SELF-ORGANIZATION OF FUNCTIONING PROCESS OF EXPERT SYSTEM WITH THE USE OF SUBJECT DOMAIN ONTOLOGY

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Annotation: Optimization of design, creation, functioning and accompaniment processes of expert system is the important problem of artificial intelligence theory and decisions making methods techniques. In this paper the approach to its solving with the use of technology, being based on methodology of systems analysis, ontology of subject domain, principles and methods of self-organisation, is offered. The aspects of such approach realization, being based on construction of accordance between the ontology hierarchical structure and sequence of questions in automated systems for examination, are expounded.

Keywords: Expert systems, ontology, self-organisation

ACM Classification Keywords: I.2.1. Application and Expert Systems

Introduction

Expert Systems (ES) relate to basic and most early directions of artificial intelligence. The first ES, being based on the use of the computing engineering, are known from the 60-th years of past century. Today it is difficult to name the branch of science or production, where they were not used. At the same time, swift motion on stages

<society without boundaries>→<information society>→<society, being based on knowledge>

and like avalanche growth of quantity information considerably complicate the adequate use ES, that it is related to the informative redundancy, incompleteness and illegible information, its subjectivity. We have the knowledge representation problems of experts, optimizations for receipt processes of conclusions in ES, determinations of plenitude of information bases.

The automated systems for study examination (ASSE) related to information technologies are the typical representative ES. Not deciding on the tasks of tests verification and results estimation we will mark that all foregoing problems are reflected in them to a full degree. In further exposition we will follow a conclusion [Feigenbaum, 1963] about that is "basic principle of knowledge engineering, that possibilities of Problems Solver by intelligence agent above all things are determined by its informative base and only in the second – by the used method of conclusion".

Analysis, description and component parts of expert systems creation process

An idea or necessity is pre-condition and incentive reason for new knowledge receipt. In the ES case such necessity consists in the receipt of some conclusion, being one of determinative features at decision making. With ASSE the level of knowledge is estimated. We will illustrate the process of the ES creation through three methodological structural units which are ontology (O), system analysis (SA) and self-organisation (SO).

Following the stages of SA algorithm, in accordance with [Plotinskiy, 1992], [Zgurovskiy, 1997], we will define the goal of the ES creation as a mean the attribute of which is feature to accumulate expert knowledge and afterwards possibility to replace experts in the decision making processes. The problems decided for goal achievement are determined by a subject domain. In particular, for ASSE are such the knowledge examination, their level determination and, partly, acquisition. The ES functioning is determining by an external environment, which information as themes, questions, possible answers acts from, inference rules and in which a result is passed – estimation of knowledge level.

Be complex system, ES it is possible to present by three models [Timchenko, 1991]: structure, functioning and development. The structure model is a theoretical-plural model:

$$M_b = < I_t, I_q, I_a, R_o >, \quad (1)$$

which the element base of the system is represented in: I_t – informative table for the themes examination; I_q – tables of the given questions (depending on the questions types of them can be some); I_a – tables of possible

answers with pointing of their rightness gradation; R_o – aggregate of inference rules, sometimes presented by some procedure or algorithm. The functioning model determines the process of goal achievement by the system, which is carried out by its elements, subsystems, integral ES:

$$M_f =< O_t, O_q, Q_a, P_1, P_2, ..., P_n, A >, \quad (2)$$

where O_t – dynamic operations accompanying the process of theme choice; Q_q – dynamic operations of questions set choice; Q_a – dynamic operations for forming the possible answers set and their estimation; $P_i, i = \overline{1,n}$ – aggregate of operations realizing the sequence of transitions at examination; A – algorithm for knowledge evaluation. The development model reflects the motion of ES, possessing the attributes of openness, mobility, system and informative unity, complexity on the stages of its life cycle:

$$M_d =< A_d \Theta A_m \Theta A_u, B_r >, \quad (3)$$

where Θ – logical disyunction or konyunction, A_d – adaptation procedures to the change of external terms; A_m – modernization procedures and use of new technologies; A_u – procedures of partial or complete utilization; B_r – machineries of feed-back, allowing taking into account future processes to produce the changes in ES on all stages of its life cycle.

Models (1)-(3) are an additional informative feature allowing to carry out structurisation of process of ES creation and functioning. We will remark that ES will be effectively functionate, as already it is indicated higher, if it has the adequately formed informative base. In the its capacity rationally to use ontology – the enough complex organized structure of knowledge about a subject domain from one side, with other – initial material for the receipt of new knowledge [Grechko, 2005]. Construction and use of ontology in ES is based on that:

- ontology at that rate is jointly used by the collectives of agents;
- knowledge about a subject domain are used repeatedly ;
- knowledge about a subject domain are separated from a process and algorithm of examination;
- it is needed for the analysis of knowledge about a subject domain.

Development and use of ontology on today not formalities, for their construction there are only some fundamental rules. At the same time, the application domains of ontology and aspects of their development are enough various, about what the papers analysis in 2005 year is testifies. So, in [Grechko, 2005] ontology of analysis method for the Saati hierarchies is built; in the paper [Darevich, 2005] for the rise of intellectual analysis of text it is offered to use weighing of notions in the ontology model; authors [Kucherenko, 2005] consider the questions related to presentations in ontology of fuzzy notions and relations; the paper [Shalfeeva, 2005] is devoted to research of evaluation in the process of ontology creation. The algorithm of comparison of interests for salespeople and buyers in Internet-shops is offered in paper [Gladun, 2005]; in the paper [Gribova, 2005] the problem of development of user interface with the use of different types of dialog, being based on the use of ontologies, is considered; procedure of structurisation of knowledge in an application area is studied in [Palagin, 2005]. The paper analysis shows that they can be divided into two types: the articles which the aspects of creation and improvement of ontologies are studied in behave to one, to other – decisions of the applied tasks with their use.

As, as stated above, knowledge about a subject domain exist separately from the methods of analysis, inevitably there is the problem of their composition. Such co-operation in the conditions of informative redundancy must be enough effective on the criterion of time minimization. However the problem solving comes into collision with the problem of synergetic effect [Haken, 1985], in consequence of what structures, uniting data, questions, answers and inference rules possessing some time stability, are appear. Such structures aspire in time to position with "minimum energy". But achievement of the indicated state takes place in the conditions of incomplete information. Thus, from one side there is the informative redundancy of initial data and shortage of information about process optimization and results of knowledge control (in ASSE) – with other. Solve such contradiction is suggested with the use of self-organisation of transitions process on the ES levels (sequences of questions for the knowledge estimation in ASSE). Self-organisation procedure of the ES functioning will allow to rationalize and intellectualize process of information treatment necessary for the receipt and knowledge estimation.

Aspects of ontologies creation for expert systems

The ontologies are admitting multiple use in different application, they can be complemented and modified. For many subject domains, especially in the field of commodities of consumption, to ontologies are already built. We will consider the features of their creation for the knowledge estimation. We will assume that a course on information technologies is the studied subject. Coming from the problem-oriented exposition of subject, discipline contains lectures, practical and laboratory studies, that corresponds to acquisition by studying knowledge Z, abilities U and skills N. Thus, the subject study determines realization of reflection:

$$K \to < Z,U,N > . \quad (4)$$

It is known, that ontology – it is the attempt of all-embracing and detailed formalization of some domain of knowledge by a conceptual chart, which consists of hierarchical data structure, containing all relevant classes of objects, their communications and rules accepted in this domain. Formally, ontology presents as a three elements $\{X,R,F\}$, where X – finite set of concepts (elements of knowledge), R – set of relations between concepts, F – set of interpretative functions for concepts and / or relations. Construction of ontology for ES, which is ASSE, begins from determination of subject domain limits, being based on presentation of place and role of educational subject in the general flow diagram of subjects and, as a result, finding of a priori information being the base of subject study. A subject domain includes basic concepts, and also list of problems which outline the informative field of course (fig.1).

In accordance with the list of problems it is necessary to define concepts and build a hierarchical structure. So, in a subject on information technologies concepts of the first level would be: “System”, ”Information”, ”Intelligence”, ”Technology”, Model”, ”Planning” and some other. They are determined by expert assumptions as above all, base notions. Attributive nouns or attributes of concepts of higher level will be concepts of the second level, for example, “interface design “ or “mathematical model”. Such construction proceeds to achievement of base elements – structural units possessing an independent value for the subject study.

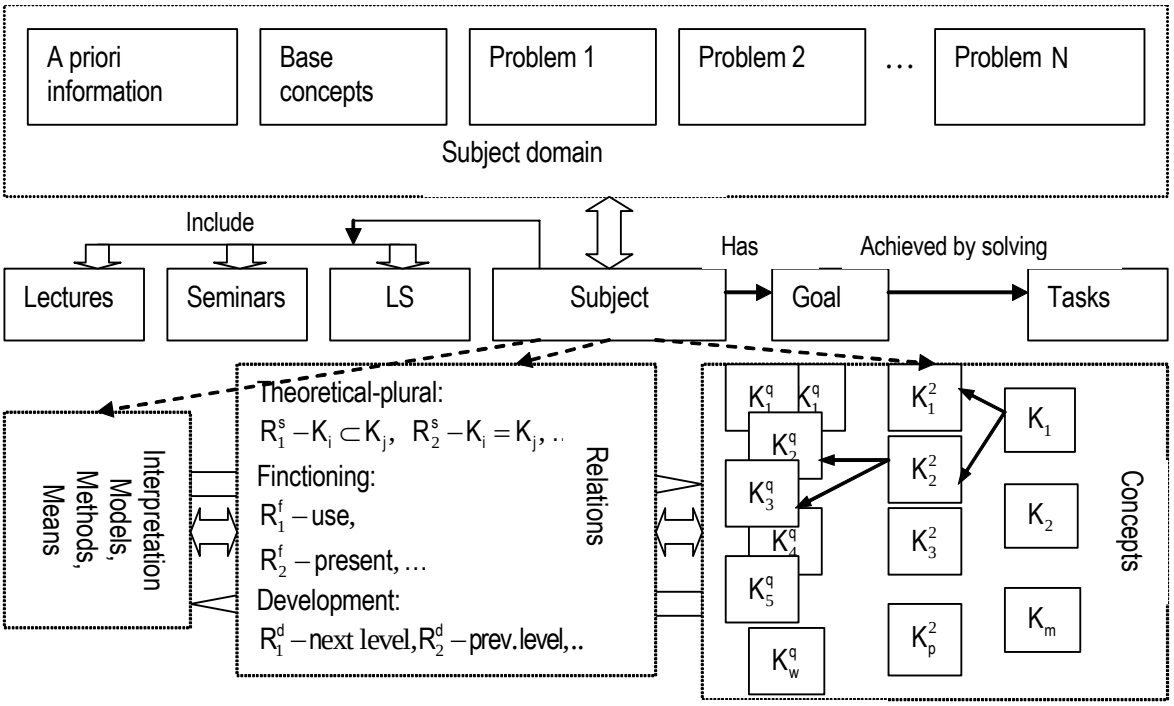

Fig. 1 – ASEE on the ontology base structural chart

Some objectivisation in the process of ontology construction can be brought the automated analysis of electronic summary of lectures text. For this goal on the first stage it is necessary to count up the number of the most often meeting words-concepts of the first level. On the second stage the number of the most often meeting words-attributes (adjectives) or attributive notions (nouns) of the first level concepts is calculated. The third stage (can be inverted with the second) is dedicated to determination of often meeting relations of concepts functioning of

the first level (sometimes jointly with concepts of the second level), expressed by the verbs of action and etc. Automated treatment allows to define concepts of low levels being attributes, by determining concepts for higher levels. Resulting ontology is got, carrying out composition of the data receipt it is automated, and expert conclusions.

Ontology and questions superposition technology in expert system

Technology of interactive intercourse, supposing the presence of decision making person and user (expert) answering questions of the system, lies in the ES basis. Rational conducting of such dialog which on an eventual stage is conducted between a user and computer is possible at implementation of such terms: a questions and possible answers data-base is enough complete for acceptance of decisions; procedure of examination is verification; the algorithm of examination must be time optimized.

Traditionally, conducting procedure of examination was fully determined by a decision making person, investigation of what was the decision being based exceptionally on the subjective preferences. In the ASSE lecturer made a list of questions from different theme of subject. For the examination their definite number was offered. For an answer for a question student got marks and their summary number made estimation, which, in the general case, did not guarantee subject knowledge, as a random selection of questions did not reflect the complete picture of the studied problems and tasks. Material of some sections remained out of examination, and some questions with insignificant modifications repeated oneself.

We suggest to use by examination principles of self-organisation [Ivakhnenko, 1975], [Molchanov, 1988]: "multiplicity" of models and choice freedom. Their interpretation in relation to our problem consists that there is the set of well-organized sequences of test questions resulting in a correct result, and also that on any stage of testing a few variants of its continuation can be chosen.

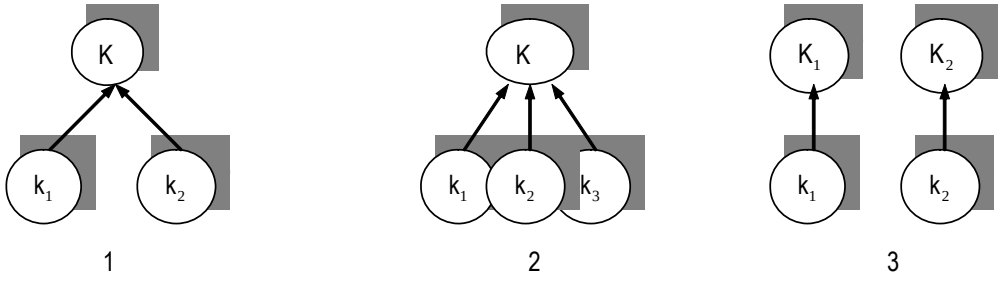

Fig.2 – Possible constituents of ontology construction

Making the examination sequence, we will follow a structure definite by the graph of ontology. The variants of accordance choice, resulted on the fig. 2, are thus possible. We will remark that graph presenting ontology, has the descending orientation. At the same time, the examination process can have as descending (deductive – from general to partial), so ascending (inductive – from partial to general) character. On the fig. 2 fragments proper to ascending approach are shown. Forming of questions sequence at that rate answers a "And-Or" structure. Concepts of low level k_1 and k_2 (see fig. 2.1.) make concept K and between them it is possible to put logical "OR". Then in the questions sequence there must be necessarily questions on essence of both concepts and right answers on them suppose knowledge of essence K and deliver from questions on its maintenance. We will remark that concepts of low level for k_1 and k_2 have not general elements, notions, functions. If this is not so (see fig. 2.2), rationally to set questions on concept essence, or its constituent, being general for one level concepts. If concepts are at one level (see fig. 2.3) and have not crossing at more low level, right answers for questions an incident to all one level concepts are the necessary condition of examination passing.

A expert system can function in the "active" and "passive" modes. In the "passive" mode a questions sequence by the system are determined beforehand and written in a data-base, in "active" mode – the sequence of questions is formed in the process of student answers. In the first case the time on the question generation is minimized, but the adequate reaction on the rightness of answers is absent, in the second – if power of ontology is enough large, time of determination of a next question can be considerable. Advantage of the "active" mode consists that

there is possibility of flexible reaction and determination of sequence of next questions depending on previous answers.

Problems and prospects of functioning process optimization for expert system

The process of extraction of knowledge with the use of ES is based at function of three subsystems [Luger, 2003]: editor of knowledge base, conclusion machine and subsystem of explanations. Optimization of their functioning requires the decision of such tasks:

- formal presentation of ontology in the element bases of knowledge base;
- providing of determination possibility of accordance between presentation of ontology and table containing thematic questions;
- developments of examination algorithm (knowledge examination) foreseeing possibility of the flexible tuning as a result of self-organization of questions base in real-time mode;
- development of models and methods of examination, the initial stage of which is formalization of questions depending on the types of answers;
- consideration of possibility of fuzzy presentation of subjective judgement;
- development of the reporting system and interpretation of the ES functioning results, foreseeing explanation of examination logic.

As a result of indicated problems solving the prospects of systems approach to the ES creation in different domain of knowledge are opened. The considerable degree of standardization of process of their creation and planning optimizes the process of receipt of expert conclusions. Forming of the ontologies proper subject domains is the necessary condition of this, a sufficient condition consists in realization of technology of superposition of test elements and elements of ontology.

Conclusion

The offered technology of expert system creation, being based on methodology of system analysis, ontology of subject domain, and also principles and methods of self-organisation is another step in the direction of effective expert systems creation. Efficiency consists in time minimization of examination conducting; in decisions objectivisation, being based on automation of expert analysis process, more complete scope of subject domain and reduction of informative redundancy of test questions and their sequences; indirect forming at experts and student conception of subject domain structure, its base elements and their functional intercommunications.

Swift development of distance learning is another arguments in behalf on creation and use of the ASSE, being based on the use of subject domains ontologies being the basis of educational courses. We will remark that development of ontology is an enough difficult and labour-intensive process, therefore rationally this process within bounds of educational establishment, and afterwards in more wide scales unify, for what to develop the program-methodical providing. Their use as base platforms for development of distance courses, integrating in itself the subsystems of learning, reference information, methodical literature, test examples, receptions of reports and control tasks, will be another application for developed ontologies.

Bibliography

[Feigenbaum, 1963] E.A. Feigenbaum. The simulation of verbal learning behavior. In Feigenbaum and Feldman. – New York: McGraw-Hill, 1963.

[Plotinskiy, 1992] Yu.M. Plotinskiy. Mathematical design of dynamics of social processes. – Moscow: MSU, 1992. – 133 p.

[Zgurovskiy, 1997] M.Z. Zgurovskiy, A.V. Dobronogov, T.N. Pomerantseva. Research of social processes on the basis of systems analysis methodology. – Kiev: Naukova dumka, 1997. – 222 p.

[Timchenko, 1991] A.A. Timchenko, A.A. Rodionov. Informatics bases of the system design of new technique objects. – Kiev: Naukova dumka, 1991. – 152 p.

[Grechko, 2005] A.V. Grechko. Ontology of analysis method for the Saati hierarchies // Artificial intelligence. – 2005. – № 3. – Pp. 746-757.

[Darevich, 2005] R.R. Darevich. Rise of efficiency of test intellectual analysis by weighing of notions of ontology model // Artificial intelligence. – 2005. – № 3. – Pp. 571-577.

[Kucherenko, 2005] E.I. Kucherenko, D.A. Pavlov. Some aspects of development analysis of fuzzy ontology // Artificial intelligence. – 2005. – № 3.– Pp. 162-169.

[Shalfeeva, 2005] E.A. Shalfeeva. Classification of structural properties of ontology // Artificial intelligence – 2005. – № 3. – Pp. 67-77.

[Gladun, 2005] A.Ya. Gladun, Yu.V. Rogushina. Ontology how perspective direction of intellectualisation information retrieval in the multiagent systems E-commerce // In Proc. XI-th Int. Conf. "KDS-2005". – Varna.– Vol. 1. – Pp. 158-165.

[Gribova, 2005] V. Gribova. Implementation of various dialog types using an ontology-based arproach to user interface development // In Proc. XI-th Int. Conf. "KDS-2005". – Varna.– Vol. 1. – Pp. 153-158.

[Palagin, 2005] A. Palagin, V. Peretyatko. Development of procedures of objects recognition with usage multisensor ontology controlled instrumental complex // In Proc. XI-th Int. Conf. "KDS-2005". – Varna.– Vol. 1. – Pp. 140-147.

[Haken, 1985] H. Haken. Synergetycs. – M.: Science, 1985. – 320 p.

[Ivakhnenko, 1975] A.G. Ivakhnenko. Long-term prognostication and management by the difficult systems. – Kiev: Naukova dumka, 1975. – 311 p.

[Molchanov, 1988] A.A. Molchanov. Design and modeling of the difficult systems. – Kiev: Visha shkola, 1988. – 359 p.

[Luger, 2002] G.F. Luger. Artificial intelligence. Structures and strategies for complex problem solving. – Addison Wesley: Boston, 2002. – 864 p.

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PROTOTYPING ADAPTIVE ONLINE LEARNING COURSES[1]

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Abstract: This article describes the process of prototyping adaptive online learning using the authoring tool for developers, which is based on ontologies. The article also gives a brief overview of contemporary situation and describes modern trends of evolution e-learning courses and present standards in this area. It also describes architecture of system VITA II.

Keywords: E-learning, ontologies, user modeling, LOM.

ACM Classification Keywords: K.3.1 Computer Uses in Education – Distance learning, K.3.2 Computer and Information Science Education – Computer science education, E.1 Data Structures – Trees, I.2.6 Learning – Concept learning (Knowledge acquisition).

Introduction

Using new computer technologies modern teachers can easily create online-courses accessible through the Internet.

However there are a number of problems with the creation of e-learning courses. The first one is that not every teacher posses an equal good knowledge in computer technologies, which are necessary for creation and management of e-learning courses.

The second problem is that users of e-learning courses do not posses an equal knowledge level. They also have different psychological, social and other personal characteristics. (All these facts, defining personal characteristics of users, create so-called "user model"). That is why the data, assignable to different users, must be different. As a result, the e-learning system is needed of some measure to be adaptive for ensuring the best process of education, or in other words it must be slaved for exact user model.

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