformations* (OTs). *The system of optimizing transformations* is a set of OTs together with the strategy of their utilization [Kasyanov, 1988].

Program models provide theoretical base for studying and substantiating algorithms of program transformations. Thus, at present there are models of both sequential and parallel programs in the field of program transformations. Program transformations are introduced in terms of program models, i.e. over schemas not programs. The transformation description consists of two parts – the description of *contextual conditions* of the transformation, i.e. conditions under which the application of the transformation is possible and preferable, and the description of the *transformation* itself that assigns what should be changed in the schema. The same transformation under various contexts can determine transformations different in their contents. Each transformation is described in terms of one model and its application, as a rule, does not exceed its limits. It makes it possible to consider the transformed schema as a source one for further transformations. The transformation context is described in terms of program model and flow analysis, which is a means of getting reliable and accurate information about program performance without its execution. There are various classifications of transformation that are reflected in catalogues and information systems of transformations. There are means of formalizing knowledge about program transformations. One can state that program transformations are a developed field of the applied science that has already accumulated/acquired/gained extensive knowledge.

The knowledge about program transformations is necessary for using it in the professional activity while developing optimizing compilers. At present, there are compilers with wide sets of transformations for most widespread programming languages and types of computers. Thus, optimizing compiler manufacturing is a practical application of program transformations.

Scientific and practical activities connected with program transformations require training relevant specialists. Some of these specialists perform practical tasks of developing optimizing compilers; others conduct research on program transformations. Thus, specialists in the sphere of optimizing compilers are still needed both in science and practice. They are trained by leading universities of Russia, the Commonwealth of Independent States (Former Soviet Union), and other countries. Knowledge of modern scientific achievements and ability to develop

optimizing compilers are the essential requirements for the level of their training that is supported theoretically, methodologically, and instrumentally.

However, there are a few interwoven problems in science, practice and education in the field of program optimization that are analyzed in the following part.

Analysis of Problems and Possible Ways of Their Solving

The main problem in the sphere of program optimization science is that it is impossible to carry out computer experiments opportunely. Their goal is to define how often transformations can be applied in real programs and what effect can be achieved. The only means of conducting such experiments is optimizing compilers. However, the period between the moment of the publication of the new transformation description and the moment of the ending of realization of optimizing compiler containing this transformation is so long that the results of computer experiments with this transformation appear to be out-of-date. Besides, an optimizing compiler usually contains a wide set of transformations and built-in strategy of their application so it is quite problematic to get results of computer experiments related to one transformation (not to the whole set).

The heterogeneity of notions and models in the sphere of program transformations, impossibility to prototype optimizing compilers and their quick moral aging are important problems.

The object of transformation is modeled by a lot of various schemas that are described in different terms, which makes it difficult to select one program model when designing each optimizing compiler. Describing transformations authors use different systems of notions, which hampers reading scientific literature by optimizing compiler developers.

Optimizing compiler is an extremely complicated program system the development of which is quite labor-intensive and time-consuming. Real characteristics of such a compiler are not quite know until it is used. Usually when developing it they prototype it to determine its characteristics. However, no prototyping facilities for optimizing compilers have been proposed yet which makes the risk higher.

Finally, each optimizing compiler is a program that is difficult to modify, i.e. it is virtually impossible to change a set of transformations in it. Because of a long period of its development, the compiler becomes somewhat obsolete by the moment of its putting into operation in comparison to the current level of program optimization science and gets more obsolete during its utilization.

The above-mentioned heterogeneity of notions and models in the sphere of program transformations and impossibility to use active teaching methods in education are major problems.

This heterogeneity creates difficulties for teachers when they systematically give information on the results achieved in this sphere and for students when they apprehend it.

Training students needs acquiring logically complicated theory and gaining practical skills of using its results. Special tools are necessary to let students do practical tasks and carry out research sufficiently within the time limits set by the curriculum. However, such tools have not been designed yet. Therefore, as a rule, students try to assimilate program transformations as a theoretical discipline gaining practical skills after their graduation from the university.

Thus, in spite of significant scientific, practical and educational achievements in program transformations there are a few problems hampering their development. To solve the above-mentioned problems is a topical task. The multipurpose computer knowledge bank is used as the general concept within the framework of which these problems can be solved [Orlov, 2003a].

The following section considers Specialized Knowledge Bank on Program Transformations (SKB_PT) as the concept of program transformation information control to solve the problems [Orlov, 2003a].

Concept of Specialized Knowledge Bank on Program Transformations

The general tasks of SKB_PT are centralization of knowledge on program transformations, coordination of their processing and collective development in order to achieve the most quality and up-to-date knowledge in this sphere and facilitate its using in science, education and professional activity.

The definition of Multipurpose knowledge bank (MKB) is given in the work [Orlov, 2003a]. According to it, MKB is a set of specialized knowledge banks (SKB). SKB for support of scientific research, educational and professional activities in a domain is a resource integrating the relevant information, providing specialists and computer programs with the access to this information, and containing tools for performing those tasks of information processing the effective methods of solving them have been already developed.

SKB_PT consists of Information Content (IC), Shell of IC, Program Content (PC) and Administration Block (AB). IC contains the relevant information. Shell of IC provides computer programs with the access to the information. Editing tools are necessary to form and develop IC. The work [Orlov, 2003b] proposes the concept of universal editor of information of different integration levels (Editor of IDIL). Other tools of information processing can be added to PC as effective methods of solving the corresponding tasks are developed. AB of SKB_PT manages users and controls the life cycle of SKB_PT. A special user of SKB_PT – Administrator – performs functions of managing other users and information resources. Shell of IC can be built on; new programs can be developed for PC. A special user of SKB_PT – Supporter – is responsible for building on Shell of IC and adding new programs to PC of SKB_PT [Orlov, 2003a]. The work [Orlov, 2003c] describes general methods of realization of MKB and specialized knowledge banks.

The information contained in IC of SKB_PT includes the ontology of knowledge on program transformations, ontologies of programming languages, the ontology of Structural Program Models (SPM), the program base storing source programs represented in the ontology of SPM, the knowledge base storing knowledge about program transformations, the archive of program transformation histories.

The editing tools are the editor of the ontology of knowledge on program transformations, ontologies of programming languages and the ontology SPM, the specialized editor of database and editors of programming languages that are developed using the editor of IDIL.

The users of the editing tools are carriers of the following information: ontologies of programming languages (linguists), the ontology of SPM, the ontology of knowledge on PT (knowledge engineers), knowledge on a domain (experts) and programs (programmers).

Besides information carriers, other users solving other IC tasks (connected with program transformations) can work with SKB_PT: scientists, optimizing compiler developers, teachers, students (users solving training IC tasks), and guests (users that are allowed only to view IC).

PC of SKB_PT (i.e. service programs realized through the shell) includes editing tools of SKB_PT, Program transformer of SKB_PT, Tools visualizing program transformation histories and Code generators on different platforms. The prototyping tool for optimizing compilers (PT_OC) is also a part of PC. When entering, Program transformer gets the structural program model (the object of transformations), the data about necessary transformations from the database; when the processing is over it gives the transformed model of structural program and the information about the applied transformations – the program transformation history. The visualizing tools make it possible to view the history. Code generators on different platforms let generate object programs according to the transformed models of structural programs. The prototyping tool for optimizing compilers integrates four subsystems into one system (the optimizing compiler prototype): Program transformer, editors of programming languages, visualizing tools for the transformation history and Code generators on different platforms.

The following section considers ways of using SKB_PT for scientific, industrial and educational purposes in the field of program transformations.

Possible Usage of Specialized Knowledge Bank on Program Transformations for Scientific, Industrial and Educational Purposes

The proposed concept of specialized knowledge bank allows to support the collective development of information resources (first of all, databases) and process them with the help of computer programs.

The specialized knowledge bank can be used to support scientific research. It allows to minimize labor costs when writing scientific reviews, to make it possible to classify optimizing transformations, including new ones, to form and develop notion systems in this area, to include new transformations in the knowledge system, to promptly introduce specialists to new results, to conduct computer experiments, to present scientific results in a form convenient to use in the professional activity, to compare new results with the ones archived before.

Having decided to participate in the activity of SKB_PT, the scientist applies to Administrator of the bank for a registration. In the application he\she explains which class of users he/she wants to belong to, what tasks he/she would like to solve, informs of his/her qualification in the sphere of program transformations. After screening the application (and, possibly, consulting the scientific society in order to get approval of his/her qualification and whether granting his/her application is desirable), Administrator makes a decision to register the applicant as a bank user and informs him/her of it via e-mail. Administrator gives Editing tools to scientists and creates theories for editing in the experimental domain of Information content. Administrator ensures that the information being edited by one user will be unavailable to other users both for editing and using. After describing and modifying the given theories, scientists submit an application to store them in the effective domain of IC. Administrator analyses the theories and makes a decision whether to provide free access to them or send them to be improved.

Together with the application to open the edited theory in IC for free access, the scientist can give his/her articles (monographs, textbooks, etc.) describing it. That helps Administrator and other scientists to analyze the theory. When opening the modified theory for free access, Administrator makes a decision if it should substitute the old one (in case of its existence) or be left as an alternative. The base theories in the knowledge bank are the ontology and program transformation database [Artemjeva, 2002a] [Artemjeva, 2003b] [Artemjeva, 2003c]. Specialists can develop their own theories using the base ones as a foundation or propose their variants for storage and collective exchange.

Program transformation experiments can be conducted in the following way. When entering, Program transformer of the knowledge bank gets SPM. SPM can be designed with the help of high-level language editors and the program transforming the results of the work of the editors into the structure determined by the SPM ontology. SKB_PT Program transformer makes a control flow analysis and data flow analysis in SPM. The obtained information is a source for transformation modeling. First, Program transformer defines saving sectors of SPM on the base of contextual conditions; then it transforms SPM. Transformations are made on the base of the transformation knowledge given in the knowledge database. The transformed SPM is a result of work of SKB_PT Program transformer. Special code generators transform SPM into a representation necessary for further processing (for example, imperative one). Measuring systems on different platforms allow knowing experimental results of the transformation efficiency. Visualizing tools provide information on histories of applied program transformations.

SKB_PT can be used for prototyping of optimizing compilers. The specialist applies to Administrator of the bank for a registration. Administrator provides him/her with prototyping Tool, with the help of which the specialist integrates three subsystems of the bank: Programming language editors, Program transformer of the knowledge bank and Code generators on different platforms. The prototype developer selects a language of a number of languages having editors in the bank, a code generator on the necessary platform of a number of code generators in the bank, a set of optimizing transformations from the database and assigns the strategy of applying these transformations. If an empty set of optimizing transformations is assigned, the compiler prototype will be non-optimizing. Optimizing compiler prototyping makes it possible to research strategies and transformation sets in such compilers.

The specialized knowledge bank can be used for self-developing optimizing compilers: a set of optimizing transformations contains all the transformations from the database both in its current state and in all the future ones. Since the database is constantly modified – new transformations are added and morally aged ones are excluded, characteristics of the compiler prototype are automatically changed according to the changes in the database.

SKB_PT can also be used for training students. Teachers can use Information content of the bank in their preparation for lectures on program transformations. Laboratory tutorials on program transformations can be given on the base of the specialized knowledge bank. Students are to prototype optimizing compilers and conduct experiments with them, to replenish the bank database. They are supposed to find new optimizing transformations in the scientific literature, to include them in the database, carry out research. Students are to use scientific publications on program transformations to find necessary knowledge to fulfill the task, to formalize the knowledge, and to put it into the database by means of the knowledge editor. To conduct the experiment the student has to select a lot of structural programs in the source programming language as an experimental material, to put these programs into the bank Archive by means of language editors and get optimized versions of the programs by means of Program transformer. Students can get transformation histories of these programs and study them using the bank visualizing tools.

Students will better understand the subject – program transformations – by solving tasks and carrying out research. The bank mission is to provide thorough feedback in training and give an opportunity to acquire practical skills in knowledge formalizing and using; the teacher's role is to estimate the final result.

Conclusion and Acknowledgements

This paper reviews the present of scientific research, professional activity and education and analyses the problems in the area of program transformations. The information resource concept based on the modern paradigm of information computer processing is proposed as an approach to the problems. The introduced resource is called Specialized Knowledge Bank on Program Transformations. The classes of users, the structure of its information and program content are described. The paper also describes the possible usage of knowledge banks in scientific research in the industry and education.

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VIABLE MODEL OF THE ENTERPRISE – A CYBERNETIC APPROACH FOR IMPLEMENTING THE INFORMATION TECHNOLOGIES IN MANAGEMENT

Todorka Kovacheva

Abstract: *The purpose of the current paper is to present the developed methodology of viable model based enterprise management, which is needed for modern enterprises to survive and growth in the information age century. The approach is based on Beer's viable system model and uses it as a basis of the information technology implementation and development. The enterprise is viewed as a cybernetic system which functioning is controlled from the same rules as for every living system.*

Keywords: *enterprise strategy, viable system model, enterprise model, neural network, artificial intelligence, cybernetics, business trends.*

ACM Classification Keywords*: I.6.3 Simulation and Modeling: Applications; I.2.6 Artificial Intelligence: Neural nets*

Introduction

The enterprises in the information age need to be managed in different way. The traditional management techniques successfully applied in the industrial companies are not suited in the new economy. The reason is that the conditions from the past are changed rapidly. Thus the contemporary business is accomplished in highly dynamic environment and adaptation capabilities are needed. New business trends [Kovacheva, Toshkova, 2005] have to be taken into consideration. According to this, the traditional software technologies are limited in their effectiveness, as they are unable to discover and maintain the information, which is hidden, in large amounts of data. New kind of software [Kovacheva T., 2004] is needed and new information technologies must be applied.

The main challenge for the modern enterprises is to keep their viability. To do this and because of the environment complexity and the complexity of the enterprise itself, the enterprise must be managed as a cybernetic system. Thus the suggested in this paper novel approach for enterprise management is based on cybernetics and system theory. A viable model of the enterprise is developed where the needed information technologies are applied. It is based on viable system model (VSM) [Beer S., 1984] which is the basis for our methodology.

Viable System Model

Viable System Model is the "whole system" theory. It is developed from Stafford Beer [Beer S., 1956, 1959,1967, 1979, 1981, 1984, 1985] who is called the father of managerial cybernetics. He was inspired from the way the human brain organizes the operation of the muscles and organs and synchronizes all the activities in human organism. VSM is a new way of thinking about organizations based on system theory and viability. Beer considers the human organism as three main interacting parts:

- muscles and organs;
- nervous system;
- external environment.

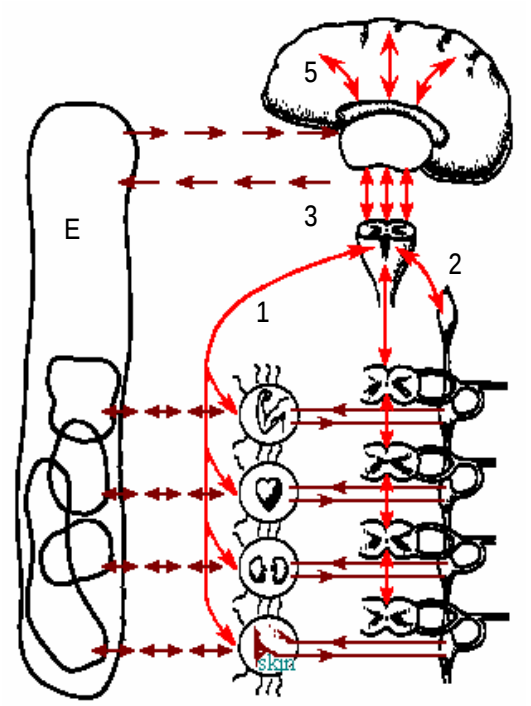
They are included in Viable System Model as follows:

1. The Operation: the units which do the basic work (muscles and organs);

2. The Metasystem: provide a service to the Operations units and ensures they work together in an integrated and harmious fashion (nervous system);
3. The Environment: all the environment elements, which are of direct relevance to the system in focus (external environment).

These three parts must be in balance. When the environment changes the enterprise must respond accordingly.

Figure 1 shows the five interacting systems in relation to the human system [Beer S., 1981]. These five systems are the basis of the Viable System Model. In Table 1, they are explained from a management point of view.



Cortex: higher mind/brain functions (5)

Diencephalons: sensory input and planning (4)

Pons & Medula: internal control (3)

Autonomic Nervous System: regulation (2)

Skeleton, Muscles & Organs: operations (1)

Environment: (E)

Figure 1: The Five interacting systems – neurophysiological approach

Table 1

System Number	*System Identification*
System 1 (S1)	Primary activities.
System 2 (S2)	Stability and conflict resolution.
System 3 (S3)	Internal regulation and optimisation.
System 4 (S4)	Sensors, adaptation, planning, strategy development.
System 5 (S5)	Policy, identity, goals

Using the Beer's Viable System Model we developed a methodology of viable model-based enterprise management where the needed information technologies for supporting business activities and keep the enterprise viable are applied.

Viable Model-Based Enterprise Management

The goal of Cybernetics is to understand and formalize the basic, underlying principles of systems, such as living systems and to study the problems of complex systems, adaptation and self-organization. The main characteristic of living systems is their viability. A viable system has the capability to successfully deal with the complexity of its

environment and is adaptable over time. Thus, the enterprise management must ensure that realization of the company strategy will keep it viable. Therefore, the relevant software is needed.

Operations are presented from the basic units in the enterprise. They do the actual work and could be departments, machines, people etc. according to the enterprise scale, activities and structure. These units need to be monitored continuously to ensure they work in the proper way. Thus, the real-time software must be implemented. Such kind are of software are the well known operational systems and OTLP systems.

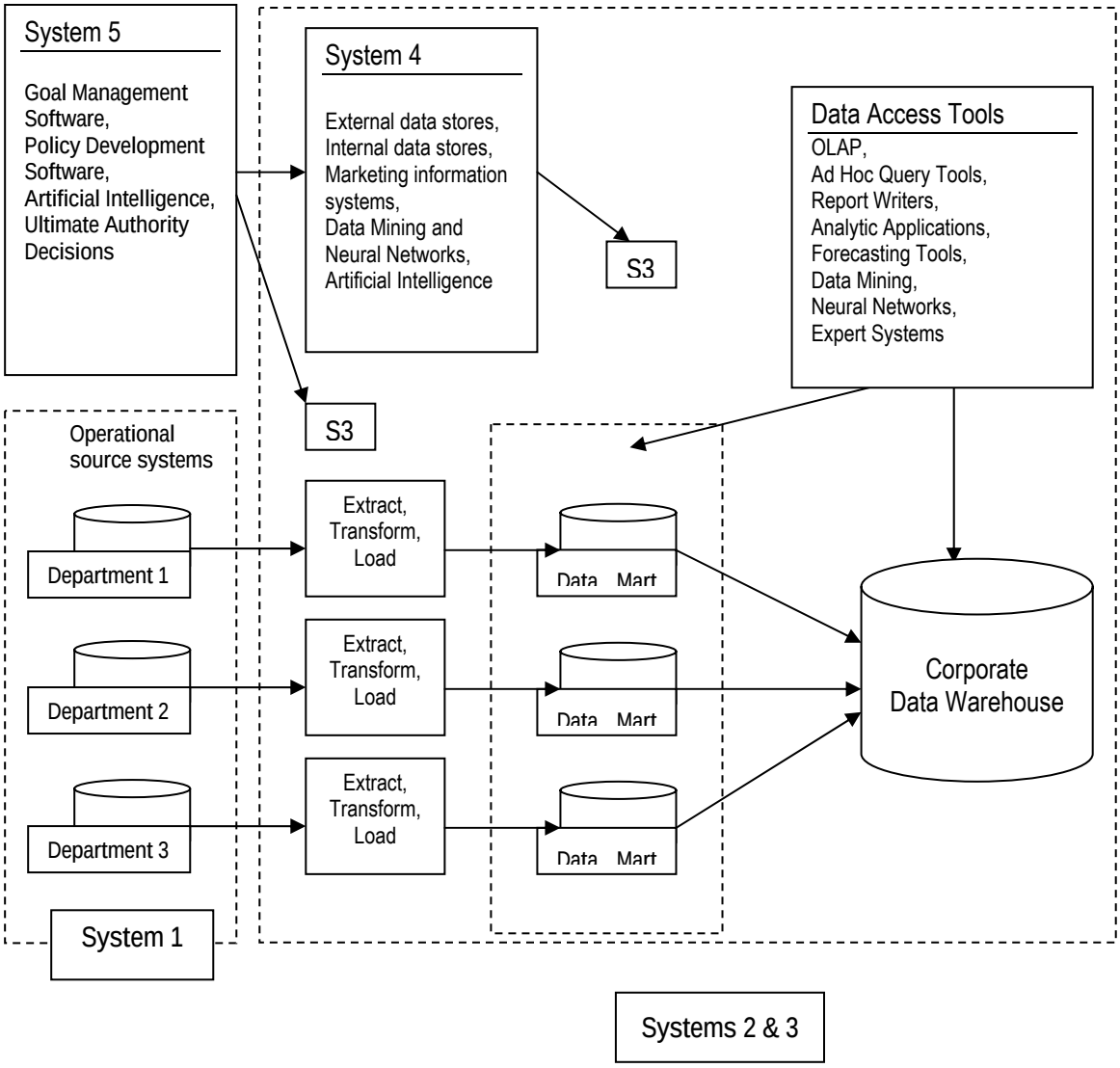


Figure 2: The Interconnections between the five systems and their elements

The daily operations in every enterprise department are registered in specific software and the department database is built. It stores all the data from the everyday activities. This information is useful for the detailed analysis of the enterprise data. This kind of software must be present in System 1.

System 2 function is to prevent and resolve conflicts. Applying the proper software the conflicts can be early recognized and prevented. The main principles of building such kind of software are given in [Kovacheva, 2004]. At this level, we need detailed and granulated data for the neural network learning process. This information than is analysed, compared and managed according specific rules, included in a conflict resolution and stability preserving expert system. The data can be organized in traditional data based as well as in data marts.

System 3 needs all the data for the enterprise everyday operations. Thus, we use the data warehousing approach, which integrates data from the operational systems into one common data store, known as data warehouse. It is optimized for data analysis purposes and decision making. We use different tools to access the data in the warehouse and discover hidden information in them.

System 4 is responsible for the enterprise adaptation. Therefore, it needs information about the external environment so it can produce strategies. It also needs a good model of the internal capabilities so it knows what tools it has at its disposal. We use different tools for forward planning and strategy development with combination of expert system, neural networks and marketing information systems (MIS). MIS [Недева В., 2003] maintain data from internal and from external sources. Both could be integrated in a big corporate data warehouse. On its basis, the external environment is analysed and the adaptation capabilities are developed.

System 5 is compared with the higher human brain functions. It is responsible for policy development, goal settings, ultimate authority and identity. At this level, a special kind of software is needed. The Artificial Intelligence is now applied. Goal definition must be done in accordance with the main Neurolinguistic Programming principles.

The interconnections between the five systems and their elements are given in figure 2.

Conclusion

The developed methodology of viable model-based enterprise management helps the modern enterprises to survive and growth in a highly dynamic environment. It uses the last achievements in the information technology at the current moment. To make this project complete we need to build a new type of Neural Networks which can work in a multitasking mode with dynamic weights generation, short and long term memory management properties and high adaptation and transformation capabilities. Such kind of networks is viable and can survive in an environment with a high degree of complexity and uncertainty because of their ability for self-development.

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TECHNOLOGY OF CLASSIFICATION OF ELECTRONIC DOCUMENTS BASED ON THE THEORY OF DISTURBANCE OF PSEUDOINVERSE MATRICES

Volodymyr Donchenko, Viktoria Omardibirova

***Abstract**: Technology of classification of electronic documents based on the theory of disturbance of pseudoinverse matrices was proposed.*

***Keywords**: classification, training sample, a pseudoinverse matrix, Web Data Mining.*

***ACM Classification Keywords**: I.5.2 Design Methodology, I.5.4 Applications, G.1.3 Numerical Linear Algebra*

Introduction

One of the most important modern applied tasks of classification is classification of electronic documents. Applications may be different. For example, classification of E-Mail and elimination of so-called spam, i.e. letters which do not represent interest for the user; or classification of documents by subjects at their reception from such not structured warehouse as Internet. The given problems concern of a class of problems of extraction of the useful data from the Internet (Web Data Mining). In presented article the technology of classification of electronic documents by the given classes is described. As the mathematical instrument the theory of disturbance of pseudoinverse matrices is used. [1]

Statement of the Task

There are some classes of electronic documents from some subject domain. Each class is characterized by a set of documents - templates. Whole subject domain is characterized by some given thesaurus identical to all classes of documents. It is necessary to construct and train the classifier with the help of training sample generated from documents - templates which will classify newly added documents to one of known classes. Standard way for decision of a task of recognition is from the one hand formation of significant attributes (Feature Extraction) [2], and from another - selecting of suitable distance function to formed classes.

The Basic Designations

Let is present K classes of electronic documents, which we shall designate accordingly, Ω_k, $k=\overline{1,K}$ for which the same thesaurus is fixed with quantity of terms that we shall designate L. Attributes on which classification will be made are relative frequencies of use of terms of the thesaurus. Thus, each document may be represented as a vector a: $a^T=(a_1,...,a_L)$ consisting of relative frequencies of occurrence of words from the thesaurus in given document. Let n_k, $k=\overline{1,K}$ is quantity of documents of the training sample concerning each of the classes.

Let's enter into consideration matrices $A_k, k=\overline{1,K}$, made of frequency vectors of each of classes. Evidently, each of matrices has dimension $L\times n_k$, $k=\overline{1,K}$.

Let's designate average of vectors of training sample on each of classes through $\overline{a}_k$, $k=\overline{1,K}$:

$$\overline{a}_k=\frac{1}{n_k}\sum_{a\in\Omega_k}a \ , \ k=\overline{1,K}. \qquad (1)$$

Let's shift each of vectors of training sample of this or that class by average on the same class, and the matrices constructed from received vectors as on vectors-columns.

We shall make the new matrices similar A_k, $k=\overline{1,K}$. We shall designate received matrices connected to each of classes through $\widetilde{A}_k$, $k=\overline{1,K}$.

Algorithm of Classification

The algorithm of classification is offered to be built on the basis of calculation of vectors $\overline{a}_k$, $k=\overline{1,K}$ and construction of singular decomposition [1] for matrices $\widetilde{A}_k$, $k=\overline{1,K}$, describing the appropriate classes. As is known, according to singular decomposition matrices allow representation:

$$\widetilde{A}_k=\sum_{i=1}^{r_k} y_i^{(k)}\left(\mathrm{x}_i^{(k)}\right)^T\lambda_i^{(k)}\ ,\quad r_k=rank\,\widetilde{A}_k=rank\,A_k\ ,\quad k=\overline{1,K}\ , \tag{2}$$

where $\lambda_1^2\geq\ldots\geq\lambda_r^2$.

Eigen values λ_i and eigen vectors $y_i^{(k)}\in R^L$, $x_i^{(k)}\in R^{n_k}$, $i=\overline{1,r_k}$, $k=\overline{1,K}$ in the given representation may be calculated, for example, by Jacobi method or a method of singular decomposition of matrix SVD [3].

Singular decomposition (2) of matrices of classes can be used for construction approximation of these matrices, which will be used for construction of belonging measures to each of classes. These approximations are constructing in two stages: highest members of singular decompositions are rejected on the first stage: items, answering to smaller values of modules of eigen values; on the second stage - received matrixes are used for construction of belonging measures to classes. An estimation of the error made after rejection of highest members of singular decomposition if it is left s_k members: $s_k<r_k$ is described by the following inequality [1]:

$\left\|\Delta_{is_k}\right\|^2=\sum_{i=s_k+1}^{r_k}(\lambda_i^{(k)})^2\left|x_i^{(k)}\right|^2\leq(\lambda_{s_k+1}^{(k)})^2\sum_{i=s_k+1}^{r_k}\left|x_i^{(k)}\right|^2\leq(\lambda_{s_k+1}^{(k)})^2$, where

$$\widetilde{A}_k=\sum_{i=1}^{s_k} y_i^{(k)}\left(\mathrm{x}_i^{(k)}\right)^T\lambda_i^{(k)}+\Delta_{is_k}\ ,\quad s_k<r_k\ ,\ k=\overline{1,K}$$

$$\Delta_{is_k}=\sum_{i=s_k+1}^{r_k} y_i^{(k)}\left(\mathrm{x}_i^{(k)}\right)^T\lambda_i^{(k)} \tag{3}$$

Parameter s_k, $s_k<r_k$, $k=\overline{1,K}$ is being chosen in the sense of smallness of the error, made at construction of suitable approximation $\widetilde{A}_k$, $k=\overline{1,K}$, and as a rule s_k may be chosen, that $\left|\lambda_{s_k+1}^{(k)}\right|$ answers several percents from module of the maximal eigen value. Such construction of approximation essentially simplifies computing procedure of construction of a belonging measure to each of classes: measures, which can be constructed either on the basis of initial matrices $\widetilde{A}_k$, $k=\overline{1,K}$, or their approximation constructed according to the procedure described above.

Belonging measures are determined as square-law forms with matrices R_k, $k=\overline{1,K}$, which are being constructed on the basis of suitable approximations of matrices $\widetilde{A}_k$, $k=\overline{1,K}$,– which we shall designate accordingly $\widetilde{A}_{k,s_k}$, $k=\overline{1,K}$ – according to formulas:

$$R_k = \left(\widetilde{A}^{+}_{k,s_k}\right)^T \cdot \widetilde{A}^{+}_{k,s_k} = \sum_{i=1}^{s_k} y_i^{(k)} (y_i^{(k)})^T (\lambda_i^{(k)})^{-2} \quad (4)$$

Procedure of classifying of the electronic document described by its frequency vector $b^T = (b_1,...,b_L)$ to one of classes Ω_k, $k = \overline{1,K}$ is made on the basis of calculation for each of them "distance" m_k, $k = \overline{1,K}$ up to a class, which is determined by expression:

$$m_k = \left(\left(b - \bar{a}^{(k)}\right)^T \cdot R_k \cdot \left(b - \bar{a}^{(k)}\right)\right), \; k = \overline{1,K}. \quad (5)$$

The classified document will belong to the class for which value of distance m_k, $k = \overline{1,K}$, determined according to (5) will accept the minimal value.

Results of Experiments

For check of correctness of work of the offered technology the book in an electronic format «The Handbook of Data Mining» [2] with size of 689 pages and consisting of 3 parts was chosen. Training sample of three classes by 5 first documents - chapters in each class was accordingly generated. After training of the classifier on its input chapters of the book which were not used in training of the classifier were inputted to be classified to one of 3 classes.

For eighth chapter of the first part given on input of the classifier, values of functional (10) are equal:

0.01959
0.15240
0.09561

As the least value of functional is equal to 0.01959 the classified document concerns to the first class.

Conclusions

In article the technology of classification of electronic documents on the given classes with use of the theory of disturbance of pseudoinverse matrices which has shown the efficiency at least in the considered modelling examples is described. The offered technology may be used for automatic classification of incoming E-Mail or for automatic extraction of interesting information from the Internet (Web Data Mining). Due to use of approximations for the pseudoinverse matrices, it is possible to essentially increase speed of work of algorithm.

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EVOLUTIONARY CLUSTERING OF COMPLEX SYSTEMS AND PROCESSES

Vitaliy Snytyuk

***Abstract**: In a paper the method of complex systems and processes clustering based use of genetic algorithm is offered. The aspects of its realization and shaping of fitness-function are considered. The solution of clustering task of Ukraine areas on socio-economic indexes is represented and comparative analysis with outcomes of classical methods is realized.*

***Keywords**: Clustering, Genetic algorithm.*

***ACM Classification Keywords**: I.5.3. Clustering*

Introduction

The process of a translational movement to creation of an information community is accompanied with problems connected to storage and handling of large scale arrays of data. Their solution is connected to intellectual analysis of data, which process engineering are formed on intersection of artificial intelligence, statistics, theory of data bases. There are KDD (knowledge discovery in databases) - detection of knowledge in data bases, data mining, OLAP (on-line analytical processing) - extraction of an information from many-dimensional data bases and others. The elements of indicated process engineering become the integral part of electronic storages of data (warehouses). A significant part of information make data, being socio-economic indexes of operation of complicated systems.

The presence of noise effects is peculiar to large scale arrays of information, their handling reduces in accumulation of a cumulative error. For overcoming an indicated problem it is necessary to determine the significant factors and to realize their analysis. The diminution of information entropy can be also reached by a grouping of systems and extraction of knowledge in smaller and functionally connected populations. Such procedures are directed on sequential overcoming of indeterminacy. The first step in this direction is a solution of the clustering task.

The Analysis of Models and Methods of Clustering

The clustering task consists in the definition of systems or processes groups, which are closest one to another on some criterion. Thus of any suppositions about their structure, as a rule, is not done [Mandel, 1988], [Gorban, 2002]. The majority of clustering methods is founded on analysis of a factors matrix of a likeness, as which appear a distance, contingency, correlation etc. If by a criterion or metric the distance appears, as a cluster name group of points Ω, such, that the average square of inside group distance up to a centre of group is less than an average distance up to a common centre in an initial set of systems, i.e. $\bar{d}_{\Omega}^{2} < \sigma^{2}$, where $\bar{d}_{\Omega}^{2} = \frac{1}{N}\sum_{X_i \in \Omega}(X_i - \overline{X}_{\Omega})^2$, $\overline{X}_{\Omega} = \frac{1}{N}\sum_{X_i \in \Omega} X_i$. Generally, criterions are:

1. Euclid's distance $d(X_k, X_l) = \left(\frac{1}{m}\sum_{j=1}^{m}(X_{kj} - X_{lj})^2\right)^{\frac{1}{2}}$.
2. Maximum distance on indications $d(X_k, X_l) = \max_{1 \le j \le m}\left|X_{kj} - X_{lj}\right|$.

3. Mahalonobis distance $d(X_k, X_l) = [(X_k - X_l) \cdot R^{-1} \cdot (X_k - X_l)^T]^{\frac{1}{2}}$.
4. Hamming's distance $d(X_k, X_l) = \frac{1}{m} \sum_{j=1}^{m} |X_{kj} - X_{lj}|$.

The solution of minimization task of a distance between systems is equivalent to a solution of minimization task of a distance up to system having averaged performances, as, for example, for a Hamming's distance

$$\sum_{\substack{j=1 \\ k<l}}^{m} |X_{kj} - X_{lj}| = \sum_{\substack{j=1 \\ k<l}}^{m} |X_{kj} - \overline{X} + \overline{X} + X_{lj}| \le \sum_{\substack{j=1 \\ k<l}}^{m} |X_{kj} - \overline{X}| + \sum_{\substack{j=1 \\ k<l}}^{m} |X_{lj} - \overline{X}| \le \sum_{j=1}^{m} |X_{kj} - \overline{X}| + \sum_{j=1}^{m} |X_{lj} - \overline{X}| = 2\sum_{j=1}^{m} |X_{kj} - \overline{X}|.$$

The task of clustering is accompanied with two problems: the definition of an optimum amount of clusters and deriving of their centres. Input data for the clustering task are the values of parameters of researched systems. It is obvious, that the definition of an optimum amount of clusters is a prerogative of contributor. Let's assume, that the number of clusters K is given and $k << m$, where m - amount of plants. Let's receive the task

$$\sum_{i=1}^{K} \sum_{j=1}^{m_i} \left\| X_j - \overline{X}_i \right\| \to \min, \qquad (1)$$

where $\overline{X}_i$, $i = \overline{1,K}$ - average value in a cluster, $\left\| X_j - \overline{X}_i \right\|$ - distance between systems. A solution of the task (1) are the centers of clusters $\overline{X}_i$, which can contain among considered systems, that is a rather strict condition, and can be represented by any points of researched area.

To traditional methods of cluster analysis refer tree-like clustering, two-way joining, K-means clustering, method of dendrites, method correlative populations and method of full-spheres [Pluta, 1989]. Advantages of indicated methods is their simplicity, invariance of their engineering concerning a type of input data and used metrics. To shortages refer weak formalizing, that hampers application of computers, and also low exactitude, a corollary that is tentative estimation of a space structures of the factors and their selfdescriptiveness. One more method of a solution of the clustering task is the use of a self-organized Kohonen's map [Kohonen, 1988]. By a problem of use such neural networks is a choice of initial weight factors, continuous type of operation and effectiveness, which evaluation for today remains by a problem.

As an alternate method we offer to use genetic algorithm.

Genetic Algorithms – Nonclassical Technique of Optimization Task Solution

The first variants of genetic algorithm and reviewing of its application aspects have appeared in [Fraser, 1962], [Fraser, 1968], [Bremermann, 1965], [Holland, 1969], [Holland, 1975]. The further researches have shown it effectiveness in a solution of engineering, economic ecological and other problems. Principal idea underlying a construction of genetic algorithm, is the use of ideas of a natural selection, selection and mutation. Its canonical variant contains such stages:

1. Definition of a general population of individuals Θ, being potential solutions of the optimization task of fitness-function.
2. Realization of preliminary steps of algorithm consisting in quantifying of the elements K of a sample population Ξ, where $k << |\Theta|$; a choice of a normalization mode for input data; a choice of recombination, mutation and inversion variant and also appropriate probabilities.
3. For each element $\theta_i \in \Xi$, $i = \overline{1,k}$ computed values of fitness-function $f_i = F(\theta_i)$.

4. With probabilities P_i^k, proportional by a values f_i, to select two individuals and to realize recombination, owing to which realization we shall receive two new individuals.
5. With probability $\frac{1}{2}$ to select one of obtained individuals and with probability P^m to realize mutation.
6. The obtained individual is putted in a new population Ξ^n.
7. Repeat stage 3-6 $\left[\frac{k}{2}\right]$ times.
8. Rewrite the elements Ξ^n in a population Ξ, deleting old individuals.

By criterion of a termination of genetic algorithm the following conditions can appear: convergence of the elements of a population Ξ to one element; the maximum absolute deviation between elements of a population Ξ will be less some positive number δ; maximum absolute deviations between values of fitness-function will be less some small positive number ε.

Table 1

Values of researched factors

1	x_{11}	x_{12}	…	x_{1n}
2	x_{21}	x_{22}	…	x_{2n}
…	…	…	…	…
m	x_{m1}	x_{m2}	…	x_{mn}

Shaping of Fitness-function for the Clustering Task

Input data of the clustering task are factors values (tab. 1). Beforehand, we execute their normalization, for example, under the formula $x'_{ij} = \frac{x_{ij} - x_{jmin}}{x_{jmax} - x_{jmin}}$. Owing to such transformation of all factors values will lay in a single hypercube $[0,1]^n$. The fitness-function is realized by the following algorithm:

Step 1. A value of fitness-function to put equal to zero ($F = 0.$)

Step 2. To set a number of clusters K and to specify a value m.

Step 3. To execute initialization of a membership matrix of the elements to clusters T_k.

Step 4. For all systems to execute the following steps. Let $n = 1$.

Step 5. To calculate a distance from n-th system up to centres all K clusters, which are individuals from a sample population.

Step 6. Among all distances d_j, $j = \overline{1,K}$ to select minimum d_q and to refer n-th system to q-th cluster. To bring an appropriate entry to a matrix T_k.

Step 7. $F = F + d_q$. $n = n + 1$.

Step 8. If steps 5-7 are carried out for all systems, the value of fitness-function F is obtained, otherwise to pass to step 5.

It is obvious, that the algorithm of fitness-function deriving can be optimized. The possibility of improving is its absolute property. A variety of operations variants of genetic algorithm represent a set of exterior properties of the process of fitness-function deriving. The possibility of task solution of its optimization also assumes binary and

decimal representation of input data. And if in the first case in procedures of genetic algorithm dominating is the rectangular distribution, in second - at searching an optimum solution the preference is returned to values having normal distribution with mean value, conterminous with a centre of cluster. The definition of an optimum variance - one more task, which remains unsolved.

Clustering of Ukraine Regions on Socio-economic Indications

For check of effectiveness of the offered clustering method regions of Ukraine were selected. The clustering should be realized, proceeding from values of socio-economic indexes. Such indexes are:

X_1 - total surplus value in account per one man (in actual values, UAH);

X_2 - territory (thousand sq. km);

X_3 - investment in a fixed capital per one man (in comparative values, UAH);

X_4 - direct foreign investments per one man (USD);

X_5 - employment of the population per 10 thousand;

X_6 - money incomes of the population per one man (UAH);

X_7 - credits submitted to subjects of managing per one man;

X_8 - amount of the obtained patents on the inventions on 10 thousand.

As classical techniques were selected tree-like clustering and K-means clustering. A priori two clusters are given. On K-means clustering techniques the following outcomes (tab. 2) are obtained. To the first cluster are referred Dnepropetrovsk, Donetsk, Zaporozhye, Nikolaev, Odessa, Poltava and Kharkov regions. According to tree-like clustering (fig. 1) to the first cluster the same regions, except for Donetsk region are referred, though it is close to elements of the first cluster.

The clustering was carried out also with use of evolutionary modelling. For a termination criterion of computing process was selected a maximum quantity of iterations equal 1000. For the same two clusters and eight factors the amount of variables (chromosome), for which the optimization of fitness-function was carried out, has made 16. Twenty elements have come in a sample population. As the fitness-function was polyextreme, the mutation probability has made 0,4. Such value has increased time of evaluations, but has considerably increased an exactitude of accounts for the score of beating out of function from local minima.

For process of evaluations monitoring in real-time mode the information about a value of fitness-function on each iteration (fig.2) was output; about an average distance to centre of clusters (fig. 3); values of centres of clusters (fig. 4). The value of fitness-function has decreased with $6 \cdot 10^9$ down to 11351587, and on the initial stages the diminution happened as hyperbola, and on last - linearly. The average distance to centre of clusters decreased linearly, with a constantly decreasing variance.

In an outcome of evaluations two centres of clusters are obtained. Coordinates first are $X_1 = 4553,\ X_2 = 0{,}01, X_3 = 915, X_4 = 99, X_5 = 4623, X_6 = 2554, X_7 = 791,\ X_8 = 1{,}34.$

Coordinates second are $X_1 = 2952,\ X_2 = 0{,}02,\ X_3 = 530,\ X_4 = 58,\ X_5 = 4288,\ X_6 = 1555,$ $X_7 = 297,\quad X_8 = 0{,}59.$ To the first cluster concern Dnepropetrovsk, Donetsk, Nikolaev, Odessa, Poltava and Kharkov regions. The outcomes of three considered techniques are close, that testifies to an exactitude of evolutionary modelling. Its advantage is also indication of clusters centres and formalization of the computing process. As was indicated above, the offered process engineering can be advanced.

Table 2

Results of clustering for Ukraine regions

Domain	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Cluster	2	2	2	1	1	2	2	1	2	2	2	2	2	1	1	1	2	2	2	1	2	2	2	2

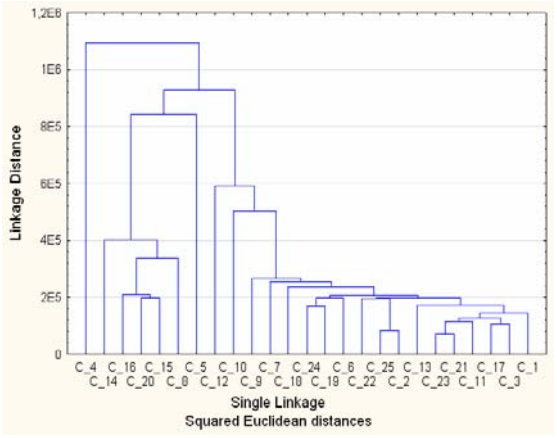

Fig.1 - Outcomes of tree-like clustering

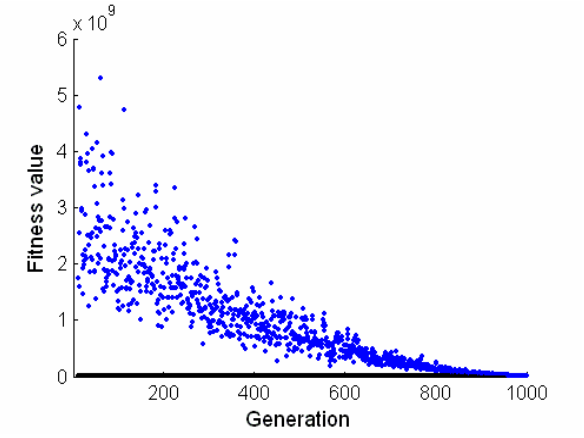

Fig.2 - Value of fitness-function

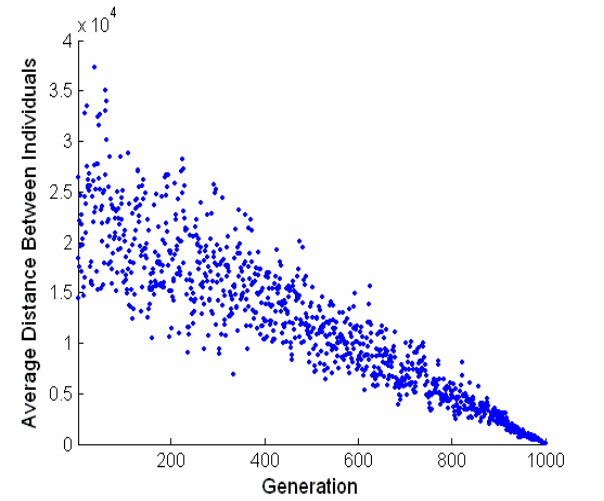

Fig.3 - Distance to centre of clusters

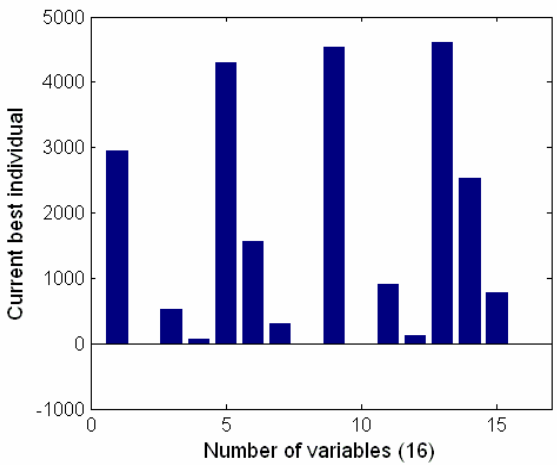

Fig.4 - Coordinate of clusters centres

Inference

The offered method of evolutionary modelling based on using of genetic algorithm, effectively functions at handling arrays of large dimensionality, as in it are optimum combined purposeful searching and elements of chance directed on beating out to goal function from local minima. Any preliminary conditions for its use is not required. A principal condition of optimization of evaluations is right algoritmization of account of values of goal function. Multidirectedness of the process of improving of algorithm speed (for genetic algorithms especially is actual) and its exactitude (searching of a global minimum of fitness-function), and also it actuality testify to necessity of the task solution of the offered technique optimization.

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ALGORITHM OF CONSECUTIVE DEFINITION OF RANKING OF THE OBJECTS NEAREST TO THE SET CYCLIC RELATION BETWEEN OBJECTS

Grigoriy Gnatienko

Abstract: *The problem of a finding of ranging of the objects nearest to the cyclic relation set by the expert between objects is considered. Formalization of the problem arising at it is resulted. The algorithm based on a method of the consecutive analysis of variants and the analysis of conditions of acyclicity is offered.*

Keywords*: ranking, the binary relation, acyclicity, basic variant, consecutive analysis of variants*

ACM Classification Keywords*: K.3.2 Computer and Information Science Education.*

Introduction

The problem of ordering of set of objects in degrees of display of some properties is one of the primary goals of expert reception of estimations [1]. The essence of a problem will consist in definition of the full order on set of compared objects under the set partial order.

Among problems of decision-making, the problem of linear ordering of objects is allocated with a plenty of concrete applications and a unconditional urgency of a theme. This problem traditionally is in the center of

attention of researchers and the quantity of the works devoted to questions of construction optimum in this or that sense of linear orders on set of compared objects is very great [2].

Practical application of problems of ranging is very various [3]. Such problems arise, for example, at the decision of

- a problem of definition of sequence of loading and unloading of a transport spacecraft;
- a finding of sequence of elimination of malfunctions of various systems;
- the complex analysis of quality of production;
- the analysis of characteristics of production and allocation of the main parameters of quality;
- a finding of bottlenecks in some complex systems possessing such properties as stability, controllability, self-organizing;
- designing of liaison channels between units in information networks;
- expert reception of estimations of projects of development of branches of a national economy or scientific researches;
- planning of building of residential areas, etc.

Problems of qualitative and quantitative ranging are considered. At the decision of such problems wide application was received with a method of pair comparisons. The set of works [4] is devoted to the analysis of the specified problems.

The problem of definition of ranging of objects is the widespread problem of the theory of decision-making. This problem is solved various methods. At application of expert estimations for ranging objects the information both from one expert, and from expert group can be used.

As the person frequently supposes infringement of a condition of transitivity of relations at estimations of objects even at the decision of a problem of ranging one expert in relations between objects can appear cycles. In such cases there is a problem of definition of the ranking nearest to the relation set by the expert.

Problem Definition

Let it is necessary to find ranking (the linear order) n objects of set A, the nearest to the cyclic relation set by a matrix of pair comparisons

$$P = \left(p_{ij}\right), \;\; i, j \in I = \{1,...,n\}. \tag{1}$$

Elements of a matrix P express result of comparison of objects $a_i \in A, \;\; i \in I,$ with indexes $i, j \in I,$ and are defined thus:

$$p_{ij} = \begin{cases} 1, & if \;\; a_i \succ a_j, \\ 0, & if \;\; i = j, \\ -1, & if \;\; a_i \prec a_j, \end{cases}$$

$$p_{ij} + p_{ji} = 0, \;\; \forall i, j \in I, \;\; i \neq j,$$

where "$\succ$" - a symbol of the relation of preference between objects.

Construction of the linear order generally demands entering enough the big changes in initial structure of preferences of a kind (1) on set of objects A. The problem of a finding of the order is a complex combinatory problem, NP - difficult in strong sense [2]. Therefore algorithms of local optimization, heuristic algorithms or the algorithms basing a method of branches and borders are applied to construction of ranking R*. Methods of the consecutive analysis of variants in the offered interpretation for this class of problems were not applied, though their use in this area of researches is perspective.

The linear order nearest to the set relation of a kind (1), we shall search as

$$R^* = Arg \min_{R \in \Re} d(P, R),$$

where $\Re$ - set of matrixes which correspond to linear orders n objects, d(R,P) – distance between ranking $R \in \Re$, which is under construction, and set cyclic relation P of a kind (1).

For measurement of distance between set relation P and ranking R, we shall use the most widespread in this class of problems metrics Hamming

$$d(P, R) = 0{,}5 \sum_{i \in I} \sum_{j \in I} \left| p_{ij} - r_{ij} \right|,$$

where p_{ij}, r_{ij} – accordingly elements of matrixes P and R.

Formalization of a Problem

As matrixes of relation P and R are slanting symmetric they can be written down as vectors C and X with elements

$$\begin{aligned} & c_t = p_{ij}, \quad x_t = r_{ij}, \\ & t = (i-1)n + j - (i+1)i/2, \ 1 \le i < j \le n. \end{aligned} \tag{2}$$

Then the distance between relations P and R will be written down as

$$d(P, R) = \sum_{j \in J} \left| c_j - x_j \right|, \quad j = 1,..., n(n-1)/2 = N, \quad J = \{1,..., N\}.$$

The problem of a finding of the linear order nearest to set on set of objects to the relation (1), is formalized as

$$\sum_{j \in J} \left| c_{ij} - x_{ij} \right| \ \rightarrow \ \min, \tag{3}$$

$$x_j \in X_j^0 = \{-1,1\}, \quad j \in J, \tag{4}$$

$$x \in D^A \subset X^0, \quad X^0 = \prod_{j \in J} X_j^0, \tag{5}$$

where D^A – set of vectors of a kind (2) which correspond{meet} to acyclic relations between objects.

Specificity of a problem (3) - (5) will be, that its decision $x \in X$ should satisfy to a condition of acyclicity as the relation which is set by matrix R, should belong to a class of linear orders.

We shall consider a chain of objects a_{i1}, a_{i2}, a_{i3} with the set relations of preference which we shall designate symbols $a_{i1}\ \pi\ a_{i2}\ \pi\ a_{i3}$, $i_1, i_2, i_3 \in L$, $\pi \in \{\succ, \prec\}$.

Basic sub-variant b, which is generated by the three of objects (a_{i1}, a_{i2}, a_{i3}), we shall name elements of a vector of a kind (2) with components

$$b = (c_{j1}, c_{j2}, c_{j3}), \ 1 \le j_1 < j_2 < j_3 \le N, \quad c_{j1}, c_{j2}, c_{j3} \in c, \quad c_{j1}, c_{j2}, c_{j3} \in \{-1,1\}, \tag{6}$$

which values answer relations of a kind

$$\left(a_{i1}\ \pi\ a_{i2}, \ a_{i2}\ \pi\ a_{i3}, \ a_{i3}\ \pi\ a_{i1}\right), \quad a_{i1}, a_{i2}, a_{i3} \in A, \quad \pi \in \{\succ, \prec\}.$$

The basic sub-variant is a minimal subset of objects from set A, on which it is possible to reveal a cycle.

Allowable basic sub-variant we shall name a basic sub-variant which is generated by the three of objects, relations between which satisfy to a condition of acyclicity.

Full variant (variant of length N) we shall name a vector which answers the full binary relation on set of objects.

Allowable variant x^D we shall name a full variant which answers the acyclic relation on set of all n objects, that is $x^D \in D^A$.

At check of an admissibility of basic variants of a kind (6) which are formed by objects a_{i1}, a_{i2}, a_{i3}, $1 \le i_1 < i_2 < i_3 \le n$, it is necessary to consider relations as ($a_{i1} \pi\ a_{i2}$, $a_{i2} \pi\ a_{i3}$, $a_{i1} \underline{\pi}\ a_{i3}$), where $\underline{\pi}$ - inversion of the relation π: $a_{i1} \underline{\pi}\ a_{i3} \Leftrightarrow a_{i3} \pi\ a_{i1}$, $\pi = \{\succ, \prec\}$.

Set $X^s = \{\cup X^s_j, j=1,...,N\}$, $X^s \subseteq X^0$, s=1,2,..., we shall name reduced (concerning initial set X^0).

For the decision of a problem (3)-(5) procedure of reduction of set of allowable decisions Z on a condition $X^s = (X^s_1 \times X^s_2 \times \ldots \times X^s_N)$ of acyclicity of the relation which corresponds to the decision of a problem of a finding of strict resulting ranging of objects of set A is used. The analysis of variants in view of a condition of acyclicity of the decision is carried out with use of the procedure described in [5].

Let's designate set of all possible values which can get elements of a basic variant, through B^0. Sets of a kind B^0 are formed of set X^s by association of three various columns of a matrix X^s: $X^0_{j1} \cup X^0_{j2} \cup X^0_{j3}$, $1 \le j_1 < j_2 < j_3 \le N$, $X^0_{j1}, X^0_{j2}, X^0_{j3} \in X^s$. Capacity of this set is equal $|B^0| = 6$.

Basic set $B^0 = B^0_1 \times B^0_2 \times B^0_3$, $B^0_i = (-1,1)^T$, i=1,...,3, we shall name set of elements of a matrix of which values of basic vectors get out.

Columns of basic set $B^0_i = (-1,1)^T$, i=1,2,3, we shall name subsets of basic set.

The reduced basic set B^s, $B^s \subset B^0$, s=1,2,..., we shall name a matrix which is formed of a matrix B^0 by removal from it separate elements.

It is known [6], that for matrixes of pair comparisons with elements of a kind (2) requirement of absence of cycles is equivalent to the requirement of absence of cycles of length three (T=3).

As the top triangular matrix of a matrix P^i, $i \in I$, contains the full information on all matrix indexes of objects need to be considered only on increase, that is $1 \le i_1 < i_2 < i_3 \le n$. Indexes of elements of a vector of relations between objects also satisfy to conditions $1 \le j_1 < j_2 < j_3 \le N$.

Let's designate through ψ function of two arguments which values are calculated under the formula

$$j = \psi(i_1, i_2) = (i_1 - 1)n + i_2 - (i_1 + 1)i_1 / 2, \ 1 \le i_1 < i_2 < n.$$

Algorithm

In a problem of definition of the linear order nearest to the set cyclic relation, it is possible to present algorithm of the consecutive analysis and elimination of inadmissible elements in the following kind.

Step 1. Let's put initial values of the decision of a problem equal $x(j) = c(j), \quad j \in J$.

Step 2. The organization of three enclosed cycles: i:=1 до n-2; i_1:=i+1 до n-1; i_2:=i_1+1 до n. Variables of cycles i, i_1, i_2 are indexes of objects. In a body of these cycles the following steps are executed.

Step 3. Definition of indexes of elements *j, j_1, j_2* the current basic set B^0_j on indexes of objects *i, i_1, i_2*: $j = \psi(i, i_1)$, $j_1 = \psi(i, i_2)$, $j_2 = \psi(i_1, i_2)$.

Step 4. Definition of three of objects, relations between which form cycles. Quantity of all three n objects equally: : k3=n*(n-1)*(n-2)/6.

Quantity of cycles on set n objects it is equal $d = (n^3 - 4n)/24$ for even and $d = (n^3 - n)/24$ for odd values n.

Step 5. Generation of a vector of indexes of participation of relations between objects in cycles:

$vc(j),\quad j \in J$. That is, value $vc(j),\quad j \in J$, is equal to quantity of ocurrences of the relation with an index $j,\quad j \in J$, in cyclic three.

Step 6. Definition of values of vectors of indexes $vic(j),\quad j \in J$, participations of the inverted relations $x(j) = c(j) - 2,\quad j \in J$.

The choice of an index of the relation between objects is carried out in view of three criteria:

K_1 – inversion of the relation does not generate new three;

K_2 – the total quantity of cycles for the inverted relation is minimal;

K_3 – the difference of quantity of cycles for the set relation and inverted is minimal.

Step 7. Definition of relations, which replacement on inverted, as much as possible reduces quantity of cycles.

Step 8. Choice of an index of the relation for decision-making on its final inverting.

Step 9. The termination of cycles on i, i_1, i_2.

Step 10. Recurrence of points 1-9 of the resulted algorithm until in the decision $x(j),\quad j \in J$, problems (3)-(5) exist cycles.

Conclusion

The resulted algorithm allows to find consistently for final quantity of steps the ranking of the objects nearest to the cyclic relation set by the expert between objects.

Computing experiments have confirmed efficiency of the resulted algorithm. Received with the help of algorithm of the decision are one of the rankings, the nearest to the cyclic relation set by the expert on set of objects.

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ONTOLOGICAL APPROACH TO DOMAIN KNOWLEDGE REPRESENTATION FOR INFORMATION RETRIEVAL IN MULTIAGENT SYSTEMS

Anatoly Gladun, Julia Rogushina, Victor Shtonda

***Abstract**. An ontological representation of buyer interests' knowledge in process of e-commerce is proposed to use. It makes it more efficient to make a search of the most appropriate sellers via multiagent systems. An algorithm of a comparison of buyer ontology with one of e-shops (the taxonomies) and an e-commerce multiagent system are realised using ontology of information retrieval in distributed environment.*

***Keywords:** ontology, e-commerce, multiagent system.*

***ACM Classification Keywords**: I.2.4 Knowledge Representation Formalisms and Methods*

Introduction

Now we are participants of the evolution of the post-industrial society to the information one where a prior tendency is directed to an accumulation and an effective use of knowledge and information resources.

Great perspectives in the development of commodity market and services by Internet market make an impression even to specialists in information technologies (IT). The technical progress in this area renders active a world economy globalization and makes e-commerce the more attractive object to investments.

However, existent alterations result in a whole series of new problems. Variety of goods and services and lots and lots of offers as well as high dynamics of market changes bring to challenging increasing of processing complexity and laboriousness in the network either of sellers or buyers. It takes a lot of time and thereby increases the cost of e-commerce services.

Only the fundamental change of the Internet information processing concept allows to substantially answering customer queries, efficiently respond to varying demands and adapt flexibly to market circumstances.

The entry of Ukraine in the global information space requires deciding a multifold problem of automation of modern business applications. By electronic business (e-business) they understand all forms of electronic business activities including such as e-commerce, e-consulting, e-publishing etc. E-commerce is a special case of e-business. E-commerce joins the various forms of the goods and services trade by use of electronic means, including Internet. The order of the goods in e-commerce is carried out by telecommunications, and accounts between buyer and seller are realized by electronic payment means [1].

Improvement of the e-business tasks efficiency requires a further development of methods of the business-processes automation. E-commerce systems have to provide the user access to the information on goods that is represented in an electronic form as well as a fast information search in a network environment. Transaction complexity is very high due to a dynamic quality and a lot of information to be accessed to users over the Internet. An industrial software development for e-commerce requires creating and using the proper models, standards, languages and formats oriented on knowledge processing. For solving these problems, the agent-oriented technologies are successfully applied based on the use of intelligent software agents (SA).

Related Work. E-commerce Support Systems

Now a lot of various software products with different complexity levels are design for the e-commerce support. Modelling of real applications has to represent the multiplicity of real world business processes. It seems to be evident that only an intellectualization of such means can relieve user of necessity to carry out the oft-recurring actions.

One of the most perspective approaches in e-commerce is now based on SA and multiagent systems (MAS). The main problem in its practical application deals with integration of complex intelligent capabilities in mobile SA's.

SA is software that has some specific features and intend for a simplification of the user dialog with a complex dynamic information environment. An agent works autonomously and for a long time in an actual or simulated environment in cooperation with other agents and processes [2]. They inhabit a complex and dynamic environment with which it may interact to achieve a given set of goals. An intelligent SA can reason in a rational manner and report back result to humans. In the ideal variant an intelligent SA that works for a long time can learn by its own experience. Besides, when coexisting with other agents and processes the SA have to be able to communicate and to cooperate in a team work [3,4].

We have analysed a number of e-commerce agents. PersonaLogic [5] filters out the list of goods that satisfy to user restrictions. Firefly [6] selects the goods by estimations of consumer's preference. BargainFinder [6] is a virtual agent of purchases that can be able to estimate their prices and their suitability for the user. It represents a consumer question in parallel to a group of on-line sellers by filling the form on each site. Kasbah [7] is an on-line MAS for transactions of the "consumer – to - consumer" type. If user wants to sell or buy some goods she/he creates an agent, sets to it the main strategic direction and sends it to the centralized agent market. The agents Kasbah proactively search for potential buyers or sellers and negotiate with them on behalf of their founders. Tete-a-Tete [8] is used for intermediary and negotiation by providing requirements either of sellers or buyers.

For retrieval of a product a buyer chooses a set of the good characteristics that are of interest of her/him. If any goods that satisfy all requirements aren't found then user has notice of it, or the list of the goods that partially satisfy to these queries is generated. The ranking principles of retrieval results frequently are not clear to the user. The customer does not receive neither a precise review of results, nor propositions for further research.

The situation would be better if some closest to her/his needs alternatives were proposed to buyer. But for this purpose the system should process knowledge about the concrete customer.

Unfortunately, the most part of the existing e-commerce systems do not provide a general interaction language, a standard domain description as well as adaptability, learning ability, and personalization. E-commerce agents created by different developers are not capable to cooperate with each other. Besides, many terms and expressions are extremely ambiguous, and their meanings depend on the user subject domain.

Problem Statement

When only key words are applied by user for informational retrieval then SA have not knowledge about domain that interested the user. SA is able to an independent knowledge acquisition only after the communication with user for a long time. Therefore it is necessary to find means of a formalized representation for such domain knowledge and to develop the algorithms of knowledge processing to make the agents more effective in goods and services retrieval.

We propose to employ the ontologies for a description of a domain being interesting for a particular user. Ontology is an universal tool for a representation of distributed and heterogeneous knowledge bases. It allows to avoid disagreements in use of a terminology and to help agents in establishing a correspondence between seller offers and buyer requirements. It is expected that sellers propose an ontological representation of knowledge about the offered goods

Ontological Representation of Knowledge

Ontology is a knowledge represented on the basis of conceptualization that intends a description of object and concept sets and relations between them. Formally, ontology consists of the terms organized in taxonomy, their definitions and attributes, and also connected with them axioms and rules of inference.

Ontology is a semantic basis in a content description. It is a logic theory that consists of the dictionary and the set of statements in some language of logic [10]. It can be applied for communications between the people and software agents.

Frequently, ontology has the form of the first order logic theory where the terms of the dictionary are names of unary and binary predicates. In a simple case, ontology describes only the hierarchy of concepts that are connected by categorization relations. As for more complex cases the axioms that represent other relations between concepts and restrict their interpretation are added to the ontology. Ontology is a specific knowledge base that uses the dictionary containing standard term meanings. It describes facts that are always true within a certain community.

A formal model of an ontology O is an ordered triple O = < X, R, F >, where X is a finite set of subject domain concepts of the ontology; R is a finite set of relations between the concepts of the given subject domain; F is a finite set of interpretation functions that are given on concepts and the relations of the ontology O.

Nowadays, a lot of ontology representation languages (e.g., DAML-OIL, OWL [11]), free distributed software tools for an ontology design (e.g., Protégé [12], OntoEdit [13], OilEd [14]) and for an ontology analysis (mapping, alignment and merging, e.g., PROMPT [15], Chimaera [16], OntoMerge) are developed.

The tools of ontology integration help users to find similarity and difference between initial ontologies and create resulting ontology that contains elements of initial ontologies. For this purpose, they automatically determine conformity between the concepts in initial ontologies or provide environment where the user can easily find and determine these conformities. These tools are known as tools of ontology mapping, alignment and merging because of they carry out similar operations.

Buyer Ontology Design

Large ontology, such as CYC, is created on the base of the abstract and much generalized description of domain concepts and their relations. The main purpose of the project CYC is to construct finally the knowledge base of all general concepts that will be accessible to various software. But in practice every user prefers the own context for representation of the terms that depends on the situation, the user task and the user model of the world. Therefore frequently huge ontology containing the description of all world is not necessary to user.

It is obvious that the ontology design is an enough complex and laborious process. User has to represent subject domain precisely and structurally be able to work with the appropriate software.

Besides it is expedient only in a case of buyer carries out relatively the same purchases during the long period of time (experts in purchases in small and medium business - B2C, B2B) and in the large volumes (for example, supply departments of large organizations - B2B, state purchases - B2G).

The advanced user creates ontology of that area that deals with her/his order and then uses this ontology for retrieval of most suitable seller. To increase the retrieval relevance user has to describe her/his knowledge and beliefs about domain objects, their relations and rules of their transformation on base of standard means of ontology representation. It provides independence of the user of the applied software because the same ontology can be processed by various e-commerce systems.

In this approach we are oriented on the simplicity and compactness of the ontology that is created by the user. The set of functions of interpretation is empty - F=∅, and R - set of the relations between domain concepts contains only a few base relations ("to be an element", "to have the price", "to have property", "synonym", etc.).

Seller ontologies also are quite simple. Even if they contain a lot of concepts, their structure is enough standard. Usually ontology that describes goods of e-shop are simple taxonomies - hierarchical systems of concepts connected by the relation "to be a class element", i.e. $O=T^0=<X, \{\text{"to be a class element"}\},\varnothing>$.

Ontologies allow determining a common terminology for the communications between the users (either people or software entities). The user query is supplemented by ontological information about corresponding subject domain (fig.1).

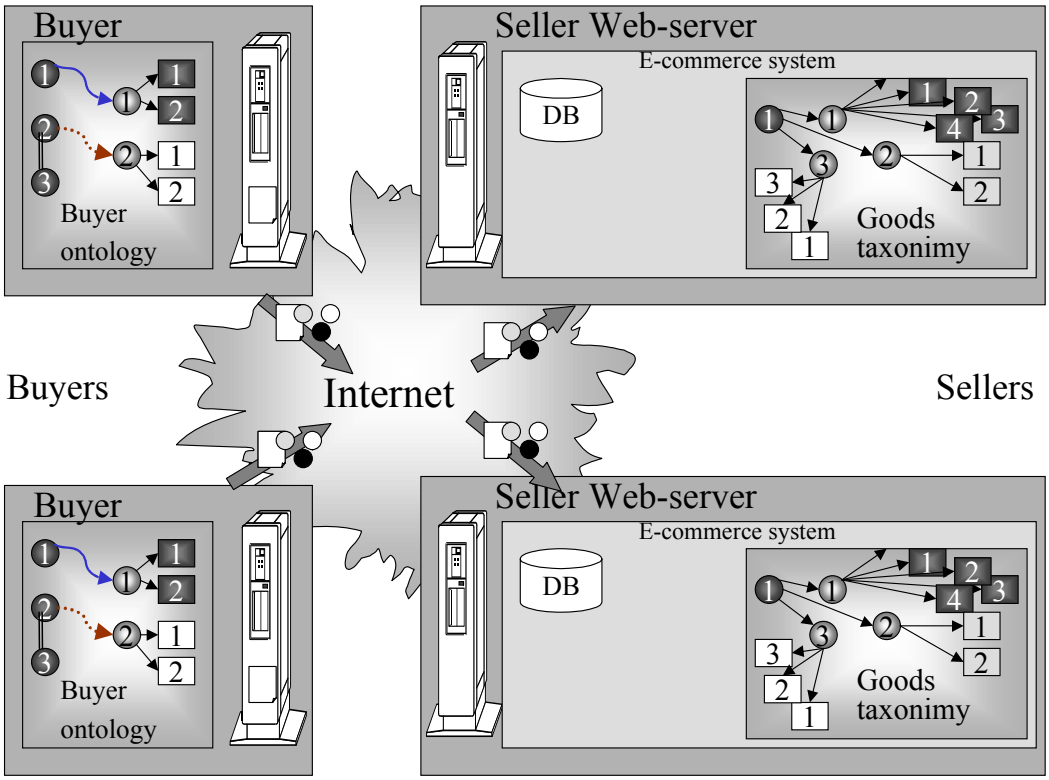

Figure 1. Ontological information use for information retrieval of sellers by buyers

Comparison of Buyer and Seller Ontologies

We use ontological representation of knowledge in prototype of e-commerce MAS for personification of the buyer and seller agents: if other conditions are equal the advantages are given to the seller whose ontology contains more terms from buyer ontology.

The ontology comparison requires various methods, methodologies and technologies that are necessary for an effective use of ontological knowledge. Each domain ontology covers the certain knowledge aspects and uses a different terminology. Special ontologies should be created for representation of connection between the various terminologies and styles of modeling that are used in ontologies of some domain.

Today a lot of software tools are designed for these purposes. For example, in the project Sesame the comparison of the ontology versions represented in RDF format and analysis of these changes is provided. But such software is too intricate for the users who are not specializing in IT.

We propose to compare ontologies in the following way: for pair of ontologies O1 = < X1, R1, F1 >, and O2= < X2, R2, F2 > the valuation function f (O1, O2) is built. This function determines their proximity measure. All pairs (x1 : x1 $\in$X1; x2 : x2$\in$X2) are analyzed. Thus the following factors are taken into consideration:

- term belongs to both ontologies - $x_1 \in X_1 \cap X_1$, - $x_2 \in X_1 \cap X_1$;
- pair of terms x_1 and x_2 belongs to both ontologies and they are in the same relation $r \in R_1 \cap R_1$;
- pair of terms belong to both ontologies by they are in the different relations of the same type (for example, in the hierarchical relations $r_1 \in R_1$ and $r_2 \in R_2$);
- pair of terms belongs to both ontologies by they are in the relations of different types (for example, in the hierarchical relation $r_1 \in R_1$ and synonymy relation $r_2 \in R_2$).

At a preliminary stage of ontology comparison (fig. 2) the set of elements - domain concepts that belong to both ontologies - is formed. Then all relations between these concepts are tested.

The user determines the type of each relation in ontology. In seller ontology such problem does not arise because the unique hierarchical relation is used.

The coefficients that determine the weight of the various factors depend on domain specificity and are determined by the user. In the simplest case only the first factor is taken into consideration.

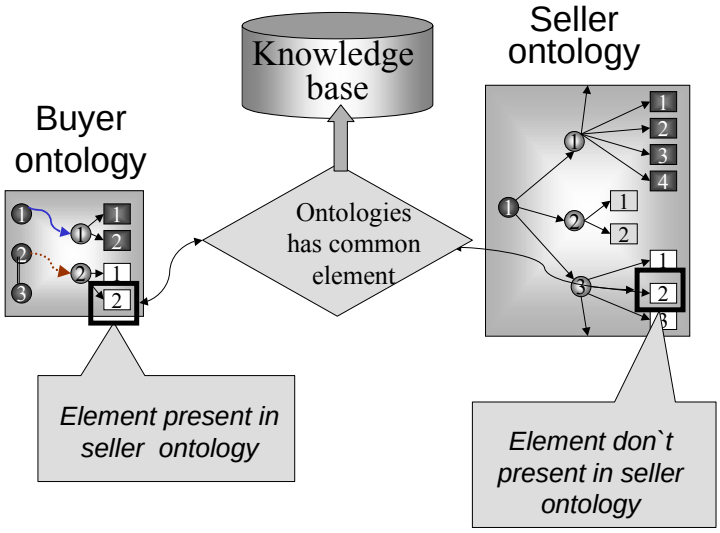

Figure 2. Preliminary stage of ontology comparison - retrieval of elements that belong to both ontologies

Prototype Implementation

In e-commerce system three interconnected subsystems are allocated: trade, dialogue management and ontology-based search of the goods and services. In a trade subsystem there can be agents of the goods and orders, and also the agents of sellers and buyers, warehouse, suppliers etc. Agents of the goods and orders negotiate with discounts strategies for patrons, wholesales, overstocking of the warehouse etc.

Some buyer agents (potential competitors) can join their orders for profit earning by the greater discount, i.e. pass from a competition to cooperation.

In the subsystem of dialogue management it is necessary to create system that returns the results of agent negotiations. The ontological subsystem provides intelligent search in distributed environment of the goods relevant for buyer.

On the basis of the existing e-commerce MAS analysis [5-9] we formulate the requirements to software realization:

1. Assurance of code portability on various platforms (UNIX, LINUX, Windows).

2. Availability of other platforms in a network. This requirement is a sequential of previous one. The mobile agents should carry out the work in heterogeneous computer environment.

3. Support of network interaction. Besides operations directly connected to moving between agent servers, the agent should have means for the communications with other agents and access to the removed resources. Therefore support of network services should include a wide spectrum of opportunities (service of names, RPC, OLE, CORBA, RMI etc.).

4. Multiflow processing. For realization of synchronous execution of several actions MAS should include support of parallel agent function execution and support of synchronization means.
5. Safety. The mobile agents coming from the network can contain potentially dangerous, harmful code. Therefore system should support safety means that are sufficient for its normal work.

For development of logic model of MAS we use UML language. The MAS structure includes: the interface module; the user interaction module (event handler); the main module MAS - module of coordination and management (according to the problem put by); ontological data processing module (sorting, filtration, search etc.); the module that returns the results to user (as a log-file - messages on the user interface).

All intelligent agents of MAS are developed on a basis of Java class CIAgent which is in details described in [17]. FacilitatorAgent (agent - intermediary) operates the market, BuyerAgents (agents - buyer) and SellerAgents (agents - sellers) are used for interaction inside this market are developed on a basis of Java. MAS contains a number of buyer and seller agents that differ, first of all, by complexity of their negotiation strategy. The negotiations are begun by simple logic rules (in the terms if-then-else), and then pass to methods of rule formation that are based on the acquired facts.

The KQML language concretizes a format and contents of interactions between sellers and buyers. The procedure BuySellMessages describes negotiation between seller and buyer in process of the market transaction. Buyer and seller never communicate directly and use for this purpose FacilitatorAgent (agent-broker) as the intermediary in negotiation on sale and purchase. The manager of the communications (BuySelMessage) comprises the messages that should be sent to other agents. These messages by means of communication language with KQML primitives: *to make a request, to accept, to reject, to change, to offer, to inform, to request the data, to refuse* and *to confirm*. Fig.3 shows the MAC window for negotiating between the seller and buyer in process of sale.

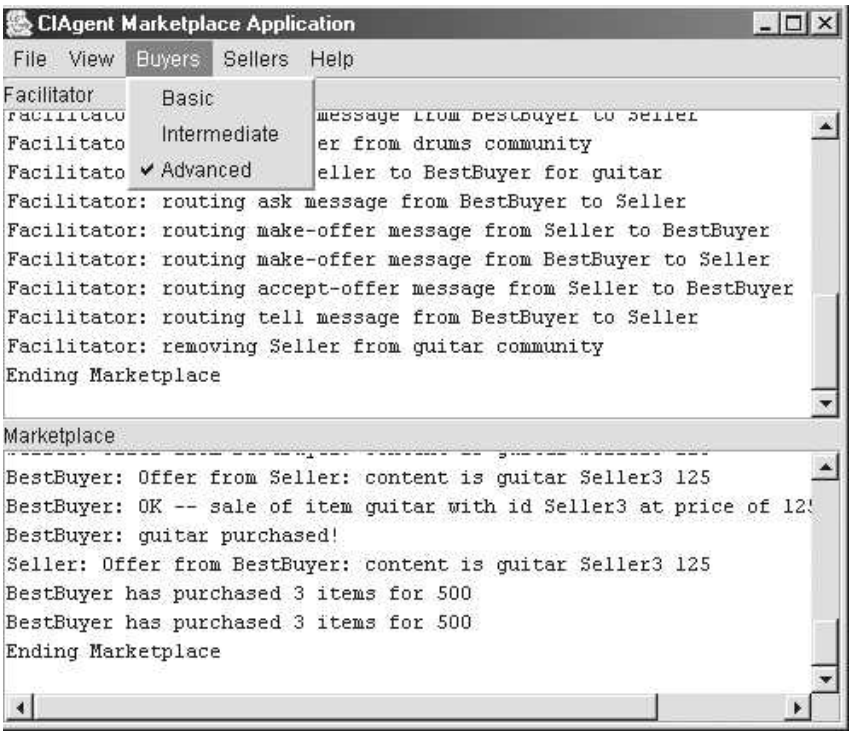

Figure. 3. MAC window for negotiating between the seller and buyer in process of sale with mediator

Conclusion

It seems to be sound to employ the ontological representation of knowledge in e-commerce for automated building of a buyer-seller common dictionary. The application of standard formats for representation of ontologies provides an interoperability of these ontologies and a possibility of their reuse for other tasks solving.

The approach proposed in this article considerably raises the retrieval relevance and allows finding offers of sellers the most favorable and appropriate to the user requirements. Besides, it stimulates sellers to build descriptions of their goods at a semantic level that is one more step to the transformation of Internet to a global distributed knowledge base.

The algorithm of comparison of buyer ontology and e-shop taxonomy is realized. E-commerce MAS that uses ontologies for informational retrieval in distributed environment is developed. The decision making module of MAS is constructed using elements of fuzzy set theory (a combination of numerical and linguistic approaches). The algorithms of the decision making allow allocating three groups of agents in a system by level of their intelligence.

The protocol of sale negotiations is described. It gives wider opportunities to control a sale process. In e-commerce, as well as in other areas, increasing efficiency is connected directly with the knowledge use in interoperable formats.

The e-commerce MAS prototype presented in this work can be apply to modeling market situations or for development of complete software products not only for e-commerce, but also for other business-applications, e.g., for electronic document interchange in corporate systems.

The e-commerce MAS prototype presented in this work is applied to modeling and studying market situations and to development of complete software products. It can be used not only in e-commerce area, but also for other business-applications, e.g., for e-learning, e-publishing, electronic document interchange in corporate systems.

Future Work

The ontology analysis is very important in the context of the Semantic Web project. The Semantic Web is an extension of the today Web where informational resources will be automatically processed taking into consideration their semantic. To generate a real semantic network, that will allow computers to combine and deduce new knowledge it is necessary to form a lot of different domain ontologies and then to order and to join them.

The ontology design is a difficult task that requires deep knowledge of the domain and, in most cases, special skills from knowledge engineering area. To facilitate a process of the ontology design it is necessary to develop a methodology that allows automating the extraction of a user's structured knowledge. If user (seller or buyer) gained wide experience of e-commerce usage than this experience can be generalized by methods of inductive and traductive inference. We have developed some original inductive algorithms for incomplete and semistructured data processing and now we intend to apply them for data mining tasks to increase the intelligence of e-commerce MAS.

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FORMING KNOWLEDGE BASES IN THE COMPUTER KNOWLEDGE BANK ON MEDICAL DIAGNOSTICS [1]

Mary Chernyakhovskaya

***Abstract**: Basic types of information resources for the computer knowledge bank on medical diagnostics are presented. They are observation ontology and some examples of observations bases from various fields of medicine. By the observation ontology observation bases can be formed, checked and used in the computer knowledge bank.*

***Keywords**: computer knowledge bank on medical diagnostics, information resources, observation ontology, observations bases, observation group, observation*

***ACM Classification Keywords:** I.2.4 Knowledge Representation Formalisms and Methods; H.2.8 Database Applications*

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Introduction

Computer systems for intellectual supporting medical activity related to examination, diagnostics and treatment of patients are among the most effective means for achieving a high level of physician's skill. These systems have to contain large and repeatedly updated knowledge bases that should be relevant to the up-to-date level of medical science. Such knowledge bases are formed in terms of appropriate medical observation bases [Chernyakhovskaya, 1983]. In turn the observation bases should be reusable, i.e. they should have such properties to be useful in various applications.

The multipurpose knowledge bank developed in the Intellectual systems department of the Institute for automation and control processes, FEBRAS, can contain specialized knowledge banks on different domains including one on medical diagnostics [Orlov, Kleschev, 2003]. This knowledge bank can contain large knowledge bases on various fields of medicine. It is targeted for supporting medical education, medical scientific researches, medical consultations and remote diagnostics of diseases. The knowledge bank on medical diagnostics consists of an information and program content. An ontology and bases of observations are among the components of the information content of the knowledge bank on medical diagnostics.

Forming the observation bases for the bank on medical diagnostics is necessary to create a unified conceptual foundation for forming knowledge bases about diseases and the case record archive. In addition, physicians can also use the observation bases as a computer terminological reference.

The Observation Ontology

The observation ontology contains definitions for all the classes of concepts related to medical observations. This ontology retains the traditional structure of medical knowledge. All the elements of the observation ontology form a hierarchy and can be divided into four classes: observation groups, observations, characteristics and values.

An observation group is a set of a few conceptually connected observations traditionally used in medicine. Complaints, case history, life history, objective examination data, laboratory and instrumental examination methods are some examples of observation groups.

Observations are such elements in the hierarchy that are traditionally defined in medicine as these concepts. Pain, asphyxia, general condition, auscultation, blood count are some examples of observations. An observation can be simple, without an inner structure, or compound, described by characteristics.

Characteristics are elements that describe an observation from different points of view. Localization of pain, character of pain, and intensity of pain are some examples of characteristics of pain. In turn a characteristic can be simple or compound.

A simple observation and a simple characteristic are described with a possible value range. The possible value range of an observation (characteristic) is a set of values that can be obtained as a result of executing this observation (characteristic).

Values can be qualitative or quantitative. In the latter case the possible value range is a numerical interval. For example, a simple observation of the beginning of a disease from the group of case history is described with the possible value range that consists of two values (acute and gradual).

An observation base is a formal representation of observations in a field of medicine. It can be used to form knowledge bases on diseases and case record archives. When described observation groups or examples of observations are too large dots (…) signal that the description of this observation groups or examples of observations is unfinished. Below general descriptions of observation bases for various fields of medicine are presented.

All the observation bases have the structure that is traditional for medicine. This structure is described with the following observation groups:

- COMPLAINTS.
- CASE HISTORY.
- LIFE HISTORY.
- OBJECTIVE EXAMINATION DATA.
- LABORATORY AND INSTRUMENTAL EXAMINATION METHODS.

The observation base on THERAPY contains 45 observation groups, and 252 observations. 140 observations from them are simple and the total number of characteristics is 502 [Chernyakhovskaya et al, 1998].

The observation group of LIFE HISTORY is described with the following observations and observation groups: place of the birth, maturity of the fetus, ontogeny, living conditions, unfavorable factors of the labor activity, had illnesses, had operations, had traumas, hereditary history, allergological history, bad habits, insurance history.

The observation group of BAD HABITS is described with the following observations: smoking, smoking history, use of alcoholic drinks, use of narcotics.

The observation of SMOKING has the following values: does not smoke, smokes sometimes, smokes less than 10 cigarettes a day, smokes more than 10 cigarettes a day.

The observation of SMOKING HISTORY has the following values: less than 5 years, 5-15 years, more than 15 years.

The observation of USE OF ALCOHOLIC DRINKS has the following values: 2 times a month, weekly, a few times a week, daily.

The observation of USE OF NARCOTICS is described with the following characteristics: the name of preparation, duration of use. …

The observation base on SURGERY contains 32 observation groups, and 203 observations. 105 observations from them are simple and the total number of characteristics is 403 [Chernyakhovskaya, Shramko, 2000]...

The observation group of OBJECTIVE EXAMINATION DATA is described with the following observation groups: general examination, neck, chest, mammary gland, gastroenteric tract, rectum, circulatory system…

The observation of MAMMARY GLAND is described with the following characteristics: developmental defects of mammary gland, side, changes, discharge from papilla, indurations, and tumor.

The characteristic of DEVELOPMENTAL DEFECTS OF MAMMARY GLAND has the following values: amastia, monomastia, polymastia, polythelia.

The characteristic of SIDE has the following values: to the right, to the left, to the both sides.

The characteristic of CHANGES has the following values: increase in volume, different form of mammary glands, different dimensions of mammary glands, different levels of papillae, pulling in of papilla, pulling in of skin (the symptom of orange peel), swelling of papilla, nipple crack, hyperemia, painfulness, fluctuation, hematoma, ulcers, cicatrices, fistulae.

The characteristic of DISCHARGE FROM PAPILLA has the following values: achromatic, yellowish and green, brown, sanguinolent…

The observation base on OPHTALMOLOGY contains 56 observation groups, and 207 observations. 92 observations from them are simple and the total number of characteristics is 539 [Chernyakhovskaya et al, 2001]…

The observation of REDUCTION OF VISION (the observation group of COMPLAINTS) is described with the following characteristics: eye, character of the beginning, character, degree of reduction, conditions, influence of correction, recoverability.

The characteristic of EYE has the following values: right and left.

The characteristic of CHARACTER OF THE BEGINNING has the following values: acute and gradual.

The characteristic of CHARACTER has the following values: far, close by, skipping individual letters during reading.

The characteristic of DEGREE OF REDUCTION has the following values: insignificant, moderate, and significant.

The characteristic of CONDITIONS has the following values: in the day-time, in the twilight, in the dark.

The characteristic of INFLUENCE OF CORRECTION has the following values: resist to correction, by spectacles, by contact lenses.

The characteristic of RECOVERABILITY has the following values: not to be restored, after sleep, after rest.

The observation base on NEUROLOGY contains 45 observation groups, and 232 observations. 119 observations from them are simple and the total number of characteristics is 592 [Chernyakhovskaya, Zaitchenkov, 2003]…

The observation of BREACH OF SLEEP (the observation group of COMPLAINTS) is described with the following characteristics: character, conditions of origin, frequency of rise, and accompanying phenomena.

The characteristic of CHARACTER has the following values: breach of falling asleep, early awakening, impossibility to fall asleep a second time, sleep in short intervals, daily sleepiness, and slow awaking.

The characteristic of CONDITIONS OF ORIGIN has the following values: without apparent causes, after psychical and emotional loads, and after stimulants.

The characteristic of FREQUENCY OF RISE has numeric or verbal values.

The characteristic of ACCOMPANYING PHENOMENA has the following values: headache, erethism, sensation of morning fatigue, fluctuation of mood, and heart pain.

The observation base on UROLOGY contains 48 observation groups, and 210 observations. 88 observations from them are simple and the total number of characteristics is 569 [Nagornyi, Chernyakhovskaya, 2002]…

The observation of ANALYSIS OF THE SPERM (the observation group of OBJECTIVE EXAMINATION DATA) is described with the following characteristics: volume, Ph, color, viscosity, leukocytes, flora, citric acid, fructose, ions of zinc, quantitative value of spermatozoa in ejaculate, and categories of spermatozoa mobility.

The characteristic of VOLUME has numeric values (normal values are between 2.0 and 6.0 ml).

The characteristic of PH has numeric values (normal values are between 7.2 and 8.0).

The characteristic of COLOR has the following values: whitish, red, yellow and brown, and yellowish.

The characteristic of VISCOSITY is described verbally (in 30 min after dilution sperm drips out is normal)…

The observation of URINARY BLADDER (EXCRETORY UROGRAPHY AND DESCENDING CYSTOGRAPHY from the observation group of LABORATORY AND INSTRUMENTAL EXAMINATION METHODS) is described with the following characteristics: changes, type of filling defect, and localization of filling defect.

The characteristic of CHANGES has the following values: absent, increase of capacity, and small capacity.

The characteristic of TYPE OF FILLING DEFECT has the following values: calculi, neoplasm, and prostate.

The characteristic of LOCALIZATION OF FILLING DEFECT has the following values: fundus, neck, lateral wall to the right, lateral wall to the left, and apex...

The observation base on IMMUNOLOGY AND ALLERGOLOGY contains 10 observation groups, and 110 observations. 81 observations from them are simple and the total number of characteristics is 174 [Chernyakhovskaya et al, 2002]…

The observation group of COMPLAINTS is described with the following observation groups: chief complaints and additional complaints.

The observation group of CHIEF COMPLAINTS is described with the following observations: dyspnea, asphyxia, cough, difficulty of nasal breathing, sneezing, lacrimation, irritation of eyelids, and so on.

The observation of ASPHYXIA is described with the following characteristics: time of beginning, character of beginning, duration, frequency of daily attacks, frequency of nightly attacks, and heaviness.

The characteristic of TIME OF BEGINNING has the following values: in the day-time, in the night-time, in the morning-time, and in the evening-time.

The characteristic of CHARACTER OF BEGINNING has the following values: sudden and gradual.

The characteristic of DURATION has the following values: 5-15 min, 16-30 min, 31 min-1 hour, 1-3 hours, 4-6 hours, and more than 6 hours.

The characteristics of FREQUENCY OF DAILY and NIGHTLY ATTACKS have the following values: 1 time a day, 2-3 times a day, more than 3 times a day, 1 time a week, and 2-3 times a week.

The characteristic of HEAVINESS has the following values: light, of middle heaviness, and serious.

The observation group of CASE HISTORY is described with the following observations: the date of the disease beginning, character of the beginning, the cause of the disease, the first manifestation of the disease, aggravations, development of the disease before a visit to a physician, conducted therapy, conducted examination, diagnosis, and the cause of hospitalization.

The observation of THE CAUSE OF THE DISEASE is described with the following characteristics: had illnesses, everyday allergens, derma allergens, alimentary allergens, pollen allergens, medicinal preparations, perfumery, chemical substances, physical substances, psychical and emotional factors, professional harmfulness, cold and thermal factors, and inoculations.

The characteristic of HAD ILNESSES has the following values: influenza, acute respiratory and viral infections, chronic bronchitis, chronic infection of ears, throat and nose, pneumonia, bacterial infections of skin and subcutaneous fat, fungous infections of skin and mucous membranes, urogenital infections, inflammation of lymphatic glands, rheumatoid arthritis, hemolytic anemia, fever of vague etiology, and inflammatory processes of various localizations.

The characteristic of EVERYDAY ALLERGENS has the following values: domestic dust, library dust, carpets, downy (feather) goods of custom, fodder of aquarium fish, allergens of insects in dwelling (cockroaches, bugs), and allergens of rodents in dwelling (mice, roots).

The characteristic of DERMA ALLERGENS has the following values: hair of domestic animals (cats, dogs, rabbits, hamsters) and feather of birds.

The characteristic of ALIMENTARY ALLERGENS has the following values: fish, egg, milk, flesh, crabs, shrimps, squids, citrus plants (tangerines, lemons, oranges), fruits, (banana, melon, apples), berries (strawberries, raspberries, currants), and chocolate.

The characteristic of POLLEN ALLERGENS has the following values: pollen of grass (timothy-grass, fowl-grass, black grass, fescue, couch-grass, nettle, plantain, sorrel, ambrosia, wormwood), pollen of flowers (buttercup, dandelion, daisy, poppy, tulip), pollen of shrubs (dog-rose, elder, lilac, hazel, filbert), and pollen of trees (birch, oak, ash, poplar, willow, alder, chestnut).

The observation of DIAGNOCTICS OF AUTOIMMUNE COMPONENT (the observation group of LABORATORY AND INSTRUMENTAL EXAMINATION METHODS) is described with the following characteristics: the level of circulating immune complexes, detection of rheumatoid factor, antibodies to DNA, and antibodies to own tissues of the organism.

The characteristic of THE LEVEL OF CIRCULATION IMMUNE COMPLEXES has numeric values (normal values are between 4 and 20).

The characteristics of DETECTION OF RHEUMATOID FACTOR and ANTIBODIES TO DNA have the following values: reaction “-“, and reaction “+” (the normal value is «-»).

The characteristic of ANTIBODIES TO OWN TISSUES OF THE ORGANISM has the following values: reaction "-", and reaction "+" (the normal value is «-») or is described by numeric values (depending on an applied method).

For a preliminary approbation of a few observation bases a PC prototype of a system for intellectual supporting patient examination was developed at the close of the eighties [Koktyisheva, Petryaeva, 2004]. The system gives a possibility to form case record archives by these observation bases. Every case record contains a description of a process of changing patient status with time. The system has been tested at several chairs of the Vladivostok state medical university in the process of teaching students.

Conclusion

Thus, at the medical expert systems laboratory of the Institute for automation and control processes, FEBRAS, observation bases in various fields of medicine have been formed and formalized on the basis of the observation ontology. These bases are components of the information content of the knowledge bank on medical diagnostics. In these observation bases practical medical knowledge is represented that is used for diagnostics of various diseases.

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THE LOCALIZATION PROCEDURES OF THE VECTOR OF WEIGHTING COEFFICIENTS ON THE SET OF TEACHING EXPERTS IN THE TASKS OF CONSUMING

Elena Drobot

Abstract: *In terms of binary relations the author analyses the task of an individual consumers' choice on the teaching excerpts set. It is suggested to analyse the function of consumer's value as additive reduction. For localization of the vector of weighting coefficients of additive reduction the procedures based on metrics of object distance towards the ideal point are suggested.*

Keywords: *The theory of consuming, the function of value.*

ACM Classification Keywords*: I.2.1 Artificial Intelligence: Applications and Expert Systems*

Introduction

The typical task in the theory of mathematical economy consuming is traditionally considered [Пономаренко, 1994] as the task of the construction of the function of consumer's value. It defines their preferences considering the definite set of goods. In this case the so-called "teaching excerpts" are under consideration: the vector sets of goods $X = (x_1, x_2, ..., x_n)$ each component of them is the quantity of corresponding goods unities. The prices of goods and budget limits are considered to be set.

The consumer's choice is characterized by the attitude of preference R. The sense is the following: the consumer can point either availability of preference or the fact they are equal (about each 2 sets of goods). A priori is considered that the consumer's choice is made in accordance with his own function of value $U(X)$. Its meaning on the teaching excerpt $X = (x_1, x_2, ..., x_n)$ corresponds to the individual consumer's appreciation for this set. The task of consumer's choice is supposed to be in the choice of such a consumer's set which maximizes its function of value within the defined budget limit.

The classical methods used for the definition of the function of value on binary set of preferences R relations in general are pretty rigid. The basis for their usage, in particular, is a sufficient condition of its existence which are set, for example, by Debre theorem [Пономаренко, 1994]. The preference relation must be complete, reflexive, transitive and continuous, the set of the decisions – connected. If Debre's conditions are not completed (subjective attitude of preference can be, firstly, intransitive), and the function of value which introduces the attitude and does not exist, it's impossible to use the classical methods of the consuming theory.

The alternative approach to defining the function of value is suggested. It's considered that the expert (the consumer) while evaluating the object means its vector value. The procedure of problem formalization is suggested in the way of transition of "vector value" into the additive reduction. Then the task is in specifying weighting coefficients of additive reduction.

The Task Set

Let's consider the final set of consumer's goods, the teaching excerpt on the endless set of goods. The prices of goods are set, the budget limit on summary value of goods unities in the excerpt is set as well. Let's take X as the set of teaching excerpts x^j, $j \in J$, when J is the set of excerpts indexes, which is formed within the budget limit frames.

Each excerpt $x^j \in X$, $j \in J$, is characterized by its unities distribution for each goods $x^j = (x^j{}_1,...,x^j{}_i,...,x^j{}_n)$. Let's mark the set of indexes of goods of excerpts I, $I = \{1,...,n\}$. We suppose that each excerpt, $x^j \in X$, $j \in J$, vectors mark in the dimension of goods Ω^n.

The corresponding set $\omega(x^j{}_i)$, $i \in I$, $j \in J$, where ω – some monotonous reorganization which defines the degree of quantitative characteristics declination from the optimum meanings for each goods $x^j{}_i$, $i \in I$, $j \in J$, and reorganizes all the meanings of goods quantitative characteristics towards the normal type in interval [0,1].

Let the consumer [expert] consequently define his preferences on the set X as binary relations of preference R.

The following approach to the task solution is suggested: we suppose that evaluating the object (in our case – the teaching excerpt) the expert (consciously or subconsciously) means its vector value. If we consider "the vector" function of value as additive reduction, the task is considered as defining of weighting coefficients' reduction (1)-(2):

$$x^1 R x^2 \;\Leftrightarrow\; \sum_{i\in I}\rho_i\omega_i(x^1) \le \sum_{i\in I}\rho_i\omega_i(x^2),\; x^1, x^2 \in X, \tag{1}$$

$$\rho = (\rho_1,...,\rho_n),\; i \in I,\; \rho_i > 0,\; \sum_{i\in I}\rho_i = 1, \tag{2}$$

where (2) – normal vector of object's relative importance parameters for the experts statement about the preference relation between the objects.

So, the task is in localization of weighting coefficients of additive reduction (1) – (2).

The Localization Procedures of the Vector of Weighting Coefficients

The procedures of localization the of vector's component of weighting coefficients in the way of successive intervals specifying of changing of corresponding vector ρ components (hyperparallelepiped of weighting coefficients in the sphere of preferences):

$$\rho \in \Pi = \prod_{i\in I}[\rho_i^H, \rho_i^B],\; \rho = (\rho_i,\; i \in I),\; 0 < \rho_i^H \le \rho_i^B < 1, \tag{3}$$

$$\sum_{i\in I}\rho_i = 1,\; \rho_i > 0,\; i \in I.$$

The ideological procedures' basis is the hypothesis about the "ideal point" which reflects the "ideal excerpt" in the dimension of goods (vector of preferences in the preferences sphere). The expert possesses the excerpt's complex "image" of this. It is supposed that while comparing teaching excerpts the expert compares their closeness degrees within some metrics limits of to the "ideal" set with the optimum good units' distribution.

For reorganization of all the meanings of goods units x… to the normalized kind in the interval [0,1] the formula [Волкович, Волошин, Заславский, 1993] in particular is used.

$$\omega(x^j{}_i) = \frac{x^{opt}{}_i - x^j{}_i}{x^{opt}{}_i - x^0{}_i}, \tag{4}$$

where $x^j{}_i \in X$, $i \in I$, $j \in J$; $x^{opt}{}_i \in X$, $i \in I$ - the most desirable quantity of the units of i-goods on the set of possible excerpts: $x^0{}_i \in X$, $i \in I$ - the least desirable quantity of the units of i-goods on the set of possible excerpts. Let's consider that x^{opt} and x^0 can be set directly by the expert on the set of admitted teaching excerpts.

Taking into consideration (4), the generalized criteria, which reflects the total declination of j-object $j \in J$ from the optimum meanings, will be presented as

$$D(x^j, x^{opt}) = \sum_{i\in I}\rho_i\omega(x^j{}_i) = \sum_{i\in I}\rho_i \frac{x^{opt}{}_i - x^j{}_i}{x^{opt}{}_i - x^0{}_i},\ j\in J.$$

The last formula is the proximity metrics of vector $x^j \in X,\ j \in J$, which presents the distribution of goods units j-excerpts to some ideal (optimum) vector of distributions $x^{opt} = (x^{opt}_1, x^{opt}_2 \ldots x^{opt}_n)$ weighted in the dimension of goods. Formula (1) will be presented as:

$$x^1 R x^2 \ \Leftrightarrow\ \sum_{i\in I}\rho_i\omega_i(x^1) \le \sum_{i\in I}\rho_i\omega_i(x^2) \ \Leftrightarrow\ \ D(x^1, x^{opt}) \le D(x^1, x^{opt}),\ x^1, x^2 \in X.$$

Last inequality can be interpreted in the following way: the statement "excerpt X.. is preferable than the excerpt X.." means that in the dimension of goods Ω^n the point which corresponds to excerpt x^1 is located within less distance according to the ideal point than the point which corresponds to excerpt x^2. In case of ratio of equality of excerpts points in Ω^n which correspond to them are located within the same distance from the point corresponding to the ideal object.

The procedures of localization of vector of weighting coefficients (2) represent factually two procedures: the procedure of intervals of weighting coefficients specifying (3) and the siftings procedure of "not perspective" excerpts from the original set of teaching excerpts under consideration.

The procedures are based correspondingly on the statements 1 and 2 which are given further. The evidences of these statements which are generalized for the case of defining preferences by the expert in metrical form are given in the work [Волошин, Гнатиенко, Дробот, 2003].

Statement 1. Vector of preferences, which corresponds to equal excerpts in the dimension of preferences E^1, defines the intervals limits of the change of goods' weighting coefficients. That is expressed numerically

$$\sum_{\substack{i\in I_1\\ \rho_i^s\in\Pi^s}}\rho_i^{(s)B}\omega_i(x^1) + \sum_{\substack{i\in I_2\\ \rho_j^s\in\Pi^s}}\rho_i^{(s)H}\omega_i(x^2) = \sum_{\substack{i\in I_1\\ \rho_i^s\in\Pi^s}}\rho_i^{(s)B}\omega_i(x^1) + \sum_{\substack{i\in I_2\\ \rho_j^s\in\Pi^s}}\rho_i^{(s)H}\omega_i(x^2),\ x^1, x^2 \in X,$$

where $\rho_i^{(s)B}$, $\rho_i^{(s)H}$, $i\in I$ - correspondingly the upper and the lower borders of I-interval of weighting coefficients on s-repetition of comparisons; $I_1 = (i : \omega_i(x^1) > \omega_i(x^2)) \ne 0$, $I_2 = (i : \omega_i(x^1) \le \omega_i(x^2)) \ne 0$, $i \in I = I_1 \cup I_2$.

So hyper-parallelepiped of weighting coefficients (HWC) on s+1 step will be equal

$$\Pi^{s+1} = \prod_{i\in I_1}[\rho_i^{(s)H}, \rho_i^{(s+1)B}] \times \prod_{i\in I_2}\left[\rho^{(s+1)H}, \rho^{(s)B}\right]. \qquad (5)$$

The discovering of preferences vector, which corresponds to equal objects [Волошин, Гнатиенко, Дробот, 2003] is suggested to accomplish by solving of n equations of the type:

$$\rho_{\ i\in I_1}(\omega_i(x^1) - \omega_i(x^2)) - \rho_{i\in I_2}(\omega_i(x^1) - (\omega_i(x^2)) = 0,\ x^1, x^2 \in X, \qquad (6)$$

$$\sum_{i\in I}\rho_i = 1,\ \rho_i > 0,\ i \in I.$$

Statement 2. The condition of object selection ω^j, $j \in J$, from the set X^s is unbelongingness of HWC vector which passes through the coordinates beginning and point $\omega(x^j)$, $x \in X^s$, $j \in J$, namely $\rho(\omega(x^j)) \notin \Pi^{(s+1)}$. Vector of weighting coefficients is defined according to the formula given in [Волкович, Волошин, Заславский, 1993]:

$$\rho = \rho(\omega(a^j)) = \{\rho_i : \rho_i = \prod_{\substack{t\in I \\ t\neq i}} \omega(a^j{}_t) / \sum_{q\in I} \prod_{l\in I} \omega(a^j{}_l)\}.$$

The procedures of localization of vector of weighting coefficients are used in the following person-computer procedure.

Step 1. Pointing out the ultimate set of teaching excerpts X on the unlimited consumer goods' set. The very first HWC is set as equal to single hypercube.

Step 2. Expert's choice of two excerpts x^1 and x^2 from the set X^s in HWC Π^s, s =1,2,... (step of limiting HWC) with stating of the preference and equivalence fact.

Step 3. Constructing equation system of type (6). Finding solution of the equation system.

Step 4. Specifying HWC limits according to formula (5). If hypercube $\Pi^{(s+1)}$ satisfies the expert it means the end of the procedure. Otherwise we pass by to the next step.

Step 5. Pointing out the set of "perspective" excerpts $X^{(s+1)}$ ($X^{(s+1)}\subseteq X^{(s)}$) in HWC $\Pi^{(s+1)}$ and presentation of them to the expert for the choice of next two objects with stating for them the preference attitude.

Step 6. Uniting the excerpts, chosen by the expert on the previous step to the set of discussed excerpts and analysis on the given set of transitiveness. If the transitiveness is not destroyed then increase of iteration number s=s+1 and passing by to step 2. If the transitiveness is destroyed then the exclusion of these excerpts from the set of considered objects and passing by to step 6.

Repeated process is finished when the expert is satisfied with the discovered intervals of changing of goals weighting coefficients.

To find team solutions on the basis of interval team evaluations which are formalized in such a way, we can use, for example, the methods, suggested in [Гнатієнко, Дробот, Санько-Новік, 2002].

Conclusion

The suggested procedures do not demand the complete metrics of binary comparisons of teaching excerpts and allow restoring the function of consumer's value on the binary relations' set.

Besides the task of vector of weighting coefficients in the kind of intervals can be interpreted as the reflection of indistinctness in social-economical systems. That is why the suggested procedures allow reducing the uncertainty level in indistinct models of making decisions.

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NEURAL NETWORKS FOR MODELLING OF LARGE SOCIAL SYSTEMS. APPROACHES FOR MENTALITY, ANTICIPATING AND MULTIVALUEDNESS ACCOUNTING.

Alexander Makarenko

Abstract. *It is consider the new global models for society of neuronet type. The hierarchical structure of society and mentality of individual are considered. The way for incorporating in model anticipatory (prognostic) ability of individual is considered. Some implementations of approach for real task and further research problems are described. Multivaluedness of models and solutions is discussed. Sensory-motor systems analogy also is discussed. New problems for theory and applications of neural networks are described.*

ACM Classification Keywords: *I.6.5 Model development: modelling methodology*

1. Introduction

There is one principal feature of the present state of contemporary World: their evolutionary nature. That is the rate of changes that is accelerating rapidly now and the problems of evolution of global systems became more and more complicated. So, the applicability of existing theories and models of society are under question. One of the main tools for the investigation of evolution is the approach from the physical theories - that is synergetic.

There also exists the great variety of the mathematical models. It is known that the above models present mostly three types of global blocks (biospherical, climate and anthropological). The block of human (anthropogenic) factors actually seems to be the less developed one. The artificial intelligence theory can give the answers on some questions, but there is the lack of practical operational models with artificial intellect.

We may say that in spite of many successes of system analysis and mathematical modelling there is the necessity to have socio-economics models. So, main basic items for the theories and models of the World exist: the society as the whole object, the evolutionary nature of the society, the mentality problems and some propositions on the laws of their behaviour. In proposed report, we briefly consider the principles of new models construction, some applications and further scientific problems. The main goal of this report is to describe the ways of mentality accounting and especially the anticipatory property accounting consequences.

2. Short Description of Models

Let us take that society consisting of N >> 1 individuals and each individual characterising by vector of state $S_i = \{s_1^i,..,s_{k_i}^i,s_{k_i+1}^i,..,s_{M_i}^i\}$, $s_l^i \in M_i^l$, $l = 1,...,M_i$ where M_i^l is a set of possible values s_i . There are many possibilities to compose the elements in blocks and levels in such models. In sufficiently developed society individuals have many complex connections. Let us formalise this. We assume that there are connections between i and j individuals. Let J_{ij}^{pq} is the connection between p components of element i and q component of element j Thus the set Q = ({ s_i },{ J_{ij}^{pq} }, i,j = 1,...,N) characterises state of society. Analysis of recent models for media from sets of elements and bonds shows the resemblance of such society models to neural network models.

2.1 Possible Structures of Models

Now we follow the description of hierarchical systems similarly the one in papers by Mesarovich and Takahara. We suppose initially that there are M hierarchical levels in the socio-economical system with N_j elements on

j-th level. Each I-th element on j-th level have description by vector of parameters Q_i^j i=1,2,...,N $_j$; j=1,2,...,M. Some elements on chosen levels can be in associations, marked by set of possible indexes in associations $L_i^j \subset \{1,2,..., N_j\}$. Many elements in developed society have a vast number of interconnections on there and on upper and lower levels. We may denote connections (bonds) between i1 elements on j1 level with i2 element on j2 level by J(i1,j1;i2,j2). Remark that other fields of interest (political, social, educational and so on) have similar network representation and society, as a whole is a union of such networks.

The bonds from the connection sets may be very different on the nature. The values of bonds may represent the normalisation of economical, informational, control channels, nationality, family bonds, and participation in professional associations and so on. The general model of system as in general system theory can be introduced with the help of input X1, X2, …, XM and output Y1, Y2, …, YM spaces for every level with input variables xi ∈ Xi and output variables yk ∈ Yk.

In reality society is evolutionary system with dynamical changes on time. Further we for simplicity will consider only discrete time models with moments of time: 0, 1, 2, ..., n,… . Following evolutionary nature of systems considered it is natural to consider as input of system in moment n the values of parameters from X in n-th time moment and as output the values at next (n+1) time moment (for n=0, 1, 2, …). Remark that in developing society the content of elements set may changes. For example in economics the list of firms and corporations changes gradually by bankruptcy and by creating of coalitions. Social, political, governmental networks are often in transformations. This lead in general to changing the number of elements N $_j$ (n) and number of hierarchical levels M(n) for different moments of time. Next if we wish to take into account the past states of society explicitly we should introduce to equation (1) or (2) the values X(0), X(1), X(2), … , X((n-1)). Than the system description takes the form

$$Y(n)=f(X(0),X(1),X(2),\ldots,X((N-1)), X(n), P, E).$$

2.2 Dynamics in Model

The equation above is rather general but for further investigations and practical applications we should have more developed models. Because we should consider evolutionary problems the main difficulties consist in searching the principles for modelling dynamics.

The author's models consider the Society as large complex object constructed from many elements with interconnections. The considerations of Society properties allow picking out some interesting properties and then to propose the models, which can imitate society behaviour. Surprisingly the models are familiar with models of brain activity - the neuronets [1]. Such models are under investigation by author since 1992 and yet had some interesting applications. In the processes of model consideration author continuously tried to take into account recent state of above mentioned sciences.

Now let us briefly describe the models. The first step of model building consists in the choice of model element and their description. Because it is need to take into account mentality of peoples in simplest models as the elements was took the individual with their description by series of mental and other (economical, demographic, and other parameters). These parameters may be evaluated in some scales psychology, sociology and other humanity sciences.

Next there are a lot of interconnections between elements in society - informational, business, relationship, and infrastructure. The elements are connected by bounds. The bounds correspond to influence by individual, the money flows and others. Such connections are created historically. The set of element states and bounds give the description of society in some period of time. Remark that such description is familiar with verbal description in humanity sciences. For example the pictures in L.White's works remember the pictures for global socio-economical models. But if we wish to describe the dynamics of society and to evaluate the influence of control, we must to know dynamical laws or tendency in dynamics. The proposed models have such dynamical principles

that they can imitate the behaviour of global culture in time. This is because the models have the property of associative memory. That is it can learns from historical processes the bounds and tends to very stable constructions- to so called attractor in pattern recognition in informatics and neuroscience. It is important that many social sub-processes in society also have the properties above allow considering the separate sub-models.

In earlier papers author introduced new class of society models as modification of neuronet models such as Hopfield, Potts, Izing. It is well known that Hopfield model is derived from the functional called 'energy'. In case of hierarchical systems and symmetrical bonds between different elements and different levels there also exist functional – counterpart of 'energy'. Remark that there also may be formulated generalisation of Hebbian learning rules.

3. Mentality Accounting

The mentality accounting requires considerations internal structures and incorporating them in global hierarchical models. There are many approaches for mentality accounting (see review of some aspects in [2, 3]). The most natural way for implementing this task is to consider as model for internal structure also neuronet models. Remember that originally neuronet models were introduced in the investigation of brain. Firstly we can change the basic laws. On phenomenological level it may be implemented by introducing subdivision of elements parameters on external and internal variables and establishing separate laws for two blocks of parameters. But one of the most prospective ways for mentality account lies in searching equation also in neuronet class. Here proposed to introduce the intrinsic mental models of World in elements, which represent the individuals or decision-making organisations with human participation. The simplest way consists in representing image of World in the individual's brain or in model as collection of elements and bonds between elements. In such World pattern there exist place for representing individual himself with personal beliefs, skills, knowledge, preferences. The mental structures on other individuals are also represented. Then the laws for element evolution should depend on such representation.

4. Anticipatory Property

The next step of developing models consists in accounting anticipatory aspects of individuals. It is evident that individuals in decision-making processes have prognoses on future. In such case the states of elements in model should depend on the images of the future described in internal representation. As in usual reflexive system there may exist some stages of iteration in anticipating future. We call such case as hyperincursion.

The verbal description of internal structure was described in previous section. Now we give the possible structure of models and some corollary. First we describe the model structure with one element with internal structure. If there were no internal structure it was the system in section above for dynamical law. Let the individual with internal structure has the index i=1. Their dynamic is determined by two components. First component determines by external mean field as above. Second part of dynamic is connected with internal dynamics of individual. Remark that such dynamic partially accounts the willing of individual. There exist many models for such part of dynamics but it is useful to put the neuronet models for our purposes.

Let us named the pattern of society $Q^{(1)}(t)$ in section above as 'image of real world ' in discrete moment of time t. We also introduce the $Q_{wish}(t)$ - ' desirable image of world in moment t by first individual' as the set of element states and bonds wishes by first individual in moment t. $Q^{(1)}_{wish}(t)=(\{s_l^{wish}(t)\},J_{ij}^{wish}(t)\})$. Then we assume that the change of first individual state depend on difference between real and desirable image of the world. The resulting system takes the form:

$$S_l(t+1)=G_l(\{s_l(t)\},\{s_l(t+1)\},\ldots,\{s_l(t+g(l))\}, R),$$

where R is the set of remaining parameters. It is very prospect that the structure of system above coincides with anticipatory systems with incursion [4]. This follows possible similarity in properties.

5. Multivaluedness in Neural Networks

So far the neuronet approach had followed after the original problem formalisation. But with spreading neural network methodology some new mathematical problems had aroused which may have long- term influence on the development of neurocomputing and not only it. Such problems follow from models above. First topic concerned the neuronet models with hierarchical structure. The second and very interesting connected with possible multivaluedness in neuronet.

The main source of multivaluedness lies in neural elements with internal structure with anticipatory property when the dynamical behaviour of element depends from desired pattern of future [3]. Some preliminary results were received with R.Pushin on modelling unique multivalued neuron. Also the principles for dynamics were considered.

In parallel (and forwards) some possible range of applications may be proposed. Some such issues are brain processes and conscious, quantum mechanical analogies, many worlds concept in physics, logic and philosophy, complexity, multivalued solutions of differential equations.

6. Some Relations to Sensor-Motor Robotics

The models described in previous sections already were applied to some practical problems. Further development will follow by exploiting concepts from another research fields. Surprisingly such enrichment leads to considering some fundamental problems of cybernetics. The main tool is inter- disciplinarily methodology.

One of the sources of new ideas is the psychological investigation of visual perception. Remember that the perception process not only include the reception of signal by visual sensor system but also include internal comparison with patterns. Such patterns are internal constructs of visual perception system [5, 6]. Further development of proposed models will lead to complication of internal models and to modelling of process of norms learning. It is directly connected the investigations on norms ruled behaviour. Society norms, morals, religion and so on determine the rules. Remark that till now there was a little investigation on such topics mostly of model character [7].

From another side further development of proposed models needs further re- considering of basic principles of artificial intelligence in application to such problems. From such point of view especially interesting are investigations in formally different research field in automation and control – that is from behaviour theory of mobile robot. The short list of investigations (see [8, 9]) includes analysis of sensor- motor robotics; comparison of formal language's and behavioural approaches; internal representation of external environment; role of sensor information channels. Some of such concepts may be transfer to the neural type models of large socio-economical systems. One of the basic concepts in the mobile robot theory is physical landscape. In social systems case the evolution takes place in many- dimensional space constructed from physical and mental space. The points in this space are representation of system space in different time moment. Remark that the description of environment as network from [10] may be useful building internal description of world.

Conversely, the author's model may be interesting for considering mobile robot problems. The neuronet description of external environment is first example for such application. But more prospects may be the investigation on anticipatory agents. As already had formulated above, anticipating property account leads to multivaluedness of behaviour scenarios in systems with self- reference. Concerning mobile robot it may lead to more intelligent behaviour (in definition of intelligence from [11]).

The next perspective approach follows from the considering neuronal models with many agents. As background for modelling large systems it allows to solve the optimal control and game- theoretical problems. The robot soccer may be one of such issues. The second is the control problem for many vehicles with internal structure in 2D and 3D space cases.

7. Applications and Discussion

Now we should discuss some issues connected to above problems. It should be stressed some relations to another topics in artificial intellects. One of such item is so called artificial agent's theory. Now there are many investigations on artificial agents. In this approach some non-classical logic are accepted. Moreover our neuronet type models follows to consideration of some non-classical logic. Another interesting aspect is the structure of neuronet models itself. Our investigations lead to the necessity of considering set valued neural networks.

The possible applications of models with mentality account to election processes, negotiations, public relations, education are discussed. Also pure mathematical problems on multi-valued maps and on conflictly-controlled systems are posed. As application it were considered the modelling future geopolitical relations and collective security system structure in World after the destruction of the USSR, sustainable development, epidemiology, conflict theory, stock market and others [12, 13]. It was created as mathematical model as computer program implementation. Remark that recently we had received interesting result on models with internal structure application to the stock market process. This is the example of mental agent application. Recently new possible fields of applications are outlined. Moreover the connected to multi–agent modelling, cellular automata, decision-making in social systems became visible. Also new analogies of quantum mechanics and social system behaviour are found. Besides, the theory of distributed reflexive systems can receive the strict models for consideration. Ontology of knowledge and systems description may easy take into account mentality aspects. All this follows to new problems in neural network design and in neural network theory, which the author supposes, discuss in the report. One of the main conclusions is that the new proposed fields of neural network applications can lead to reconsidering some backgrounds of the network considerations.

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TOWARDS THE PROBLEMS OF AN EVALUATION OF DATA UNCERTAINTY IN DECISION SUPPORT SYSTEMS

Victor Krissilov, Daria Shabadash

Abstract: *The question of forming aim-oriented description of an object domain of decision support process is outlined. Two main problems of an estimation and evaluation of data and knowledge uncertainty in decision support systems – straight and reverse, are formulated. Three conditions being the formalized criteria of aim-oriented constructing of input, internal and output spaces of some decision support system are proposed. Definitions of appeared and hidden data uncertainties on some measuring scale are given.*

Keywords*: decision support systems, straight and reverse problems of data uncertainty, three conditions of aim-oriented object domain constructing, appeared and hidden uncertainties.*

ACM Classification Keywords*: H.4.2 Information Systems Applications: Decision support Systems*

Introduction

One of the most actual questions of decision making theory – is the question of forming aim-oriented description of an object domain, namely, description of input, internal and output spaces of decision support systems (DSS). Practically, any input data has uncertainty, sources of which can be: inaccuracy of measuring and inaccuracy of rounding-up, scale restrictions, impossibility of measuring or definition of values with needed precision, hidden semantic uncertainty of qualitative data, etc [1, 2]. In addition, uncertainty in DSS may be caused by methods, used for obtaining, storage and processing of knowledge. A great deal of uncertainty to the decision making process brings the subjective factor that appears when the person making a decision (PMD) formulates the set of alternatives decisions and the set of descriptive criteria for them.

Main known approaches to the evaluation of uncertainty in DSS are methods of the probability theory [3, 4] and methods of fuzzy logic [2, 5]. The first are used in that case, when the extensive statistical information about the decision making process is accessible. The second are applied for description of system behavior, when it is too expensive or practically impossible to construct precise mathematical models. However, frequently in real DSS there is a necessity of the composite approach for estimation and aim-oriented handling of input and output space uncertainty.

The given paper is devoted to the problems of an estimation and evaluation of data and knowledge uncertainty in DSS.

Straight and Reverse Problems of Data Uncertainty in DSS

We will consider some DSS in the way of a "black box" (fig. 1).

On fig. 1. are represented:

$X = \{x_1, x_2, ..., x_n\}$ - the set of input parameters (dimensions);

$Y = \{y_1, y_2, ..., y_m\}$ - the set of output parameters (dimensions);

$Q = \{q_1, q_2, ..., q_l\}$ - the set of internal (intermediate) states (dimensions).

The representation form of results, to be exact – uncertainty that exists in them, we shall designate it N_3, essentially influences on a constructional usage of them in a particular problem of decision making, and it is characterized by the working conditions of DMS as a whole. Uncertainty of results N_3, is conditioned by uncertainty of input data (N_1) and uncertainty of system (N_2) (fig. 1.) [1].

Fig. 1. Uncertainty in DSS

Within the frameworks of such approach, let's formulate two main problems of estimation and evaluation of data and knowledge uncertainty in DMS – straight and reverse.

The straight problem consists of determination of result's limit accessible uncertainty N_3, on the base of known uncertainty of input data N_1 and uncertainty of system functional N_2. Then making a comparison of received N_3 with the value of a result's limit acceptable uncertainty N_{3max}, that is determined by PMD, on the base of solving tasks aim. This problem arises when, on the base of already available data, for example, stored in some data warehouse [6, 7] and had some level of uncertainty, it is necessary to construct the definite rules for decision making.

The reverse problem consists of aim-oriented forming of internal and input dimensions so, that it can provide an uncertainty of output dimension N_3 not bigger than top limit acceptable uncertainty N_{3max}. This problem arises at solving tasks of pattern recognition, cluster analysis, constructing of object domain of some DSS [6, 7].

Solving two main problems of estimation and evaluation of data and knowledge uncertainty in DMS makes possible to formulate three main conditions, being the formalized criteria of aim-oriented constructing of input, internal and output spaces of some DSS.

1. Condition of insufficient detailing (an excessive generality) of space:

$$N_3 > N_{3max}$$

2. Condition of redundant detailing of space:

$$N_3 < N_{3min}.$$

3. Condition of constructive usage of space:

$$N_{3\,max} \geq N_3 \geq N_{3\,min}.$$

Where:

N_3 – uncertainty of result, calculated on the base of input data uncertainty (N_1) and uncertainty of system (N_2)

$N_{3\,max}$, $N_{3\,min}$ – respectively, top limit acceptable and low limit sufficient uncertainties, determined from the aim of decision support task

Surely, essential requirement is that - $N_{3\,min} <= N_{3\,max}$.

Concepts of Appeared and Hidden Data Uncertainties

In practice, usually, process of formation of DSS's input and output spaces has iterative character. At the same time, each iteration represents conversion between various types of scales, or transition to more or less detailed scale of the same type. So, the straight problem formulated above is, from this point of view, the process of sequential granulation. The reverse problem represents the process of sequential decomposition. Traditionally values N_1, N_2 and N_3 characterize uncertainty of DSS on some final iteration [3, 4]. Hence, the big influence on the solving problem has type of the scale, which is used for display of input and output spaces. Depending on a required precision, measuring scales of various types are used: nominative, order, interval, relative and absolute [7].

Let's consider more in detail representing of some data on different scales.

First of all, in an explicit form, there is some set of values on a scale, the amount and form of which depends on the type of selected measuring scale. Up to the moment of measurement (observation), there is uncertainty of what value on a scale will be selected as a result of measurement. This uncertainty can be semantically compared to the entropy of the initial alphabet, known in information theory [3, 4]. Thus, the uncertainty of the measuring scale values set, described above, we shall name *the appeared uncertainty*, and designate as H_{np}.

Usually, during the characterizing of some measurement uncertainty only this uncertainty is taken into consideration.

However, on the other hand, data on a measuring scale are represented with some finite precision. It means, that each value on the scale hides in itself whole "cloud" of the real values. At that, distinguishing these values is impossible because of resolution limitation of measuring devices or inexpedience of this for the given task. Thus, some value on a scale represents analogue of concept of the granule, offered by L. A. Zadeh [2]. Therefore, takes place the uncertainty of the data, which is "hidden" in values of a measuring scale. We shall name it as hidden uncertainty, and designate as $H_{ск}$.

Let's choose the scale of absolute type and consider the limiting case, when only two values are located on it (for example, «0» and «1»). In this case, appeared uncertainty of the scale is minimal, as the possible quantity of values on it – is minimal. Hidden uncertainty, in this case, on the contrary – is maximal, as in two values, that lies on the given scale, all variety of possible values of entrance data is contained. When increase in scale detailing, obviously, the quantity of values on the scale increases and the number of the "not distinguished" values decreases. Hence, appeared uncertainty of the scale increases, and hidden - decreases. At use of all possible values on the absolute scale, hidden uncertainty - is minimal and is defined only by inaccuracy of the received data. Appeared uncertainty, at the same time, - achieves its maximum.

As there is unique transformation from strong to weaker scales, the changing of appeared and hidden uncertainties values, described above, is valid for other types of scales - nominative, order, interval, and relative. Definitions of appeared and hidden uncertainties are given independently of measuring scales types.

Conclusion

Choice of measuring scale type determines the form of data representation in DSS data domain. Then, the ratio of hidden and appeared uncertainties can characterize conversion between various measuring scales, on each iteration of forming DSS's input, internal and output spaces.

So, considering the straight problem from the point of view of appeared and hidden uncertainties, formulated above, we shall receive the following. At the known uncertainty of input data (N_1) and uncertainty of the system (N_2) the process of solving the straight problem represents the process of sequential granulation of input scales values up to obtaining the result with the uncertainty $N_{3\,min} \le N_3 \le N_{3\,max}$. Thus, it is expedient to estimate changing of appeared and hidden uncertainties on each iteration of this transformation, in order to check up conditions (1), (2), (3).

Similarly, at solving of the reverse problem, the basic carried out operation is – decomposition. At the known uncertainty of results N_3, it is expedient to characterize process of sequential decomposition from the result scale to the input space scales by changing of appeared and hidden uncertainty values on each iteration.

Real tasks often are the composition of these processes, i.e. demands iterative execution of both: granulation and decomposition. And exactly the analysis of appeared and hidden uncertainties changes on each iteration makes all process of solving straight and reverse problems aim-oriented. Hence, on the basis of the introduced concepts of appeared and hidden uncertainty, it becomes possible to characterize and manage the processes of decomposition and granulation at formation input and output spaces of DSS.

The further studies should be directed to the development of formalized methods of the quantitative evaluation of data and knowledge uncertainty, supplying a choice and/or developing of adequate means for decision making process.

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INFORMATICS, PSYCHOLOGY, SPIRITUAL LIFE

Larissa Kuzemina

***Abstract**: How the processes of human perception exert influence on the development of the information science is discussed in the article.*

***ACM Classification Keywords**: I.2.0 General: Philosophical foundations*

Informatics as a key link of our life is directly connected to a human perception with all its sides. Everything in our life rises in perception, stems from it and develops.

To live means to perceive, to perceive means to develop oneself, to develop oneself means to live more and to perceive more [1].

The process of perception is connected to a psychological self-programming for selection, comprehension, accumulation and transmission of information. This brings us into the channel of a personal freedom psychology forming (ability of a person to control his development closely connected to self-consciousness, resourcefulness, openness, readiness to changes). In the course of self-consciousness development the range of the human choice and his freedom widens.

Freedom is considered as a form of activity characterized with three indicators: perceptiveness, instrumentality of "what for" value and controllability at any point. Respectively, deficiency of freedom may be related to misunderstanding of the forces acting on a subject, absence of clear value patterns and indecision, incapability to interfere in the course of the own life.

Under favorable conditions merging of freedom as a form of activity and responsibility as a form of regulation takes place. Under adverse conditions either own activity retreats to the background giving way to external requirements, situations, factors, or responsibility as a form of regulation doesn't regulate a manifestation of freedom.

Freedom is formed in the process of gaining by a person the internal right for activity and value patterns.

The general principle is expressed in the brilliant formula presented by Hegel: "Circumstances and motives have domination over a person only to such a degree that he himself allows them to have" [2]. So, freedom consists in rising regulation to a higher level.

Lest freedom be degenerated into tyranny it should have a value-semantic substantiation.

The same algorithm is present in a self-appraisal as a flowing value. The case in point is a strong personal appraisal moment (subjectivism of perception). As every individual exists in a medium (family, affiliation, society as a whole) then his perception by his associates and his self-perception is formed on the background of the existing standards and value patterns (general cultural, collective and individual ones). In brief, self-appraisal is a personal judgment about own value expressed in aims inherent in this individual.

There is an ingenious formula derived by James (1890) indicating two ways of raising a self-appraisal:

$$\text{SELF-APPRAISAL} = \text{SUCCESS} / \text{CLAIMS}.$$

In fact an individual can perfect his own appraisal either increasing the numerator of this fraction or decreasing its denominator as only relation of these indices is important for a self-appraisal. As James noted "our self-perception in this world depends purely on what we are going to become and what we are going to do".

In the system of multi-channel information the art is one of powerful means of action on perception, psychology and, ultimately, on the spiritual life of a person [3]. In this connection

1. purposeful action of all genres and aspects of art,
2. selection of coming information,
3. accumulation of positive information, development of art taste

are essential.

At the end of XIX century B.L.Yavorsky established the link between the vocal side of the verbal speech and expressiveness in music. Investigations led the scientist to revealing the concept of intonation. It is precisely the intonation i.e. the vocal side of the verbal speech that is the main decisive factor of its expressiveness.

Intonations of the human speech initiated the development of science dealing with music – theory of musical thinking by B.L.Yavorsky.

He devoted the article "Text and Music" to the problems of the intonation expressiveness; the fragments from this article are cited here:

"When we listen to the conversation in the language unknown to us we, being unable to define the subject of the conversation, often guess about the mood, the contents of the conversation itself. When we hear the sounds of the human speech behind the wall or hereabout we, failing to make out words, always define faultlessly define whether it is conversation, narration or reading aloud.

In the second case the hearing is guided by the presence or absence of the intonation of rising and lowering, increase and decrease, quickening and drawling, joining and dividing, respites and stoppages. In the first case the hearing defines mood or the general contents of the conversation by the correlation of the same alterations.

Performance of the same dramatic play by different actors produces different impression solely due to reproduction of the words of this work in spite of the appearance of the actors, their mimic and plastic acting. And even separate persons posses the ability to pronounce one and the same word repeatedly giving it another expression" [4].

And further B.L.Yavorsky makes a conclusion that the human voice intonations assign a specific meaning to our speech; within our facility and quick wit we provide mentally those being read by us just with intonations. It is sounding that transmits intention of the words pronounced by us is an essential affiliation in a vivid human word and not vowels and consonants; a word itself consisting of vowels and consonants only fixes this expressiveness relative to a definite object, to a definite phenomenon. Here the set of vowels and consonants, their relation can underline only a concrete meaning of the word itself and simultaneously it can give abundant material for expressiveness of intonation itself.

B.L.Yavorsky indicates that having fixed with a phonograph a human speech and having removed vowels and consonants from the recording having left only sounding we will find in such a phonogram a recording of the intonations only, a melody of a human speech – a musical composition. Every speaking person during the speech becomes a composer and a good dramatic actor differs from a mediocre one only in that he is better composer and plastic (as a plastic is also a speech but a dumb speech).

Not being a creator of a "literary" (from the word "litera" – letter) side of the composition the artist is a creator of intonation, musical part of the composition for the given stage performance, endowing a word with a sound, duration, dynamics, timbre and emotion using only insignificant author's instructions in the majority of cases.

If one listens to the interrogative and affirmative sounding of the same words (for example, "at home?" and "at home"; "is this ready?" and "this is ready"; "is this clear?" and "this is clear" etc.), he can notice that the intonation of the question takes out hearing from the state of rest and tolerance and brings it to the state of obstinacy and inclination. The most significant thing in the obstinacy is the direction of the inclination, at the same time the rest has no direction at all. The answer meets the hearing in the case if it restores the violated hearing stability and leads the hearing in the required direction.

In a word, the intonations of the question, complaint, request, appeal, irritation, anger are unstable. Intonations of an answer, order, narration are stable.

B.L.Yavorsky underlines that there is no self stability. There is only quite definitely inclined instability, all other relations are of no importance, i.e. they can produce by ear this or that impression depending on the sounds they consist of – stable or unstable.

The following conclusions can be made:

1. About the presence of sounds of different functions in speech – unstable ones which tend in a definite direction to resolution and stable ones relative to their resolving ones (in the following period B.L.Yavorsky linked the concept of instability-stability with a general psychological law of excitation-inhibition).
2. About the link of two sounds of different functions between themselves; under conditions of gravity (inclination) it forms two-frequency intonation of speech.

All people having normal ear easily catch functional difference of sounds. To do this it is necessary only perform with a voice or instrument an unfinished construction under conditions of the simplest hear tuning: a hearer will catch this unfinished state at once and he himself will solve unstable sound with a voice or ask to solve it with an instrument.

Hence it follows that the feeling of sounds instability is an organic property of the human hear. It is the main stimulus in organization of the musical thinking.

The scientist defines the concept of “intonation” at different periods in the following way:

1. Intonation is the least sound form with time; it is a path of an unstable sound to the side of inclination, to its transformation into a stable one and also violation of stability with an unstable sound to the direction opposite to tension. Intonations can be stable and unstable.
2. By intonation is meant all possible cases of the least sound constructions, which can be reproduced by the human sounding organ with the concrete internal hearing tuning. Evidence for the sound construction means not alternation but relationship of sounds in the presence of energy overcoming gravitational force.

Thus, the sound is perceived in two ways: as a physical phenomenon and intonation-expressive one.

Hearing regularities, instability and a role of intonation predefined historical study of the sound in two directions: acoustic and “living” sound as a material of music.

In one of his letters B.L.Yavorsky noted:

“Musical art could appear only when the human mental work was organized, when its process revealed, i.e. the musical speech. Till the known stage of their development the sounds used by a man are subordinated to the acoustic laws but as soon as sounds reach the stage of the social expression, i.e. become musical ones the acoustic laws cannot embrace the complexity of the new phenomenon and become the secondary ones; the laws derived from the social process become the main ones” [5].

It is probable that, in more recent times, having mastered his achievements during systematic labor process a man harmonized his working movements with impacts (his own pulsation) and established their proportionality.

Sound speech appeared as a transition of strenuous labor movements (labor motor) organized with physical working efforts – movements of respiratory muscular –into sound relations – intonations, into sounding relations of breathing.

Labor sound relations having turned to the sound reflexes formed the basis of sound movements organizing (and not being organized) communication in the working being, in labor behavior. Such labor songs as “Dubinushka”, “Ai, ukhnem”, the songs performed when forging with two hammers, when threshing with several flails, etc., round dances, marches may serve as examples.

Thus, B.L.Yavorsky justified origination of the "living" sound, which in its development became the material of the musical art.

The history of a centuries-old sound practice of the musical art evidences that this sound scale evolves constantly depending on development both of sound scientific consciousness and technique of musical-artistic practice. This evolution of the sound scale tends to reveal the increasingly more possibilities of the external sound manifestations of the processes of internal sound thinking and internal hearing.

"To vivify" music, to represent peculiarities of different style epochs of musical culture is possible only on the basis of understanding and perception of intonations (speech and musical).

Though discoveries made by B.L.Yavorsky are referred to the end of the XIX-th – the first quarter of the XX-th centuries, they haven't yet lost their urgency and at present they are practically advisable for development of the information science in all spheres of human activity.

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TOWARDS THE NOOSPHERE OF INTANGIBLE (ESOTERICISM FROM MATERIALISTIC VIEWPOINT)

Vitaliy Lozovskiy

***Abstract**: Exploration of intangible world is under the serious influence of esotericism. Mystics, religions, unrestrained use of metaphors, fairy tales, gossips, unverified and uncertified "facts" – all this needs accurate well-disposed, but sound scientific consideration. Our society really needs new ideas, new approaches and new paradigms. Technological civilization becomes more and more complicated, risky and ecologically critical. The current level of AI research cannot guarantee successful solution of societal control and management. Besides, the human being itself practically did not change its mental and psychological abilities for many thousands years. We can lose control over our society and its technology, if we do not change cardinally ourselves. In this text, I tried to approach this problem – the problem of our noosphere from materialistic viewpoint.*

***Keywords**: philosophy, noosphere, esoteric, intangible world, beliefs, soul, God, materialism, idealism, egregors*

***ACM Classification Keywords**: I.2.0 General: Philosophical foundations, H.1.1 Systems and Information Theory: Information theory, I.6.5 Model Development: Modeling methodologies*

"Go there, don't know where, bring that, don't know what…"

Russian fairy tales folklore

"We believe that 2 * 2 = 4. Without this belief we would fail in our everyday calculations. We should be the true believers the whole yearlong. But once a year we ought to stop and think over this issue one more time…"

V.Lozovskiy, Wise Thoughts (unpublished)

Introduction

I was greatly embarrassed when decided at last to step forward with this theme. First, I am a newcomer to the field of esoteric, while this sphere of human activity is philosophized, theorized and practiced from the very beginning of humankind. Yes, the progress of human society started with the first inventions to support physical existence of prehistoric people. But no one society can exist without "ideal" world – semiotic systems which, of course, have material carriers, but whose sense is in representing some knowledge and communicating it between intellectual subjects.

It is very hard to handle existing information fund on esotericism: abundance of paradigms, approaches, term interpretations, metaphoric way of consideration (usually the authors never admit it, but go on in developing their personal viewpoints as if it was scientifically proven truth). Thus, for our current goals the idea to make substantial comparative presentation of this field was abandoned from the very beginning. And, again, it is unusually hard to make specific literature and author reference. I understand that in these circumstances one should leave the hope to pinpoint exact scientific priorities of all researchers in this field, including your obedient servant… Instead, we are aimed at much more important issue – try to find correct estimates of what is going on in our civilization, and how should we together handle all difficult problems, which life evolved around us. As a partial compensation for this liberty in approach, we shall try to give as precise definitions, as we can, for the nontrivial concepts, with which we are going to deal.

Amen!

Knowledge, Civilization, Noosphere, AI, Esotericism and the Future of the Humankind

Speaking about human beings, about society, we cannot bypass the question of human destination, goal, sense of living in this World. Of course, the answer varies among specific individuals, epochs, situations and the fundamental issue of humankind creation – was it done according to Creator's will, or was it completely natural process – including evolution, mutations, natural selection, or even extraterrestrial visitors interference. Looks like we can find the common denominator for all these variations and alternatives. I guess, it is knowledge.

Obtaining ***Knowledge*** is the sound motive for any human deeds and actions irrelevantly to the prime cause: material, or ideal (In the beginning was the Word, and the Word was with God, and the Word was God [Bible]). Knowledge is obtained as a result of ***need, boredom, pleasure, curiosity*** and ***chance***. The universal method of obtaining knowledge is ***activity***. Life is activity. The natural frame of activity is ***adequacy***, or ***harmony***.

Of course, we cannot prove this thesis, but one can easily try to fit it over any imaginable situation – is it striving for life, scientific research, creating work of art. In any kind of human activity, we should obtain knowledge. New feelings are also new knowledge. Just imagine that due our inactivity or due completely routine activity one stops to acquire new knowledge. At that point life ceases its sense and we prefer to name it ***existence***.

From now, we will use the concept of Creator (God, Lord in Christianity). Even the orthodox materialist should agree, that such concept exists, and until now, science could not prove neither (His? Her? Its?) existence, nor absence. In our argumentation here we shall – not accept – but touch and from time to time refer to this concept. Assume, for the moment, existence of Creator who created World and humans. In all idealistic philosophies and religions, Creator is Omniscient and Almighty. In such case – what could be the reason for material World creation? What could be the sense for creation of humankind? The reader should agree that He created the whole World having no other way for obtaining new knowledge. Such ideal entity as Creator, by definition, could

not be interested just in shuffling the matter. So, obtaining knowledge really is the sound candidate for the goal of human existence.

Humans became humans only due the creation of ***society***. Civilization is the product of social activity - communication, interaction of people, creation of crafts, engineering, science, art, religions, traditions. Civilization is the natural cradle for new knowledge creation. It became possible only because each human generation could absorb the knowledge of previous generations and, in its turn, lay its own knowledge strata for future generations to rest upon. Along this reasoning thread, we arrive at the concept of noosphere. It was formulated by V.I.Vernadsky [Vernadsky, 1943] and Père Pierre Teilhard de Chardin [Teilhard, 1947]. My own vision of noosphere in semiotic context could be found in [Lozovskiy, 2003]. The term «noosphere» (Ionian Greek "noos" = mind) is used for integrative designation of physical world realities together with the whole mankind knowledge.

One of the key milestones in the humankind development was when people tried to attack the fundamental concept of knowledge creation and handling. Information technologies (IT) and even artificial intelligence (AI) sprang into existence and were developed to the current level. Before the information age only humans (and, to some extent, higher animals) could generate, process and communicate knowledge. Now it could be done much more efficiently with the help of artificial means.

The stunning progress of IT and AI cannot conceal the problems encountered in this way of technological development of civilization. We encounter difficult problems in every step of knowledge acquisition, formalization, handling in computer systems. One of the main obstacles is a bad ergonomics of artificial systems. Many managers and applied specialists fail in efficient communication with expert systems and remain on primitive level of using technology of paper, pencil, phone, and maybe calculator. From the other side, human intelligence in its entirety and, in general, human performance, remains unreachable for current technical counterparts. We have very weak understanding of human intuition, emotions, flexibility of behavior, methods of handling imprecise, unreliable, incomplete information. The notorious human factor, intrinsic difficulties of management in organizational systems are still beyond the reach of contemporary knowledge engineers.

From the other side, our civilization is inevitably approaching its crucial point. We have serious ecological problems, which have definite tendency for deterioration, we more and more depend upon technological world, created by us: the failure in power supply, communication, automated management and control systems can not only block the normal life process, but even lead to catastrophes and tragedies (Chernobyl, for example). This overcomplicated world requires much better level of understanding, interaction and management, than can provide the human brain of contemporary people. And it is no wonder: human brain and its usage by humans practically did not change during many thousands of years.

Of course, we cannot stop, reverse the civilization, return to caves and animal skins clothes – we ought to go on in our development, changing our ways, our mental and psychic abilities, harmonizing our interaction with Nature.

But does our brain, perceptional and psychic abilities work at their extremes? Neurophysiologists say that usually human brain works within the range of 3-6% of its potential. This phenomenon is not coincidental. It means that our life conditions until now did not stimulate the growth.

Everyone can name maybe several encounters in his/her life with persons demonstrating outstanding abilities – physical, mental, psychic. One elderly woman under the affect brought out of fire her huge trunk, which later could not lift four strong men. There are people who developed their memory to fantastic level – they memorize heaps of numbers, perform complicated calculations in mind. Some behave very soundly and efficiently under the stress situations, when others just got paralyzed. All these phenomena, though rare and frequently requiring tedious and systematic everyday training – do not seem to us marvelous: we understand, in principle, how these results could be achieved, and can give scientific explanation concerning their mechanisms.

Besides above mentioned phenomena, which can be explained by “materialistic” science, from ancient times we obtain evidences of something supernatural taking place – clairvoyance, foretelling, telepathy, telekinesis, levitation, nontraditional healing, bio-field, UFO, communication with Higher Intelligence, - all what is known as esoteric, or mystics. The number of books on this theme is overwhelming – it is hard to mark out the most fundamental ones – one usually adheres to some or other school according to personal taste or belief.

There are some specific problems with esoteric… First, “official science" calls it “pseudoscience”. Phenomena, pretending to be esoteric, rarely become objects of scientific investigation. In its turn, the number of esoteric

paradigms is astonishing. As a rule, esoteric authors freely and without restraint use metaphoric presentation of their subject tacitly convincing the reader to buy it without any doubts. Personal and religious beliefs in this sphere play essential role. And again – authors usually avoid modest remarks of the type: "It seems to" or "I believe, that…", so that the reader is left to his/her own judgment concerning the objectivity status of specific presentation.

My idea is that time is ripe for humankind to approach esoteric from the positions of scientific method. AI professionals should be among the researchers in this field. And that is why. First, we should acknowledge the fact, that the modern technological society is approaching the crucial barrier of complexity, beyond which we can lose control over the civilization, we created. Our current understanding of noosphere structure, content and behavior may present only the tip of the iceberg and should be critically reconsidered. Even if majority of esoteric evidences will occur false, their remaining part may add substantially to our philosophy and practice. AIers are proficient in knowledge engineering and simulation of human behavior. Acquaintance with world of unconscious and other esoteric themes could enhance understanding of human mental and psychological characteristics and, as a result, lead to automation systems creation, which will be better adapted to the challenges of our growing and maturing society. In such research, we can expect several byproducts, for example, refining our philosophical background – handling this subtle border between material and ideal hypostases.

The proposed approach to esoteric requires refinement and elaboration of our basic definitions. Without such bureaucratic stage, we cannot attack such complicated humanitarian polyparadigmatic area.

Materialism and Idealism

Traditional approach to these paradigms is symmetric and frequently vulgar. They say that materialism does not accept in the world anything but substance and energy. Earthy materialists do not believe in good and evil, they deny the existence of soul, ethics, do not believe in God. They see only material interactions in the world and deny the existence of any higher will, intelligence governing the Universe. Contrarily to that, idealism is supposed to put forward "ideas" – abstract concepts, goals according to which sprang into existence, function and changes the physical world. That is why idealism is inevitably tied hard with the concept of God, Creator, whose goals and orders rule the Universe. Traditionally, consistent materialistic and idealistic paradigms are considered equally sound; i.e. one can adhere to any one of them, and do not be afraid of refutation from the opposite camp.

My argument is - that idealistic paradigm is weaker than materialistic one due the lack of experimental evidences. It is the routine approach to natural science theories: they all should be supported by practice. Speaking about concepts, paradigms, ideas, language, phrases, plans, intentions, emotions, etc, we should inevitably postulate existence of the following components necessary for the success of communication act:

- subject generating and issuing these "ideal" assets (source of information);
- subject receiving, understanding and perceiving these information (reception of information);
- material data medium used for transmission and/or storage of information.

Both communicants should be intelligent enough, belong, at least, to the similar cultures, have common communication language, be involved in some common goal oriented activity – otherwise such communication act will fail. The state or activity of receiving subject should change somehow due to the communication being considered.

All three communication components are really indispensable. Thus, "information" cannot exist without some material substrate – media, bearing this information. So, material data medium should first be created, and only then, it could be used for handling "ideal" (information) entities. One of the main characteristics of an ideal entity is its semioticity.

From this trivial argumentation, one can infer the following significant corollaries.

1. The ideal entity creation should be preceded with obtaining the material bearer good for generation, storing or transmission of this ideal entity. Thus, the issue of priority is solved in the favor of matter.
2. Communication of ideal entities – information – is possible only between intellectual beings belonging to the same culture and of comparable intellectual level. So, it is impossible and senseless to give orders to inanimate objects, they cannot perceive and understand information.

3. Ideal entities exist in reality, but only within certain cultural world [Lozovskiy, 2003] and have sense and meaning only within this world – intellectual beings inhabiting it.

I feel that this is correct materialistic approach to the Nature, and one can rely upon it in the following investigations. As was shown above, our world, being materialistic in form, has means for representing ideal entities - information. One more remark here – concerning the origin of Universe, Solar system and human race. Here we, of course, cannot answer the question – whether our world is the result of natural physical, biological and physiological processes and evolution, or it was the result of Creator's activity, or interference of some extraterrestrial civilization. All we can proclaim – it is the result of material processes.

Materialistic Approach to Exploration of Intangible World

Cognition of the World is the endless process. The whole Universe at each given moment of time can be divided into two subworlds: Tangible and Intangible.

Tangible World – is the part of the Universe, of which we are aware and have some positive knowledge about it. Adequateness of the paradigms used, theories created (and verified), their experimental confirmation varies within the broad range, though. From time to time this knowledge is changed to reflect better the new facts; sometimes old paradigms are replaced by the new ones within the course of scientific and technological revolutions. Knowledge (and folklore) about Tangible World as the part of cultural World [Lozovskiy, 2003] determine the current scope and state of the Tangible Noosphere.

Intangible World – is the collective term for all Unknown part of the Universe, of which we are unaware and have no rational verified knowledge.

Of course, this classification is fuzzy and provisional; there is no clear cut border between these worlds. In the course of scientific progress human cognition attacks, tries to explore the Intangible World gradually moving its fragments to Tangible one. The main obstacles on this road are fallacies, misbeliefs, fantasies which cannot be laid in the basement of natural science theories and usually become the part of human cultural World (fairy tales, religious beliefs, superstitions). If our destination really is to gain new knowledge, as we argued in the beginning of this article, we ought to permanently attack the World of Intangible. But how? This situation reminds the classic one from the Russian fairy tales: go there, don't know where, bring that, don't know what… Of course, we ought to be armed with the technological approach, for example, new instruments for measuring radiation while exploring new areas of the Universe, but the most subtle and mysterious areas are tied with humans themselves, their inner world and relationship with Nature environment. By the way, the basic goal of AI researches is to better understand "ideal" processes in human mind and psychics, try to simulate them and create better instruments to help humans solve their most important problems.

Frequently information about Intangible World researcher obtains from other humans in the form of their personal unusual experience or from witnesses of some extraordinary phenomena. These evidences, as a rule, have very troublesome features:

- extremely high level of dependence on specific person, their physical, mental and psychic state, character type, suggestibility, religiosity, innate features and personal training;
- high dependency on environment conditions: season, time of the day, weather influence (usually interfering) and even silent disbelief or skepticism of listeners;
- aforementioned peculiarities frequently result in a bad recurrence of phenomena under investigation.

Esoteric is a very intriguing potential wonderland, which in my opinion quite deserve exploration, and that is why:

- it has a long history – thousands of years; esoteric beliefs accompanied human race from the very beginning of the history, have not vanished, but broaden and flourish;
- many outstanding persons were studying and practicing esoteric mysteries, and there is abundance of literature on this subject;
- there are a lot of esoteric schools, societies and communities – one can easily find one in one's own town – according to the taste and interests;
- esoteric is full of extremely rich promises, which are quite tempting and badly needed in contemporary human society in order to better correspond to requirements of our life, society, civilization – better

physical, psychical and mental health, better control over own organism – even over its organs and subsystems, diagnostics and healing the diseases, which are caused by functional disorders or improper influence of the nerve system, mastering subconscious processes, development of extrasensory perception abilities and potential nontraditional ways of interpersonal communication and interaction.

Unbiased consideration of esoteric doctrines produces ambivalent impression. The lack of sound scientific theory and reliably confirmed facts positioned esoteric from viewpoint of Academy in the domain of pseudoscience. Situation is aggravated by very strong positions, which are held in many esoteric teachings by religions and mysticism. The time has come to investigate this problem using sound scientific method. Of course, the whole issue is exceedingly complicated, and here we will try, at most, approach it shyly not loosing solid ground beneath our feet.

So, the key source of information in esoteric is human evidence.

Evidences of Level 0. These are evidences of "folklore" character. Researcher obtains oblique information from unknown, unavailable or unreachable source: somebody had said something – no details, confirmations, trust. Most evidences unfortunately belong to this category and can be dismissed with light heart. This information probably deserves only to be put into protocol as possible hint for future, if it comes sometimes to relevant issues.

Evidences of Level 1. This sort of evidences is obtained directly from trustworthy subjects on the base of their personal experience, experience of their close friends or relatives, from direct witnesses or participants in some happening. Such evidences deserve the close examination. Their valuable feature is that it becomes possible to recur to the sources requiring detailed, probably documented and/or confirmed information; in the future it is possible to return to the issue under consideration, if new questions arise, new circumstances come to light or require clarification.

Sometimes, we may obtain distorted information, if the author of the evidence was in changed mind state: under hypnotic suggestion or in meditation. The serious problem within this Level 1 is that these evidences to high degree can be subjective.

Evidences of Level 2. Here we deal with the evidences obtained by researcher himself in the course of experiment, as a witness of some activity or observation of natural phenomenon. In this case, it is possible not only to create a protocol of the experiment, but also actively participate in it on the stage of planning, execution and discussion of the results. Sometimes it becomes instructive to change the course of experiment "on line". The main objective in this situation is to discern the true nature phenomenon from the magician's tricks. Of course, the researcher should be exceedingly aware, if the experiment requires changing his/her own mind state. One should exclude chances of being drawn to such states unconsciously. Sometimes, the presence of qualified psychiatrist, whose task should be checking mind state of the participants, is required.

Evidences of Level 3. To this class belong evidences obtained as a result of personal training of the researcher (increasing sensitivity, developing extrasensory perception, special breathing techniques, experiments with changed mind states, meditation, perception of aura, biofield, etc.). Of course, it is the most complicated and time-consuming approach. Besides, it relies on the belief that extrasensorial abilities are not only inherited, but also can be trained by any dedicated person. Results, which could be obtained on this level by researcher stem, in greater part, from his/her introspection.

There are two main problems with esoteric. Firstly, these phenomena are closely related with brain activity on conscious and subconscious levels. And, secondly, we are lacking understanding sound physical backgrounds of these phenomena and, consequently, - instruments for obtaining objective measurements. It would be a pity to rest this domain to magicians, religious figures, naive people and businessmen. Such is the motivation of the current research.

Esoteric and its Strata

The whole domain of esoteric could be seen as consisting of four strata.

Stratum 1 – Neurosomatic. The term was coined by [Wilson-Leary]. Human organism is extremely complicated system. Our orthodox sciences (medicine, neurophysiology, biochemistry, psychology, psychiatry et al.) have until now very superficial understanding of life even on the level of distinct organs, phenomena and subsystems.

When we get to the depths – the cell level, and, even more, if we are interested in integrated functioning of an organism, in gestalt effects, - our sciences really fail.

One of the big white spots is human ***subconsciousness***. Neurophysiologists fail to explain its main mechanisms. They say nothing about interfering with them. On the layman level, we understand, that subconscious work, from one side, as buffer, or long term memory, where are stored much greater volumes of data, past impressions, than we are aware, relying on our conscious sphere. It is well known fact that under hypnosis patient can recollect even events of his childhood or reconstruct forgotten relations between some events. The scope of subconscious memory is suspected to include probably genetic information – memory of generations. It could explain reminiscences of some humans about their previous incarnations.

Subconscious human sphere is not only memory – looks like it can process information in nontrivial way, finding correlations, rational solutions, of which people are completely unaware being awake. Psychologists call this phenomenon insight – as if solution comes from nowhere; but this could be the effect of processing data subconsciously and then just transferring it to daytime memory. The power and potential resources of subconscious memory exceed 90% of human brain. People from esoteric [Zykova] say, that we ought only to present our problems to our subconscious sphere, and solution found will be much better, than we would obtain "thinking" over them in ordinary way. Special methods exist which open the door to our subconscious processor: trances, meditations, which help us to lower our beta rhythm of vigil brain activity (15 - 30 and more Hz) down to alpha (7.5 – 13 Hz), teta (5 – 7 Hz) or even delta (0.5 – 4 Hz). Hypnosis, auto-training and meditation usually require subject to be brought, at least, to alpha rhythm. In this state various suggestions could be done, getting rid from negative habits and stress, solving different problems.

Human ***nerve system*** is the control system for the whole organism. We all know the saying: "All deceases are from nerves". Evolution adapted us to the current life condition, our technological civilization, primitive medicine with its strong impact on separate organs, or just illness ("from cold", "from stomach", "from any pain"…). It led us to the status, where we lost control over our own body. We can discern several aspects of nerve system functioning.

- General psychic personality type and the current nerve system state. Sanguine, melancholic, phlegmatic, choleric character types; optimists and pessimists; gloomy, cheerful, shy types. All these not only determine one's current psychic state: it has a strong influence on physical state of the organism. Psychical and physical spheres tend to be in harmony: in sound body – sound spirit and vice versa.
- Distal nerve and microcapillary systems work together near the border of the organism being sort of interface between it and environment. Ancient oriental medicine brought to us the theory of meridians and tsubo – small sensitive zones on the body surface [Serigawa]. According to oriental teaching, these zones "represent" internal organs, reflect their state and, from the other side, can be used to influence, correct the state of these organs.
- Nerve system control organs and functional systems of the body. Contemporary humans, in general, lost this ability – it was obsolete due achievements of our technological civilization. However, looks like it did not vanish forever, but is now in the passive state. With the help of special training, we can control our heart, blood pressure, pulse, functioning of liver, kidney and other organs. Good news is that all these effects could be achieved not only by yogis or humans with inherent abilities – everyone can achieve results on this path, but, of course, results will differ. Really, a great artist can create masterpiece, but everyone can be taught to draw a house, a tree and a dog under it…

Extrasensorial perception is the ability for humans to perceive outer world information much more efficiently, than majority of people. It can be attributed to four sources.

- Heightened sensorial sensitivity.
- Broader frequency band.
- Using some "unusual" or yet unknown fields, energies, radiations: magnetic, electromagnetic, electrostatic fields, biofield.
- Perceptions of gestalt type, sometimes, named hypersensory (HSP), or intuition. A person with HSP is very observant and perceptive. They may be adept at reading body language or simply be more

attentive to details than most people picking up subtle behavioral cues unconsciously, cues that are also unconsciously given. Strictly speaking, we deal here not with just perception, but with complicated process of general combined analysis of several stimuli on the basis of pattern recognition. For example, qualified and experienced physician can diagnose many organic disorders on the fly. Sometimes, he cannot even explain, how it is done – he simply feels, or it appears to him so. It means that these processes to the great degree are done subconsciously.

Nutrition and breath. These factors are exceedingly important not only for physical human body – it is self-evident. There are evidences, that breath do not only brings oxygen to the blood, but plays exceedingly important role in energetic processes in the organism and when interacting with environment, or even, Universe. This issue should be thoroughly studied by science.

Drawing a conclusion, we can state, that this neurosomatic stratum is materialistic foundation of esoteric and should be thoroughly studied, practiced and be developed further.

Stratum 2 – Bioenergetics. The issue of "bioenergetics" can be approached from different viewpoints. From physical point of view, each living organism radiates several types of energy: heat, acoustic waves, magnetic, electrostatic field and electromagnetic waves in rather broad frequency range. Correspondingly, these fields somehow influence the organism – on subconscious or biological level. Intensity of radiation is very low and drastically falls with distance. In esoteric it is postulated that there probably exists quite different type of energy – bioenergy, which is emanating from living organisms and form specific biofield around them. Sometimes, they speak about biofields of inorganic objects. The main problem with biofield is that until now we have no reliable physical methods and/or devices for measuring it. Even worse – there is no assurance, that biofield is really field – it may be bioplasma, or some other, maybe yet unknown fine material substance or radiation. Very queer circumstance is that these biofields can usually be detected and "measured" only by humans having specific sensitivity to them. Though, there exist methods (Kirlians', for example) pretending of making color photographs of aura – biofield around human body.

One of the most fascinating esoteric theories is the teaching about human chacras, auras and of the whole energetic system of the human organism, which support its functioning and play the role of interface gates between the organism and the rest of the Universe. Though these theories lack rigorous scientific confirmation, practically, one can develop personal sensitivity to the level, where some emanation from human body, or from other objects could be felt [for example, Bronnikov, 2005]. I have got training in Bronnikov's First Stage, starting from the zero sensitivity to biofield, and can present my subjective feelings and impression concerning my achievements. Really, after 10-days course and several months of training, I can feel "something" between my hands when I move them one towards another. This feeling in the palms is a mixture of elasticity – like soft children's air balloon, pricking, some heat, cold or rippling. At this stage, one can say, that, as there are no ***objective*** indications (measured with some physical device), - probably, it is psychological effect, suggestion, produced with neurons in my own brain, or between brain hemispheres. But things become more complicated when I feel the fields of other people, trees and even inorganic objects. Several successful sessions were carried, during which patient's headache, cramps and shoulder neuralgia were cured. The specific method used was of Reiki type [Reiki, 2004] and procedures known as non-contact massage. Practice here evidently goes ahead of theory, but such nontrivial phenomena should not be just ignored due the lack of sound explanations.

Even more spectacular phenomenon in this bioenergetics stratum could have been the direct effects of bioenergy, for example, telekinesis. All I have in this vein now – evidences of the zero level – as majority of us.

Stratum 3 – Bioinformatics. Here we speak about "nontraditional" information transfer between humans, i.e. such information interaction, which cannot be attributed to optical, acoustical, electromagnetic methods of information communication. The most typical example of such phenomenon is telepathy. No sound, non-equivocal, reliable and repeatable confirmations of telepathy are present up to this day. Though, parapsychologists would argue that such evidences do exist. The time is high to solve this issue on the sound basis. Either yes/no experiment conducted rigorously with participants from the natural sciences will be held, or this problem will remain on fiction level for indefinite time ahead.

Stratum 4 – General noosphere. Absolute. This stratum is fundamental from philosophical viewpoint. In [Lozovskiy, 2003] I argued in the favour of cultural layer of the Earth's noosphere, which includes all knowledge of humankind in any form or domain – from science and religions to folklore and national habits. Esoteric goes much further insisting that "knowledge" per se does exist around us, and the sources of this knowledge are many,

including non-biological objects on Earth, other galaxies and extraterrestrial civilisations. This general worldwide database, according to esoteric, not only keeps information about the past, but also about the future. At this point we should be prepared to accept the idea that such knowledge base is equivalent to the conception of Absolute, God, Creator, Higher Powers and so on. All people, according to this hypothesis, participate in creation of this database. Even the people, who have gone – their souls – can remain in this fine matter World.

In esoteric we can find even the exotic idea that human memory and even thought process are located not in the brain, but in that same global bio-informational field, and our brain function as a mere interface device between ourselves and Absolute. This hypothesis can be ignored until reliable experimental data in its support will be obtained.

The breathtaking revelation about existence of Absolute quite finely explains the principles of most marvellous esoteric deeds: clairvoyance, prophecies, voyages into the living organism cells, in the depths of matter and the Universe. And, of course, here we arrive to the concept of Creator – chief systems programmer, who made all the wheels go round…

So, the main problem here is to answer the question: does this Stratum 4 exist in reality, or it is just a beautiful metaphor. Confining ourselves to metaphorical way of reasoning, we can think of a kitten playing with her tail. For sure, at that moment she is not aware, that ***in reality*** she is playing with herself. Usually, they say, that neither existence, nor absence of God cannot be proved. Sometimes this issue is tied with personal beliefs. We shall try to clarify this problem.

The Concept of Absolute

Let us start from the agreement, that, generally speaking, Absolute could be imagined as having two hypostases (contrarily to Christianity, where Trinity approach is adopted): mental (or cultural) and objective (physical). First one cannot be empty, because we already have such ***concept***. As we stated earlier, this is an ideal entity dwelling either in somebody's brain (thoughts, beliefs, imagination, fantasies, hallucinations), or in some cultural layer. The most critical question concerns the second hypostasis: ***physical reality***. If Absolute is, at least, partially, material – it must manifest Itself (Himself, Herself) physically, and thus, be liable to physical measurements. For example, if we arrive at the idea of general database, or information field existence, there should be possible to find out the material substance – carrier – and then methods of encoding used. At last, if it is not just passive database, but functioning control system, we ought to disclose the language of programming used and the programs themselves. Until now, there are no confirmations along these lines of reasoning. Either, we worked not enough diligently, or this hypostasis is empty. Then remains the "God" within human brains: a system of beliefs, religions. Atheists have their own ethic-behavioral rules – their own "God".

We can imagine indirect methods of proving existence of Absolute – for example, carefully studying the results of predictions, clairvoyance. If these phenomena do take place – it means that Absolute exists in reality.

Of course, one can say, that there can exist methods of protection, preventing humans inspect and interfere with "systems programming" layers – as is done in computer operational systems. Then, the last argument can be drawn: there must exist, at least, some interaction with Absolute (analogy: application, calling some system function). If nothing of this sort will be disclosed, we should assume that the concept of Absolute is only a myth in human brains. Situation reminds spy story: just imagine, that some government sends its spy as a resident to other country. This person legalizes there, marries, works somewhere – nobody can guess, that he is really a spy. From the other side, he does nothing contrary to the local law. So to say, the perfect spy… The question is: can we call him spy, while in reality he does not function as a spy?

Soul

Esoteric is built around the concept of human soul. Usually is postulated existence of soul independent of physical body. A lot of attention is paid to the incarnation hypothesis. All this is very interesting and exciting. But, as we already had got accustomed, we have no reliable experimental data on existence of soul as some ***separate*** entity from human body itself. Until then, I propose much more simple and natural concept of soul.

Soul is specific functionality of higher species, of their central nervous system. In humans this functionality is very rich and represents individual personality – with all spheres including intellect, emotions, ethics, social conduct,

etc. The phenomenon of soul can be attributed to gestalt effect, where some complex entity show broader, or even new functionality than the sum of its parts have in common.

Take for example, car's engine. Being assembled, provided with gas, oil, water, air and electricity it demonstrates its gestalt functionality – its soul: it can rotate its output shaft. Of course, its "soul" is exceedingly primitive; human organism is much more complicated and perfect than our engine. But we are considering the fundamental principle. The engine works perfectly until some malfunction happens – its metal organism becomes ill. Eventually comes the day, when car mechanic says – alas, nothing could be done, it is impossible (or unreasonable) to recover the functionality of this engine… The engine is dead. It cannot accomplish its main functionality – rotating the output shaft. Its soul has gone. Where to? No one will be embarrassed with this question. The answer is self-evident: when parts cannot function together – functionality just vanishes. I can clap both my hands – and you will hear the sound. But with only one hand? We arrive at the same situation when human being dies. All his functionality disappears. Very frequently, it is done gradually – deteriorating short, long term memory, hearing, vision, coordination of movements, worsening brain's processing abilities… At last fail subsidiary systems: digestion, breath, blood circulation. Stops metabolism. Life has gone… And with it has gone human *individuality*. Knowledge, emotions, preferences, habits, beliefs… We may call all these mental and psychic abilities soul. Where does it go? Nowhere. It just disappears, ceases to exist.

Esoteric believers, who do not agree with this argumentation, should point out what soul features are missing here, certify that these features really exist and propose some candidate for their bearing media.

Beliefs

In esoteric the term "belief" is used, as a rule, in its religious sense, i.e. as belief in God. Sometimes it is said, that humans *should* believe, that those, who do not "believe" are somewhat inadequate individuals. I can argue that normal human life is impossible without belief, but beliefs are many. Let us propose the definition of belief.

Belief is some (model) entity in a knowledge representation system (KRS), which we consider to be in adequate correspondence with prototype entity in given problem domain (PD). Strictly speaking, all model entities in any KRS are beliefs. Every belief should be accompanied with two indications: prototype status and evaluation adequacy.

Prototype status can be:

- real (we shall not discuss now objectiveness of reality while perceiving World through our senses);
- ideal (mental or cultural);
- indirect evidence - personal or cultural – (for example: "as my friend told me, we will reach town in two hours")

Evaluation adequacy is very delicate issue. Even when we measure physical parameters (weight, dimensions, temperature, etc), we do it with some accuracy. Our senses can mislead us. The mapping itself is not straightforward process: it includes, as a rule some processing (interpretation). That is why our beliefs could be so uncertain. Beliefs drastically vary among different people, religions, cultures.

Let us try to classify beliefs from the viewpoint of pragmatics.

- Axiomatic beliefs. They are assumptions taken by intellectual being without proof – on some pragmatic or aesthetic base, for example, axioms of Euclidean geometry. This belief is imaginary with absolute adequacy. Everyone agrees that axioms are purely ideal entities.
- Beliefs-knowledge. They can be theoretical and applied. Theoretical – predominantly mathematical – knowledge is obtained through inference from axioms in accordance with specified rules of inference. Applied knowledge is reflection of real world entities: "The Volga flows into the Caspian Sea", "Horses like oats". Of course, applied knowledge can be imprecise, unreliable, inadequate, based on the faulty paradigm or be result of senses mistake. This knowledge is frequently questionable, and it needs to be verified. If verification fails – it is a good reason to dismiss such belief as inadequate.
- Cultural beliefs. Ideal entities, created by humankind: sciences, arts, religions, etiquette, folklore, habits, customs, etc. Holding to specific cultural beliefs tends to consolidate people within corresponding social units.

- "Pure" belief. This belief usually concerns Intangible World, about which, according to the definition, we have no positive knowledge. There is of no use to ask pure believers about foundations of their beliefs, motivations and confirmations. At most, you will receive reference to some "Holy" books or to authority of certain "known" people. Pure beliefs have nothing in common with World comprehension and can be thought of as some variety of cultural beliefs.
- Autosuggestion beliefs. They are beliefs in one's own mental sphere. These beliefs are of primary importance from the viewpoint of their influence on human personality, psychic and physical state. It correlates with cultural beliefs. We will consider these aspects closer in what follows.
- Social beliefs. The basic social unit is family. Members of normal family believe each other, believe their opinions. Intuitively, everyone tends to surround oneself and contact with people, which he could always count on in social aspects. These beliefs are verified and supported by mutuality. If you receive positive stimuli from your surroundings, it means that you are right in believing them. Social beliefs differ from cultural ones: here you tend to believe (***trust***) specific persons, and therefore – you believe to their ideas, views, advises.
- Materializing beliefs and omens. Esoteric people introduce these beliefs with the words: "We know that the thought is material". Heroes in fairy tales say: "According to jackfish will and to my wish…" – and requested action is performed in reality, or requested object materializes in the physical world. It should be said, that literally such effects are not confirmed rigorously. Though, they can have extraordinary positive material effects. But the leading factor here is psychology. In medicine is well known "placebo" effect, when some indifferent substance is given to the patient with accompanying words, that it is new very efficient remedy against his illness. The patient ***believes*** in it and mobilizes his nervous system, conscious and subconscious towards success. This effect can be obtained on the pure suggestion level – without material substance. And it supports our understanding that nerve system and psychological determination can really influence physiology of our organisms. In this aspect, such beliefs correspond to cultural, autosuggestion and social ones.

Autosuggestion and Cultural Beliefs, Egregors, Religions

The main principle, which we should, in my opinion, adhere to, is the well known philosophical maxim, Occam's razor: "Plurality should not be posited without necessity" [Occam]. It means that if we can explain some phenomenon with few simple arguments, it should be done unless we have the sound base to change our mind. In mathematics the good taste dictate choosing as simple, evident and small in number axioms, as is possible. This approach permits us filter out mysticism, metaphors, unrestricted imagination, which have no persuasive arguments in their support.

On the current stage of our research, we can assert that Stratum 1 – neurosomatic – is really good entrance into the realm of bringing up superhuman race. This way is good for everyone. Only results and achievements will somewhat differ depending on genetics, psychological type, dedication to the method and trust to the teacher. Let us formulate several issues in this concern.

- You need to construct and then strictly adhere to positive psychological pattern: you are happy, healthy, optimistic, sociable, you explain your ideas freely and persuasively, you are always in good mood, smile to everybody and sincerely wish them all the best. The power of nerve system over the physical body and over your other abilities is so high, that the results are just miraculous. Besides, we can rely on the fact that in such complex system as our organism is sometimes cause and effect change places, and you can induce some situation if you really believe in its consequence. In medicine are known situations where patients cured themselves just with their "will power".
- As we argued earlier, our subconscious sphere has tremendous memory and processing power. We can apply to it with the help of special psychic practices, known as suggestion, autosuggestion, hypnosis, trance, meditations. There is abundance of literature on this theme; procedures depend on each specific person. Mastering these techniques personally is possible, but much easier success is achieved in groups and, of course, under the guidance of qualified teacher.

- Special exercises should be done to revitalize certain organism's functions - distal nerve and microcapillary systems, acuity of vision, biofield sensitivity.
- Nutrition, and especially, breathing is of vital importance not only for overall healthy state of the physical organism, but in developing extraordinary psychological abilities. We shall not accentuate importance of the general physical training and procedures of personal hygiene – it is self-evident.

Till now, we were speaking about personal psychological technique. Now we will turn to the social aspects. In the core of this issue always lies some community. It may be family, political party, ethnic, national, religious communities; sporting team, graduates of some university, etc. Such communities have certain features in common.

- Specific community is created around some idea, belief, sphere of common interests, or just on the basis of certain common features of their members.
- Frequently there is some documentation concerning the community. It may be unwritten law, ethnic traditions, statute of the party, "holy" book – in case of religion. Sometimes members of a community are formally registered and receive personal certificates confirming their membership.
- There exist special regulations concerning the membership. It may be free, or an applicant should satisfy some requirements (believe in some idea, have certain qualities, or be eager to obtain them, etc). So, there exist a procedure of initiation, enrollment into the community, and contrarily – procedure of disfellowship.
- Usually special symbolism is present. Official colors, uniform, banners, badges, carefully developed specific rituals: initiation, meeting, worshiping, special exercises, gestures, dances. Frequently community is organized as followers of some teaching, and thus there are real or imaginary persons in the past or even at present, which are greatly respected. Very popular are their portraits, exceedingly idealized and much younger, then at present, as a rule.
- Each member has a set of liabilities concerning the broad spectrum of what should and what should not be thought, said and done at proper circumstances. As a reward community's member receive sometimes material, but – what is much more important – moral, spiritual support, that wonderful feeling of participating in something great, true, even holy activity. Frequently, such community promises take a form of future happiness to come, maybe even after physical death. This issue has paramount importance and is probably determinative in the whole community–members' affair. This mechanism works on psychological level and has powerful suggestive effect.
- The "power" of the systems being considered heightens with the number of their members and with the system's age.

Community, complying to considerable extent with the issues given above, together with its members is named "***egregor***" (see, for example, [Bernstein]). Egregors could be thought as having two hypostases. First is social and psychological, and there is not a slight doubt that it is really existing ideal entity. The second hypostasis, from the current scientific point of view is mystical. Genuine esoteric considers that, besides socio-psychological foundation, egregors have some fine-material aspects, probably being the part of Stratum 4 – Absolute. This thesis today has no scientific confirmation.

Relying on the considerations just given, we can argue, that religions, Christianity, in the first place, are the typical representatives of egregors. This issue gives us the solid foundation for understanding religious activity in human societies.

Conclusion

Let us remember what was our pathos and determination when idea of creating AI sprang into existence. Yes, it was the dream about the future society, where AI, wise and helpful robots will help us in our intellectual work. Being carried away with this noble humane idea, we forgot about humans themselves. We thought that we know all principal mechanisms of brain activity, neglected sphere of unconscious and restricted our intellect simulation to known area. At the same time, already during several thousands of years flourished alternative approach to

dealing with human intellect and psychics – religions, various beliefs, esoteric. Adepts of these disciplines suppose, that they possess much more general, powerful and complete knowledge about the World and humanity, but orthodox science usually avoid studying this domain, using the label: "pseudoscience". Benevolent consideration of this problem shows that, as always and as everywhere, the realm of esoteric encloses the broad spectrum of ideas, approaches, techniques, etc, with rather broad spectrum of utility. Some things look very unrealistic, even mystic, others could be positively considered if serious confirmations and verifications will be available. And still others look very rational and could be used in mental and psychological practice already today. Frankly saying, reality of esoteric experience should be carefully studied [JREF].

Besides that, until now we doing AI research used only hardware provided to us by engineers. It may happen, that "programming" human beings will give much more efficient results.

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TABLES OF CONTENTS OF IJ ITA – VOLUME 13

Volume 13, Number 1

Preface ... 3

Sabrina Noblesse, Koen Vanhoof
Using Sensitivity as a Method for Ranking the Test Cases Classified by Binary Decision Trees ... 5

Krassimir Markov, Krassimira Ivanova, Ilia Mitov
The Staple Commodities of the Knowledge Market ... 11

Krassimira Ivanova, Natalia Ivanova, Andrey Danilov, Ilia Mitov, Krassimir Markov
Basic Interactions between Members of the Knowledge Market ... 19

Oleksiy Voloshyn
About Problems of Decision Making in Social and Economic Systems ... 31

Igor Lyashenko, Olena Lyashenko
Optimum Trajectory of Dynamic Input-Output Balance Model for Open Economy ... 38

Alexander Kuzemin, Vyacheslav Lyashenko
Fuzzy Set Theory Approach as the Basis of Analysis of Financial Flows in the Economical Security System ... 45

Mykola Kirichenko, Volodymyr Donchenko, Denys Serbaev
Dynamical Systems in Description of Nonlinear Recursive Regression Transformers ... 51

Levon Aslanyan
Data Flow Analysis and the Linear Programming Model ... 60

Jose Joaquin Erviti, Adriana Toni
Matricial Model for the Study of Lower Bounds ... 65

Micael Gallego-Carrillo, Iván García-Alcaide, Soto Montalvo-Herranz
HI!MVC: Hierarchical MVC Framework for WEB Applications ... 75

Luis Fernández, Rosalía Peña
A Sensitive Metric of Class Cohesion ... 82

Jeff Furlong, Atanas Radenski
Handling the Subclassing Anomaly with Object Teams ... 91

In memoriam – Andrey Danilov ... 99

Table of Contents of Volume 13, Number 1 ... 100

Volume 13, Number 2

Vassil Vassilev, Krasimira Genova, Mariyana Vassileva
A Multicriteria Decision Support System *MultiDecision-1* ... 103

Mariyana Vassileva
Generalized Scalarizing Problems *GENS* and *GENSLex* of Multicriteria Optimization ... 111

Valery Kornyshko, Victor Dudarev
Software Development for Distributed System of Russian Databases for Electronics Materials ... 121

Ilya Prokoshev, Vyacheslav Suminov
The Information-analytical System for Diagnostics of Aircraft Navigation Units ... 127

Dmitry Kudryavtsev, Lev Grigoriev, Valentina Kislova, Alexey Zablotsky
Using ORG-Master for Knowledge Based Organizational Change ... 131

Todorka Kovacheva, Daniela Toshkova
Neural Network Based Approach for Developing the Enterprise Strategy ... 139

Petro Gopych
Generalization by Computation through Memory ... 145

FP6-ist INFRAWEBS European Research Project 158
Joachim Nern, Gennady Agre, Tatiana Atanasova, Zlatina Marinova, András Micsik, László Kovács, Janne Saarela, Timo Westkaemper
INFRAWEBS Semantic Web Service Development on the Base of Knowledge Management Layer 161
Gennady Agre, Petar Kormushev, Ivan Dilov
INFRAWEBS Axiom Editor – A Graphical Ontology-Driven Tool for Creating Complex Logical Expressions 169
Hristina Daskalova, Vladislava Grigorova
A Survey on the Integration of Enterprise Applications as a Service 179
Vladislava Grigorova
Semantic Description of Web Services and Possibilities of BPEL4WS 183
Tatiana Atanasova
INFRAWEBS BPEL-Based Editor for Creating the Semantic Web Services Description 188
Ivo Marinchev
Adjusting WSMO API Reference Implementation to Support More Reliable Entity Persistence 195
Table of Contents of Volume 13, Number 2 200

Volume 13, Number 3

Arkadij Zakrevskij
Randomized Parallelization – a New Method for Solving Hard Combinatorial Problems 203
Hasmik Sahakyan, Levon Aslanyan
The Boundary Descriptors of the *n*-dimensional Unit Cube Subset Partitioning 209
Mahmoud Farag, Mainouna Al-Manthari
Optimal Control of a Second Order Parabolic Heat Equation 215
Sergey Krivoi, Miroslaw Hajder, Pawel Dymora, Miroslaw Mazurek
The Matrix Method of Determining the Fault Tolerance Degree of a Computer Network Topology 221
Svetlana Chumachenko, Ludmila Kirichenko
RKHS-Methods at Series Summation for Software Implementation 227
Volodymyr Donchenko
Fuzzy sets: Abstraction Axiom, Statistical Interpretation, Observations of Fuzzy Sets 233
Dmitry Cheremisinov, Liudmila Cheremisinova
Developing Agent Interaction Protocols with PRALU 239
Evgenija Popova
webComputing Service Framework 246
Marina Fomina, Alexey Kulikov, Vadim Vagin
The Development of the Generalization Algorithm Based on the Rough Set Theory 255
Andrey Averin, Vadim Vagin
The Development of Parallel Resolution Algorithms Using the Graph Representation 263
Artem Sokolov, Dmitri Rachkovskij
Approaches to Sequence Similarity Representation 272
Tatyana Stupina, Gennady Lbov
Application of the Multivariate Prediction Method to Time Series 278
Vladimir Berikov
Recognition on Finite Set of Events: Bayesian Analysis of Generalization Ability and Classification Tree Pruning 285
Svetlana Nedel'ko
Extreme Situations Prediction by MultidimenSional Heterogeneous Time Series Using Logical Decision Functions 290

Victor Nedel'ko
Evaluating Misclassification Probability Using Empirical Risk 294
Table of Contents of Volume 13, Number 3 300

Volume 13, Number 4

Sergey Sosnovsky, Tatiana Gavrilova
Development of Educational Ontology for C-Programming 303
Alexander Palagin, Victor Peretyatko
Development of Procedures of Recognition of Objects with Usage Multisensor Ontology Controlled Instrumental Complex 308
Alexander Eremeev, Pavel Varshavsky
Analogous Reasoning and Case-based Reasoning for Intelligent Decision Support Systems 316
Valeriya Gribova
Dialog Based on Graphical Static Scenes Managed by an Ontology 325
Margarita Knyazeva, Alexander Kleshchev
A WEB-System for Computer Experiments in the Field of Program Transformations 331
Todorka Kovacheva
Viable Model of the Enterprise – a Cybernetic Approach for Implementing the Information Technologies in Management 337
Volodymyr Donchenko, Viktoria Omardibirova
Technology of Classification of Electronic Documents Based on the Theory of Disturbance of Pseudoinverse Matrices 341
Vitaliy Snytyuk
Evolutionary Clustering of Complex Systems and Processes 344
Grigoriy Gnatienko
Algorithm of Consecutive Definition of Ranking of the Objects Nearest to the set Cyclic Relation between Objects 349
Anatoly Gladun, Julia Rogushina, Victor Shtonda
Ontological Approach to Domain Knowledge Representation for Information Retrieval in Multiagent Systems 354
Mary Chernyakhovskaya
Forming Knowledge Bases in the Computer Knowledge Bank on Medical Diagnostics 361
Elena Drobot
The Localization Procedures of the Vector of Weighting Coefficients on the Set of Teaching Experts in the Tasks of Consuming 367
Alexander Makarenko
Neural Networks for Modelling of Large Social Systems. Approaches for Mentality, Anticipating and Multivaluedness Accounting. 371
Victor Krissilov, Daria Shabadash
Towards the Problems of an Evaluation of Data Uncertainty in Decision Support Systems 376
Larissa Kuzemina
Informatics, Psychology, Spiritual Life 380
Vitaliy Lozovskiy
Towards the Noosphere of Intangible (Esotericism from Materialistic Viewpoint) 383
Tables of Contents of IJ ITA – Volume 13 396
Authors' Index 399
Table of Contents of Volume 13, Number 4 400

AUTHORS' INDEX

Gennady	Agre	161, 169
Mainouna	Al-Manthari	215
Levon	Aslanyan	60, 209
Tatiana	Atanasova	161, 188
Andrey	Averin	263
Vladimir	Berikov	285
Dmitry	Cheremisinov	239
Liudmila	Cheremisinova	239
Mary	Chernyakhovskaya	361
Svetlana	Chumachenko	227
Andrey	Danilov	19
Hristina	Daskalova	179
Ivan	Dilov	169
Volodymyr	Donchenko	51, 233, 341
Elena	Drobot	367
Victor	Dudarev	121
Pawel	Dymora	221
Alexander	Eremeev	316
Jose Joaquin	Erviti	65
Mahmoud	Farag	215
Luis	Fernández	82
Marina	Fomina	255
Jeff	Furlong	91
Micael	Gallego-Carrillo	75
Iván	García-Alcaide	75
Tatiana	Gavrilova	303
Krasimira	Genova	103
Anatoly	Gladun	354
Grigoriy	Gnatienko	349
Petro	Gopych	145
Valeriya	Gribova	325
Lev	Grigoriev	131
Vladislava	Grigorova	179, 183
Miroslaw	Hajder	221
Krassimira	Ivanova	11, 19
Natalia	Ivanova	19
Mykola	Kirichenko	51
Ludmila	Kirichenko	227
Valentina	Kislova	131
Alexander	Kleshchev	331
Margarita	Knyazeva	331
Petar	Kormushev	169
Valery	Kornyshko	121
Todorka	Kovacheva	139, 337
László	Kovács	161
Victor	Krissilov	376
Sergey	Krivoi	221
Dmitry	Kudryavtsev	131
Alexey	Kulikov	255
Alexander	Kuzemin	45
Larissa	Kuzemina	380
Gennady	Lbov	278
Vitaliy	Lozovskiy	383
Igor	Lyashenko	38
Olena	Lyashenko	38
Vyacheslav	Lyashenko	45
Alexander	Makarenko	371
Ivo	Marinchev	195
Zlatina	Marinova	161
Krassimir	Markov	11, 19
Miroslaw	Mazurek	221
András	Micsik	161
Ilia	Mitov	11, 19
Soto	Montalvo-Herranz	75
Svetlana	Nedel'ko	290
Victor	Nedel'ko	294
Joachim	Nern	161
Sabrina	Noblesse	5
Viktoria	Omardibirova	341
Alexander	Palagin	308
Rosalía	Peña	82
Victor	Peretyatko	308
Evgenija	Popova	246
Ilya	Prokoshev	127
Dmitri	Rachkovskij	272
Atanas	Radenski	91
Julia	Rogushina	354
Janne	Saarela	161
Hasmik	Sahakyan	209
Denys	Serbaev	51
Daria	Shabadash	376
Victor	Shtonda	354
Vitaliy	Snytyuk	344
Artem	Sokolov	272
Sergey	Sosnovsky	303
Tatyana	Stupina	278
Vyacheslav	Suminov	127
Adriana	Toni	65
Daniela	Toshkova	139
Vadim	Vagin	255, 263
Koen	Vanhoof	5
Pavel	Varshavsky	316
Vassil	Vassilev	103
Mariyana	Vassileva	103, 111
Oleksiy	Voloshyn	31
Timo	Westkaemper	161
Alexey	Zablotsky	131
Arkadij	Zakrevskij	203

TABLE OF CONTENTS OF VOLUME 13, NUMBER 4

Development of Educational Ontology for C-Programming 303
Sergey Sosnovsky, Tatiana Gavrilova

Development of Procedures of Recognition of Objects with Usage Multisensor Ontology Controlled Instrumental Complex 308
Alexander Palagin, Victor Peretyatko

Analogous Reasoning and Case-based Reasoning for Intelligent Decision Support Systems 316
Alexander Eremeev, Pavel Varshavsky

Dialog Based on Graphical Static Scenes Managed by an Ontology 325
Valeriya Gribova

A WEB-System for Computer Experiments in the Field of Program Transformations 331
Margarita Knyazeva, Alexander Kleshchev

Viable Model of the Enterprise – a Cybernetic Approach for Implementing the Information Technologies in Management 337
Todorka Kovacheva

Technology of Classification of Electronic Documents Based on the Theory of Disturbance of Pseudoinverse Matrices 341
Volodymyr Donchenko, Viktoria Omardibirova

Evolutionary Clustering of Complex Systems and Processes 344
Vitaliy Snytyuk

Algorithm of Consecutive Definition of Ranking of the Objects Nearest to the set Cyclic Relation between Objects 349
Grigoriy Gnatienko

Ontological Approach to Domain Knowledge Representation for Information Retrieval in Multiagent Systems 354
Anatoly Gladun, Julia Rogushina, Victor Shtonda

Forming Knowledge Bases in the Computer Knowledge Bank on Medical Diagnostics 361
Mary Chernyakhovskaya

The Localization Procedures of the Vector of Weighting Coefficients on the Set of Teaching Experts in the Tasks of Consuming 367
Elena Drobot

Neural Networks for Modelling of Large Social Systems. Approaches for Mentality, Anticipating and Multivaluedness Accounting. 371
Alexander Makarenko

Towards the Problems of an Evaluation of Data Uncertainty in Decision Support Systems 376
Victor Krissilov, Daria Shabadash

Informatics, Psychology, Spiritual Life 380
Larissa Kuzemina

Towards the Noosphere of Intangible (Esotericism from Materialistic Viewpoint) 383
Vitaliy Lozovskiy

Tables of Contents of IJ ITA – Volume 13 396

Authors' Index 399

Table of Contents of Volume 13, Number 4 400