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The integration of ontologically oriented technologies in model of knowledge processing

Genadiy Mogilny, Vitaly Semenkov, Uriy Tihonov

Lugansk Taras Shevchenko National University, Oboronna str. 2, Luhansk, 91011
e-mail: zavkafinfo@lnpu.edu.ua, semvitaliy@gmail.com, e-mail: t2003i@mail.ru

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Summary. The paper discusses the model of knowledge representation, including now the most common models in the computer processing of knowledge ontology. Computer ontologies are used in medicine, biology, diagnosis, e-learning. On the example of e-learning shows the specific logical-mathematical software applications ontologically oriented technologies.

Key words: knowledge models, computer ontology, the subject area, information technology, subject discipline, e-course.

INTRODUCTION

Under the influence of the process of information now emerging new social structure – the information society. It is characterized by a high level of information technology, infrastructure development, ensuring the production of information resources and access to information, processes, accelerated automation and robotics all sectors of production and management, changes in social structures, the consequence of which is the expansion of the scope of information activities.

The process of information is logical and objective process, characteristic of the entire world community. It manifests itself in all spheres of human activity, including e-learning. Informatization included as an important component of e-learning, involves improving the quality of educational services in e-learning [19].

Formulation and investigation of problems of integration of information technology in e-learning is due to the need of their application in various stages of training in accordance with the modern concept of lifelong education.

Development of e-learning, as a branch of learning is not possible without the development of models of knowledge processing, based on which it is implemented. Available current research on the theory of information make a significant contribution to knowledge processing techniques, however, are now studies on systems approaches to solving the problems of integration of information technology in the ontological e-learning, not so much. This is due to the fact that the complexity of the problems arising here is so high that the creation of e-learning courses (EC) should be considered as subject to the complex process of high-tech design.

The introduction of new information technologies in the development of EC complexity and ambiguity caused by the objective and subjective factors:

a) the lack of evidence-based concepts and programs of e-learning,

b) an underdeveloped physical infrastructure, lack of adequate educational environment in most universities,

c) the lack of specific software that allows applications to solve specific problems,

d) inadequate level of information culture and technology training.

Specificity of e-learning technology is that it is designed and implemented a training process to ensure the achievement of the goals. New information technologies have great potential and can enhance the effect of human actions than through their individual elements, and by combining them into a single system. Their implementation, especially the rational integration with e-learning technologies will help create the conditions intensification of e-learning and techniques focused on self extraction and presentation of knowledge, skills formation.

MATERIALS AND METHODS

Known production systems of describe concepts, the shape of which in something inherit syllogisms [6].

Designing electronic courses involves the formation of sets of concepts, their descriptions.

Basic principles of the paradigm of computer ontologies have been formulated in [7].

In contrast to the knowledges encoded in the algorithms [1-3, 4, 11], an ontology provides a unified and their re-use in different research groups on different computer platforms for solving various problems [12].

Subset of the concepts of the ontology database [14].

RESEARCH OBJECT

With the integration of information technology in the processing model of knowledge necessary to choose a formal representation of knowledge. Processing model of knowledge is now being implemented in many industries and technologies. They have the greatest development in medicine, biology, diagnosis, e-learning. This paper analyzes the model of choice for knowledge representation, it is proposed to use the capabilities of the formal description ontologically oriented processing model of knowledge, on the example of the application in e-learning shows the features of logical-mathematical apparatus for processing models of knowledge.

RESULTS OF RESEARCH

The automated system of training of electronic courses are one of the components of the integration of e-learning and information technology. Designing electronic courses involves the formation of sets of concepts, their descriptions. The construction of these sets by hand is a tedious process, both in time and in the number involved in the design process of highly qualified specialists. Set EC should ensure the professional activities of an engineer to solve problems in a variety of subject areas (SA) (Fig. 1).

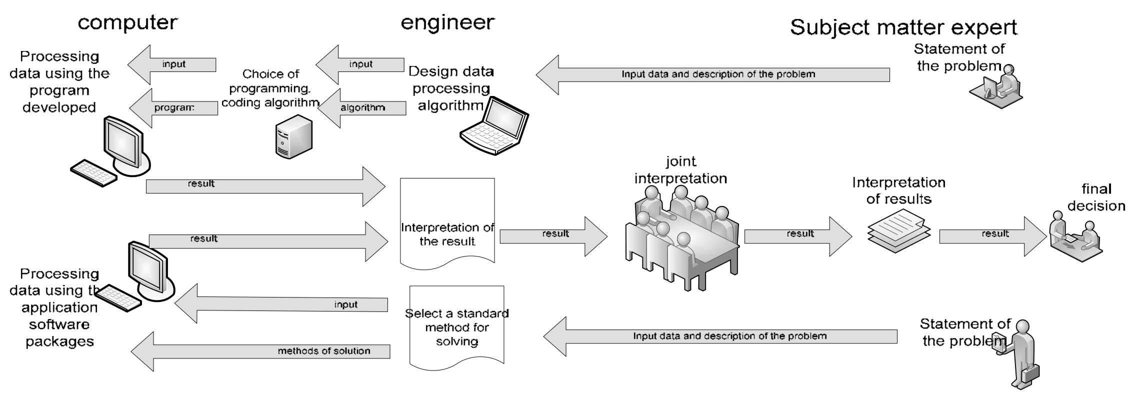

Fig. 1. The scheme of professional problem solving activity in a variety of subject areas

Based on this information model of the electronic courses must be based on a model of knowledge processing SA, on the basis of which it is implemented. To implement the model, you must identify the relationships between the concepts of SA. In implementing the model, you must use the representation of knowledge in an easy to use form. Below is a brief analysis of the formal-logical representation of knowledge [13].

The logical model (the symbolic notation of mathematical expressions using predicate logic), which can use various logical aspects of knowledge representation [11, 14]. Propositional logic is a complete, a system of iterative construction and parsing logic statements, which is the atomic structure for the components of which it is impossible to establish the truth.

Predicate calculus. The main characters are the language of predicate logic variables, individual constants, predicate constants, ligaments $(\neg, \wedge, \vee, \rightarrow, \leftrightarrow)$, quantifiers $\forall$ (for all) and the existence $\exists$ (there) [13].

In the language of the predicate is contained language statements, as saying – neither more nor less than a predicate constant no arguments or, more precisely, a predicate constant with zero seats. Convenient to replace the concept of individual constants a more general concept of functional constants. Functional constant with a certain number of seats – exactly the same as the predicate constant. Individual constant – just ary functional constant.

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Use the default payment method for reasoning about the relationship to the language of predicate logic. It represents the following sequence of steps:

1) replace the unit and common names of individual constants and predicates, respectively,

2) replace the quantifier words quantifiers and write quantifiers with their associated variables in the order quantifier occurrences of words in the sentence that expresses the proposition,

3) write out a formula that replaces the first (within the meaning of) the predicate by preceding the left bracket, and if an individual variable formula, which replaces the first predicate associated quantifier, then put it after the implication sign after sign implication or sign conjunction to put a left parenthesis,

4) if the individual variable formula, replacing the second (within the meaning of) the predicate is associated quantifier, then write it and put it after the implication sign, but if it involves an existential quantifier, then write it and put it after the conjunction sign, after sign implication or sign conjunction to put a left bracket (if translated judgment of more than double sense), and so on,

5) write a formula that replaces the last predicate,

6) after the formula, which replaces last predicate to supply the required number of right brackets (if detected logical form of negative judgments, the predicate before the last to put the negation sign).

Existentially - conjunctive logic.

Her name is associated with a logical operator conjunction and existential quantifier, which are used in it. The widespread use of EC logic gained from the development and implementation of relational databases. Thus, each database is used to fix the presence of an object (the existential quantifier) and the list of its inherent properties (connected by a conjunction). All that is not included in the database, is considered from a logical point of view as nonexistent. This restriction has created one of the most commonly used query languages SQL.

Frame model (systematization and structuring of information in the form of tables, matrices, etc.).

Frame – an abstract image to represent a stereotype perception. In general, the frame can be formally described as a structure that includes the name of the frame, a plurality of slots with their names and a host of associated procedures associated with the frame or the slots. Such frames are called frames-prototypes. Frames-examples are frames-prototypical with the values of slots and must display certain real-world objects, situations, and so on. Notion of frames was the concept of object-oriented systems, which have narrowed the interpretation of the frames of the prototype to the classes, and the frame-examples to class objects, preserving fully the structure and capabilities of frames.

Production model (a set of rules or regulations for the submission of algorithmic procedures for solving).

Production systems. The shape of the production systems in something inherit syllogisms: The system consists of rules Productions $A \supset B$ (if A, then B), which in general terms in place A and B can appear arbitrary Boolean expressions without implication. However, the automatic systems of productions as a B share a single fact or reference to a simple implementation of the Direct Output (from antecedent to consequent) [5].

Horn clauses. Production systems with the opposite conclusion in their majority are Horn systems. The reason for this is the use of Horn clauses – implicative formula $A \supset B$, where B is an atomic predicate.

Semantic model (knowledge representation using graphs, flow charts, drawings, etc.).

Semantic networks and conceptual graphs. Semantic network is a directed graph with named nodes that represent objects and arcs – relationships between objects. As the graph semantic networks use at least two measurements for its notation. The first was a semantic network of concepts with a small tree genus-species relationships, built on the categories of Aristotle. Later repeatedly builds a tree of categories, but they used a very limited set of relations. Semantic networks were developed in connection with the possibility of automatic processing on a computer, use a lot of expanding relations: linguistic (declensional, attribute), logic (conjunction, disjunction, negation, implication), quantified (all, some). Logical basis of semantic networks is the full first-order predicate logic – every relationship can be viewed as a predicate of adjacent to it (relative) peaks – objects. From the variety of semantic networks deserve special attention conceptual graphs (CG). This is evidenced by at least the fact that for the CG Committee NCITS T2 on the exchange of information and interpretations have been adopted by ANSI-standard. CG designed to represent knowledge at the level of the man-machine, although there is a form recording CG designed to manipulate graphs between machines. For CG defines the basic universal primitives for building semantic networks with arbitrary relationships. They have the ability to include images, audio information and other CG as objects (top graph)

Conceptual graph is a bipartite labeled directed graph $G = (V_1 \cup V_2, E)$, where $V_1 \cap V_2 = 0$ the vertices of V_1 the marked predicate names, and the top V_2 of the – argument names, E – set of arcs (directed edges). The arcs connecting the vertices of the graph, labeled with the name of predicates, with vertices labeled by the names of the arguments. The tops of the plurality V_1 called nodes - predicates, the tops of V_2 – nodes-concepts and predicates themselves – conceptual predicates.

From this definition, it follows that the conceptual graph must satisfy the following conditions:

1) the number of arcs that connect nodes to nodes predicate - concepts, as well arity of the predicate (i.e., the number of its arguments),

2) all nodes predicates marked with the same concept of the predicate have the same arity,

3) all the arcs that connect nodes and predicate nodes concepts in the CG, ranked from 1 to n, where n – the arity of the predicate.

Graphically nodes predicates are indicated by ellipses, and the nodes of the concepts – rectangles. If your logic is typed language, i.e., its objects are assigned certain styles, with each conceptual predicate symbol associated tuple <a, b,…, c>, called the signature of the predicate. Or in other words, the signature of the predicate describes the semantic model of correct use of arguments in the syntactic structure of a natural language, offers a maximum expressive power. Under full expressive power of understanding the motorcade without blank cells.

CG does not accidentally chosen as the data structures for the representation of predicates and their arguments. These structures were tested in long-term knowledge base systems and have proven to be the best side. This is manifested primarily in the efficiency of operations on such data structures. The operations are performed on a set of CG in order to effectively build a more complex structure – the semantic web.

The ontological model (knowledge representation using the concepts, relationships, functions, interpretation of axioms). Basic principles of the paradigm of computer ontologies have been formulated in [7].

1. **Clarity**. The terms (and concepts) of the ontology must reflect reality. Their graphic symbols (signs) should be formed on the basis of the standard rules of semiotics and to express the conventional sense of real objects. In turn, these meanings are extracted from the generally accepted definitions of terms (concepts), recorded in the dictionaries, glossaries of different. The judgments included in the definition are formalized through a formal conventional apparatus in the form of identically true logical axioms.

2. **Coherency**. Formation of the initial set of ontology concepts and their addition should be reasonable, determined, first of all, the requirements of the proposed set of tasks. Logical axioms of the initial set of concepts must be consistent. To this must be provided inference which including checks on the consistency added axioms in the ontology and output approval.

3. **Extensibility**. The core ontology are initially introduced (designed) the concepts and describing their axioms. In the ontology should be a mechanism extension (restriction) shared vocabularies of concepts without compromising the integrity of the system.

4. **Minimal encoding bias**. In the ontological system should be implemented the principle of shared ontologies, which includes: the specification of the ontology at a complete picture, not a character encoding, recording a specification for conventional and platform-independent language for defining ontologies can be transferred for use by any software agent.

5. **Minimal ontological commitment**. This principle resonates with the principles of reasonableness and extensibility / restrictions. It is important that a lot of the concepts of the ontology displayed the conceptual structure of a SA, a relatively stable throughout the “life cycle”. And the latter would offer the possibility of expanding or specialization of individual branches of the ontology graph. Department of conceptual knowledge from the knowledge expressed by facts, is the strategy of building an ontological system, or more precisely – the ontological knowledge base.

Under the ontology of the domain objects is understood Four:

$$O^O = < X, R, F, A(D, Rs) >, \qquad (1)$$

where: $X = \{ x_1, x_2, ..., x_i, ..., x_n \}$,

$i = \overline{1, n}, n = Card\ X$ - finite set of concepts (concepts-objects) of a given subject area,

$R = \{ R_1, R_2, ..., R_k, ..., R_m \}, R \subseteq X_1 \times X_2 \times ... \times X_n$,

$k = \overline{1, m},\ m = Card\ R,$ – finite set of semantically meaningful relationship between the concepts subject area. They define the type of relationship between concepts. In general, the relationship is divided into general significance (of which the release is usually the partial order) and specific relationship given subject area,

$F : X \times R$ – Finite set of interpretation functions defined on the concepts of objects and relationships,

A – Finite set of axioms, which consists of a set of definitions D_i^l and a set of constraints Rs_i^t for the concept X_i. Definitions are written in the form of identically true statements that can be taken, in particular, of the dictionaries subject area. They can specify additional relationships X_i with the notion X_j. In the set of constraints Rs_i can be specified limitations on the interpretation of the relevant concepts X_i.

An ontology defines a common, semantically meaningful "conceptual unity of knowledge", operated by the researchers and developers of knowledge-oriented information systems. It separates the "static" and "dynamic" component of knowledge from the operational knowledge. In contrast to the knowledge encoded in the algorithms, an ontology provides a unified and their re-use in different research groups on different computer platforms for solving various problems [1-3, 4, 18].

The latter view is now most common in models of knowledge processing. Computer ontologies are used in medicine, biology, diagnosis, e-learning [5, 9]. One of the reasons for such an extension is a good-quality tool support for the development and application of ontology. Now known more than a tool or software systems ontology editors with a wide range of features and functionalities.

The model of knowledge processing for use in the EC proposed to present knowledge in the form of computer ontologies.

In ontological model of EC uses a domain ontology, corresponding to the subject discipline of EC. Ontology SA is the result of using the original tool kit ontological purpose and library reference information.

The library of reference information (LRI) include: encyclopedias, thesauruses and explanatory dictionaries. Contains a library of concepts and their descriptions in Russian, Ukrainian and English languages, divided into thematic dictionaries from one (or more) domains.

LRI generally contains several definitions for each concept based on shades of meaning and focused on a wide range of consumer information. Such knowledge representation with the fundamental principles of constructing formal ontology, and their semantic interpretation is the main source of the SA for ontology knowledge engineer.

LRI module developed in object-oriented programming language Java. For Storage dictionaries used Redis - document-oriented, networked, data store of type "key-value" open source. The system keeps a database in RAM, equipped with logging mechanisms to ensure permanent storage.

The main purpose of LRI is to support the processes of transdisciplinary research.

The main functions provided by LRI.

1. Viewing entries for an arbitrary concepts.
2. View mode of a concepts and definitions (the default).
3. Representation for concepts multiple definitions of.
4. With the context menu can be called up point – "Other definitions" (of concrete concepts).
5. View mode of ontological description of concepts.
6. Authorization of users. There are two types of authentication: for "User Mode" – without password and "edit mode and filling" - requires an account on the server (username and password).
7. Search term by LRI (all Components).
8. Entering a new concept and its definition from the keyboard or with the digitized source.

LRI module consists of three subsystems, and combines information resource, software and hardware that allow the interaction with natural intelligence.

Subsystem Clearinghouse consists of a specialized database Redis. The database contains a digitized encyclopedia, thesauruses and dictionaries, as presented in the form of domains of knowledge, which in turn are divided into sections - dictionaries domains. For example, domain "Computer" includes dictionaries "Programming", "Databases", "Cryptography". Each dictionary of domain in turn contains a set of concepts and their definitions.

Subsystem of resource of software-hardware includes a block of connection to the database (information resource) and includes a control GUI with the help of which carried the interaction between a user and a knowledge engineer to be able to work with LRI.

Subsystem Natural intellect fills content dictionaries LRI, provides control and validate the contents of an information resource in case of errors or inconsistencies performs editing.

Development of a methodology ontologize EC involves the use of sets of concepts, relations, functions, axioms and interpretation. The use of ontologies in the beginning of the relevant EC design ensures its quality factor validity.

The problem of finding, reporting, understanding and knowledge of computer processing is one of the most difficult problems in the light of the relevant tasks of artificial intelligence.

If a detailed analysis of the significant types of relations by which built the hierarchy of concepts (concepts) in the representation of knowledge, we can see that they are associated primarily with the ratio of the partial order. A relationship of this type constitute a distributive lattice, which has a number of useful properties, and these properties can be used to generate the corresponding consequences, that is, to find the (generation) of new knowledge.

Thus, with the integration of information technology ontologize useful logical-mathematical description of the ontology-managed systems.

Consider a fragment of such a description relating to the partial order.

Cartesian product of $A_1 \times A_2 \times ... \times A_n$ sets A_1, $A_1, A_2, ..., A_n$ is the set of sequences (i.e., a set of ordered n-tuples of elements) of the form $(a_1, a_2, ..., a_n)$, where $a_i \in A_i$, $1 \le i \le n$.

The elements of the Cartesian product is also called tuples. Arbitrary subset R of the set $A_1 \times A_2 \times ... \times A_n$ is called a relation defined or defined on the sets $A_1, A_2, ..., A_n$. If $A_1 = A_2 = ... = A_n = A$, then the Cartesian product of $A_1 \times A_2 \times ... \times A_n$ is called the Cartesian product of the n-th degree of the set A (A^n), and the ratio R, defined on the sets $A_1, A_2, ..., A_n$, – n-ary relation on the set A.

When $(a_1, a_2, ..., a_n) \in R$, we say that the elements $a_i \in (a_1, a_2, ..., a_n)$, (i = 1, 2,..., n) are against each other R, or the ratio R of a true for $a_1, a_2, ..., a_n$. If $(a_1, a_2, ..., a_n) \notin R$, it is considered that R is false for $a_1, a_2, ..., a_n$. For n = 1 the ratio is called unary if n = 2 – binary, for n = 3 – Ternary, etc.

As the relationship defined by $A_1, A_2, ..., A_n$ – subsets $A_1 \times A_2 \times ... \times A_n$, then they define operations of union, intersection, difference, and additions:

$$(a_1, a_2, ..., a_n) \in R \cup R_1 \Leftrightarrow (a_1, a_2, ..., a_n) \in R \text{ or } (a_1, a_2, ..., a_n) \in R_1,$$

$$(a_1, a_2, ..., a_n) \in R \cap R_1 \Leftrightarrow (a_1, a_2, ..., a_n) \in R \text{ and } (a_1, a_2, ..., a_n) \in R_1,$$

$$(a_1, a_2, ..., a_n) \in R \setminus R_1 \Leftrightarrow (a_1, a_2, ..., a_n) \in R, \ (a_1, a_2, ..., a_n) \notin R_1,$$

$$(a_1, a_2, ..., a_n) \in R' \text{ в } A_1 \times A_2 \times ... \times A_n \Leftrightarrow (a_1, a_2, ..., a_n) \notin R.$$

We introduce a nested relationship between the concepts of ontology.

Suppose there is a finite set of concepts Z:

$$Z = (Z_1, Z_2, ..., Z_k),$$

where: k – the number of concepts. We call ratio R_z between the concept and the concept $Z_i \subset Z, Z_j \subset Z$ ratio of nesting, if the concept of Z_j is lower in the hierarchy concept Z_i: $Z_i R_z Z_j$. For example, we construct the set $Z' = (Z_1, Z_2, ..., Z_8)$ (a subset of the concepts of the ontology database [14] – Figure 2), a plurality of pairs satisfying the relation R_z.

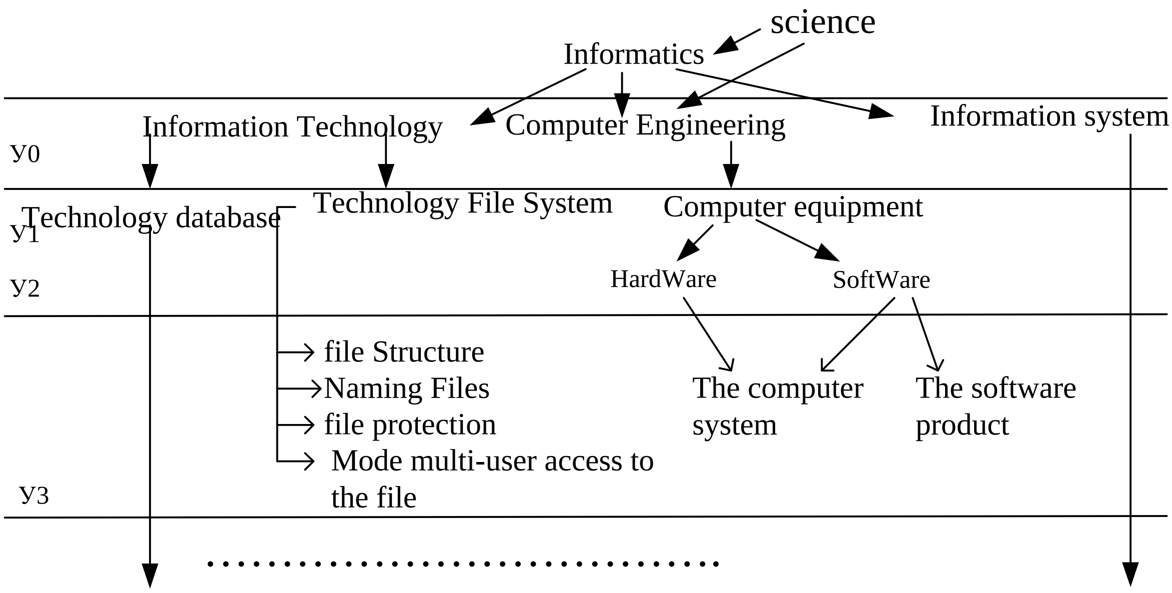

Fig. 2. Fragment of ontograf ontology "Databases"

here:

Z_1 – the concept of "Informatics",

Z_2 – the concept of "Information Technology",

Z_3 – the concept of "Computer Engineering",

Z_4 – concept "Information system",

Z_5 – concept "Technology database",

Z_6 – concept "Technology File System",

Z_7 – concept "Computer equipment",

Z_8 – concept "Hardware".

You can imagine the relationship to Z' in the form of a matrix description (Fig. 3).

	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8
Z_1	1	1	1	1	0	0	0	0
Z_2	0	1	0	0	1	1	0	0
Z_3	0	0	1	0	0	0	1	0
Z_4	0	0	0	1	0	0	0	0
Z_5	0	0	0	0	1	0	0	0
Z_6	0	0	0	0	0	1	0	0
Z_7	0	0	0	0	0	0	1	1
Z_8	0	0	0	0	0	0	0	1

Fig. 3. A binary relation R_z

By the finiteness of the set matrix relations R_z will have a precise meaning and allows algorithmic implementation relations. The matrix pair of concepts that satisfy the relation R_z, will be denoted by 1, and do not satisfy the relation – 0.

For the concept Z_1 the ratio $Z_1 R_z Z_1$ obviously, as for all other concepts $Z_1, Z_2, ..., Z_8$. That is, each concept in relation to itself satisfies the relation R_z: $Z_1 R_z Z_1$, $Z_2 R_z Z_2$,..., $Z_8 R_z Z_8$.

As can be seen from figure 3, unit depicting these pairs are diagonal matrices.

Concept Z_2 takes place in the hierarchy of the ontology concept after one, and it is the component, hence we have:

$Z_1 R_z Z_2$.

Similarly, reasoning, and considering the links between concepts, we can construct a binary relation nested R_z, and show that it has the following properties:

1. $\forall Z_i \in Z'$, i=1,…,8

$$Z_i R_z Z_i \quad (2)$$

that is, property of reflexivity.

2. $$Z_i R_z Z_k, Z_k R_z Z_j \Leftrightarrow Z_i R_z Z_j \quad (3)$$

that is, has the property of transitivity.

3. $Z_i\, R_z\, Z_j \bigcap Z_j\, R_z\, Z_i \Leftrightarrow Z_i = Z_j$ (4)
that is, property antisymmetry.

By definition, the relationship with the properties (2) - (4) is a partial order.

Take the concept (Fig. 2), which can be called a structured natural language definitions. The following are examples of such definitions, taken from an encyclopedic dictionary.

The definitions of the concept "SCIENCE".

$K(a) = \{p_1, p_2, p_3, p_4, p_5, p_6\}$ – The equivalence class (different definitions of the concept 'is one of the forms of social consciousness').

The definitions of the concept "Computer Engineering".

$K(c) = \{r_1, r_2, r_3\}$ – The equivalence class (different definitions of the concept "discipline, studying computers"…).

The definitions of the concept "informatics":

$$K(b) = \{q_1, q_2, q_3, q_4, q_5\}.$$

Introduced formalization defines a partial order as follows

$K(a) \le K(b) \Leftrightarrow (\exists p_i(a))(\exists q_j(b))(q_j(b) \le p_i(a))$, $(q_j(b) \le p_i(a))$ means $q_j(b)$ is as conjunctive terms in $p_i(a)$.

Permission thus a partial order naturally requires a predicate-object relational view of equivalence classes and within these classes (Fig. 4) [15].

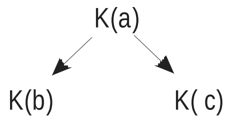

Fig. 4. Partial order K(a), K(b), K(c)

CONCLUSION

1. The paper discusses the model of knowledge representation, including now the most common models in the computer processing of knowledge ontology.

2. The model of knowledge processing for use in the EC proposed to present knowledge in the form of computer ontologies. The use of ontologies in the beginning of the relevant EC design ensures its quality factor validity. Examined the relationship between the concepts of ontology nesting SA and show that it is a partial order.

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ВОПРОСЫ ИНТЕГРАЦИИ ИНФОРМАЦИОННЫХ ОНТОЛОГИЗИРОВАННЫХ ТЕХНОЛОГИЙ В МОДЕЛИ ОБРАБОТКИ ЗНАНИЙ

Геннадий Могильный, Виталий Семенков, Юрий Тихонов

Аннотация. В статье рассматриваются модели представления знаний, в т.ч. наиболее распространенные сейчас в моделях обработки знаний компьютерные онтологии. Компьютерные онтологии находят применение в медицине, биологии, диагностике, e-learning. В онтологизированной модели электронного курса (ЭК) используется онтология предметной области (ПдО), соответствующая предметной дисциплине (ПдД) ЭК. Онтология ПдО является результатом использования оригинального Инструментального комплекса онтологического назначения. На примере e-learning показано специфическое логико-математическое обеспечение для приложений онтологизированных технологий. Рассмотрено отношения вложенности между концептами онтологии ПдО и показано, что оно является отношением частичного порядка.

Ключевые слова: модели знаний, компьютерная онтология, предметная область, информационная технология, предметная дисциплина, электронный курс.