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Semantyczna ontologia modelu zawartości modułu kursu "inteligentne technologie zarządzania podejmowaniem decyzji"

Problemy Profesjologii nr 1, 131-139

2014

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SEMANTIC ONTOLOGY MODEL OF THE CONTENT MODULE OF THE COURSE „INTELLIGENT TECHNOLOGIES OF DECISION-MAKING MANAGEMENT"

Abstract

This article analyzes the model of representation of knowledge in the form of ontology to describe a subject. Three types of the objects have been considered – domain-oriented, task-oriented and top-level. The necessity of building a common ontology which contains just the following three types of ontologies has been substantiated. A model of knowledge representation is defined as the set of syntactic and semantic consistency, which makes it possible to describe the object. For modeling a semantic model of ontology we turned to simulation. In the process of creating semantic networks in the package MATLAB we used the library SNToolbox with consistent implementation of the following steps: construction of a semantic network, visualization, and search the semantic network. In solving the problems of forecasting the curriculum, the following knowledge is highlighted – the terms of the subject domain, the relationships between the terms, property of the terms, synonyms, ways of representing and ways of expressing terms. Using the three-component model „Concept", „Action", „Property", we have constructed a semantic network of the semantic ontology of the module course „Fuzzy sets" of the subject „Intelligent Technologies of Decision-Making Management". The formal approach to the model of the ontology of the content module described above allows structuring and generalizing the knowledge of the branch of artificial intelligence technologies which is represented by the fuzzy sets theory.

SEMANTYCZNA ONTOLOGIA MODELU ZAWARTOŚCI MODUŁU KURSU „INTELIGENTNE TECHNOLOGIE ZARZĄDZANIA PODEJMOWANIEM DECYZJI"

Streszczenie

Ten artykuł analizuje model reprezentacji wiedzy w postaci ontologii do opisu przedmiotu. Trzy typy obiektów są rozpatrywane: zorientowanych dziedzinowo, zadaniowo i najwyższego poziomu. Konieczność budowania wspólnej ontologii, która zawiera właśnie wymienione trzy typy ontologii została potwierdzona. Model reprezentacji wiedzy jest zdefiniowany jako zbiór składniowej i semantycznej konsystencji, co umożliwia opisanie obiektu. Do modelowania semantycznego modelu ontologii wykorzystana została symulacja. W procesie tworzenia sieci semantycznych w pakiecie MATLAB wykorzystaliśmy bibliotekę SNToolbox z konsekwentną realizacją następujących etapów: budowy sieci semantycznej, wizualizacji i wyszukiwania w sieci semantycznej. W rozwiązywaniu problemów związanych z prognozowaniem programu, pokreślana jest następująca wiedza – warunki tematycznej domeny, relacje między warunkami,

[1] **УДК: 378.016: 004.89**

nieruchomości z warunkami, synonimy, sposoby reprezentowania i sposoby wyrażania warunków. Wykorzystując trój-komponentowy model „Concept", „Action", „Property", skonstruowaliśmy semantyczną sieć semantycznej ontologii modelu kursu „zbirów rozmytych" przedmiotu „Inteligentne technologie zarządzania podejmowaniem decyzji". Formalne podejście do modelu ontologii opisu zawartości modelu pozwala konstruować i uogólniać wiedzę o branży technologii sztucznej inteligencji, która jest reprezentowana przez teorię zbiorów rozmytych.

Problem statement and its connection with an important scientific and practical tasks. Nowadays, there has arisen a problem of using methods and techniques of artificial intelligence (AI) to create knowledge bases for structuring the concepts directly in the field of AI, which is caused by the rapid development of its methods and techniques. Intelligent technologies of decision making management which are represented by fuzzy set theory, neural networks and genetic algorithms are no exception. It is well known that at an early stage of the field of knowledge, science is the first to appear with its theoretical and practical bases followed by educational subjects (due to the need of transferring the knowledge) that describe one or more aspects of the science. The task of determining the content of the training course is solved in the process of structuring the knowledge of the course; using the terms of knowledge engineering, it is modeling the subject domain [1, p. 79].

A clear and reasoned standard is required for large-scale introduction of any technology or technique. Ontologies have become such a standard in the field of development of knowledge bases [2, p. 206]. Ontology is a comprehensive and detailed attempt to formalize some field of knowledge with the help of a conceptual scheme. Such a scheme usually consists of a hierarchical data structure containing all the relevant classes of objects, their relationships, theorems and restrictions adopted in a particular subject specialization (SS). An important advantage of ontology as a method of knowledge representation is that it is equally easy to be perceived by a human being (for example, in the form of a graph) and machine as well. Human beings' or software agents' shared use of overall understanding of the structure of information is one of the most common objectives of ontology development [3, p. 45].

Why is there a need to develop ontologies? Here are some of the reasons:

• for human beings' or software agents' shared use of overall understanding of the structure of information;

• to be able to re-use knowledge in a SS;

• to make explicit assumptions in a SS;

• to be able to differentiate between knowledge of a SS and operational knowledge;

• to analyze the knowledge of a SS.

An ontology defines a common vocabulary for users that share information about some SS. In our case it is a SS which studies intelligent technologies of decision-making management, namely, the content module „Fuzzy Systems" the basic concept of which are fuzzy sets.

A theoretical analysis of the literature shows that there is no common approach to the use of ontologies in training activities. The use of ontologies as a means of integrating knowledge about information system has been considered by Yu. Rogushyna, T. R. Gruber et al. O. Yevseyeva, V. Lubchenco et al. have studied simulation of a training subject domain. The use of ontologies in the field of AI has been studied by L. Naikhanova, A. Narinyani, A. Smirnov, S. Subbotin et al. Despite of the diversity of initial positions, all the authors emphasize the importance of the use of ontologies in learning process.

The aim of the article is to build a semantic model of semantic ontology module „Fuzzy Systems" of the training course „Intelligent Technologies of Decision-Making Management".

Material statement. From the perspective which is closer to the concepts related to artificial intelligence ontology is the knowledge which is formally represented on the basis of conceptualization. Conceptualization is a description of the set of objects and concepts, the knowledge about them and the links between them. Explicit specification of conceptualization is called ontology [4, p. 226]. Formally, an ontology consists of terms (concepts, concepts), organized in a taxonomy, their definitions and attributes, as well as related axioms and rules of inference.

In the field of artificial intelligence there is a definition introduced by A. Narinyani [5, p. 309] – ontology is a set of concepts from most general to the specific ones which provide a full range of objects and relations, events and processes, as well as values (attributes and relations) which are defined if needed, in time and space. This system of concepts is joined by both universal dependencies of „general – partial", „a part – the whole", „cause – effect", etc., and specific ones depending on the model of SS.

Ontology is a model of SS which uses all available means of knowledge relevant to SS.

There are three types of ontologies: domain-oriented, task-oriented and top-level.

Ontology of SS contains taxonomy of concepts, additional relationships, instances of classes and different types of constraints (axioms). Axioms set semantic constraints for relations system.

The purpose of the task-oriented ontology is to make knowledge available for re-use. This type of ontologies determines the level of knowledge used during an inference [6].

Top-level ontology describes the categories, i.e. top-level concepts. Examples include physical, functional, behavioral concepts and relations that belong to the general concepts and relations [7, p. 5].

Recently it has become a trend to build a general ontology which contains the following three types of ontologies at the same time. Hierarchically it looks as follows – as a rule, top-level ontology is on the top level of the hierarchy and the ontologies of SS and task-oriented ontologies are connected to it. This approach allows us to holistically address all the problems within a SS. We will stick to this approach and using the term „ontology" we assume that it contains a top-level ontology, ontology of SS and task-oriented ontology.

A set of axioms (constraints) that makes up an ontology often has a form of first-order logic theory where vocabulary terms are names of unary and binary predicates, respectively called concepts and relations. In the simplest case, an ontology only describes a hierarchy of concepts bound by ratios of inheritance and aggregation. In more complex cases, it is supplied with the appropriate axioms to express other relationships between concepts and to limit their interpretation. Taking the above into consideration, ontology is a knowledge base that describes the facts which are thought to be always true within a community based on generally accepted values of the given dictionary [8, p. 26].

So far, the most common definition of ontology has been the one by T. R. Gruber [9, p. 911], according to which an ontology is an exact specification of conceptualization . From this point of view, for each of the databases or knowledge bases, and systems based on knowledge, certain specifications based on some conceptualization should be constructed. According to [10] formal ontology is defined as

O = <C, A, S, E, Pr, Q>, where

C is a sign of conceptual object „concept";

A is a sign of conceptual object „action";

S is a sign of conceptual object „Status";

E is a sign of conceptual object „Event";

Pr is a sign of conceptual object „Property";

Q is a sign of conceptual object „Values".

When solving the problems of forecasting curriculum one usually needs the following knowledge: the terms of the subject domain, the relationship between the terms, definitions, properties of terms, synonyms, methods of representation and ways of expressing terms. Therefore, we will use the three-component model of ontology: O = <C, A, Pr>.

A model of knowledge representation is defined as „a set of syntactic and semantic consistency, which makes it possible to describe the subject". The „subject" here refers to the state of SS, that is the objects of this field, their properties, relationships that exist between the objects in a fixed moment of time.

Ontology is represented in the form of a semantic network of frame signs. It should be mentioned that three kinds of protoframes are used in the thesis: concept, action and properties.

A semantic network describes knowledge as network structures. The vertices of the network are the concepts, facts, objects, events, etc., and arcs are the relationships which connect the peaks. Semantic networks are often viewed as a general formalism for knowledge representation. A special case of such networks are scenarios in which causal relationships or relationships of „the goal – a means" are used.

The peaks of the network are connected with an arc if the corresponding domain objects are found to be in any dependency. The most common are the following types of relationships: to be part of a class (to be), to have, to be the consequence of, to matter.

As in the system based on frames, in a semantic network there can be family relationships that allow you to implement inheritance of properties from parent objects. This leads to the fact that semantic networks get all the disadvantages and benefits of the representation of knowledge in the form of frames. The advantages lie in the simplicity and clarity of the description of the subject domain. However, the latter property is lost when a semantic network gets more complicated and, what is more there is a significant increase in the time needed for the output. Another disadvantage of semantic networks is the complexity of handling all sorts of exceptions [11, p. 17].

If we want to make a semantic model of the ontology of the module „Fuzzy Systems" of the learning course „Intelligent Technologies of Decision-Making Management", we should turn to simulation modeling. Simulation modeling is the process of designing a model of a real system and implementation of experiments with the help of this model in order to understand the behavior of the system or estimate (with restrictions imposed by some criterion or a set of criteria) various strategies for the operation of this system [11, p. 38].

In general, the milestones of simulation modeling are as follows [11, p. 39]:

1. Definition of the system – setting boundaries, restraints and parameters that allow to evaluate the effectiveness of the system.

2. Designing of the model – a transition from the real system to a logical scheme (abstracting).

3. Data preparation – selection of the data required to build a model if appropriate form is submitted.

4. Broadcasting of the model – description of the model with the help of a language that can be used in a PC.

5. Assessment of adequacy – review of steps 1-4 to reach the required level of consistency between the model and the system.

6. Strategic planning – planning of the experiment which should give the required information.

7. Tactical planning – determining a way of doing each series of tests that are provided in the plan of the experiment.

8. Experimentation – the process of simulation in order to obtain the desired data.

9. Interpretation – construction of conclusions based on the data obtained through simulation.

10. Implementation – the practical use of models and simulation results.

11. Documentation – registration of the implementation of the project and its results, as well as the description of the process of creation and use of the model.

As a rule, simulation is carried out using a PC. In the case of deterministic processes where transitions from one state to another are unambiguous, the simulation is carried out with the help of simulating algorithms. In the case of the presence of random factors in the system, the simulation is performed in a certain number of implementations. To succeed in achieving our aims, we will make use of the library SNToolbox of MATLAB system, suggested by S. Subbotin in [12], which is intended for building semantic networks.

In our case, the process of creating and using semantic networks in the MATLAB package while using the SNToolbox libraries lies in a consecutive performance the following steps:

Step 1. Building a semantic network.

1.1. Outline of the semantic network and entering it into the variable of the environment of the MATLAB package.

1.2. Adding nodes to the structure of the semantic network.

1.3. Adding relations to the structure of the semantic network.

1.4. (Optional) Saving a semantic network with a variable of the environment of MATLAB to a file on disk.

Step 2. Visualization of the Semantic Network.

2.1. Download the semantic network from the disk to the variable of MATLAB environment if it is missing in it.

2.2. Bring on the function of semantic network visualization.

2.3. (Optional) Save the file with the scheme of the semantic network to the disk (or print it). This step can be performed both with the help of a software program – using relevant features of the MATLAB package, and by means of a graphical user interface using a figure menu commands, which depicts a scheme of the semantic network.

Step 3. Search the Semantic Network.

3.1. For the Semantic Network, (i.e. a knowledge base) a semantic request network in a separate variable of the MATLAB environment is to be formed. To do this, sub-steps 1.1-1.4 must be performed for the request network, or the knowledge data network must be copied to the request network variable and unnecessary nodes and links must be removed while adding a new purpose node with relevant links.

3.2. Bring on the search function which will retrieve the search results.

Uploaded library is to be unpacked into the application folder MATLAB 'C: \ Program Files \ MATLAB \ R2011a'. Open the MATLAB environment. Connect an additional library. To do this, enter into the command line : >> addpath 'C: \ ProgramFiles \ MATLAB \ R2011a \ SNToolbox'. The next step is to create a new m-file. Save the file with setting the name and location of the document. Next, build a semantic network in a MATLAB package window by introducing the program listing in the m-file (see [13] for the basic principle of listing writing). By means of MATLAB, the source code in the m-file window is separated in different colors depending on its syntax purpose: functions, attributes, or comments. As a result of the execution of the code, a graphic representation of the semantic model scheme of ontology is drawn with the hierarchical arrangement of nodes (see Figure 1), a circular arrangement of nodes (see Figure 2) and the request network (see Figure 3).

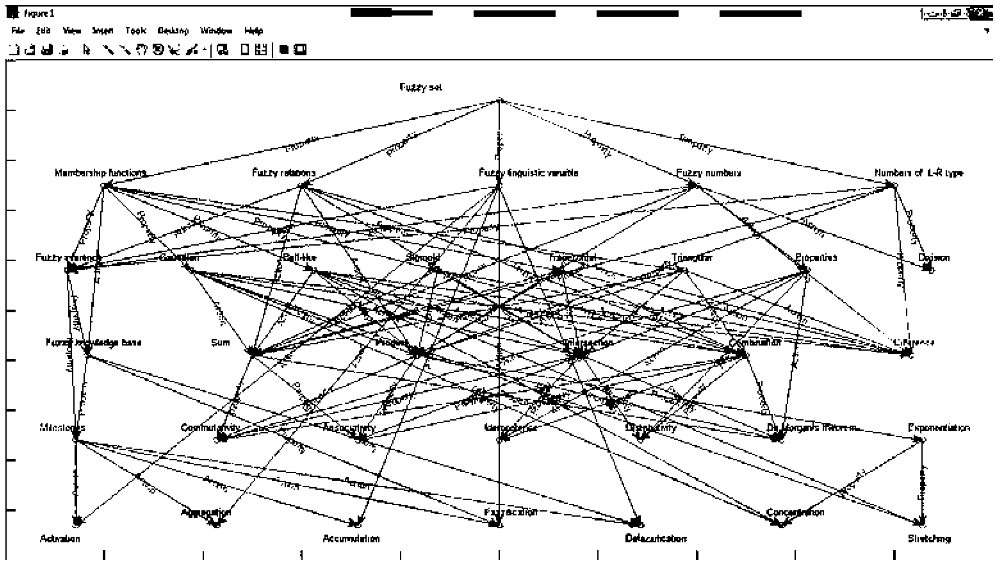

Figure 1. Hierarchical arrangement of nodes

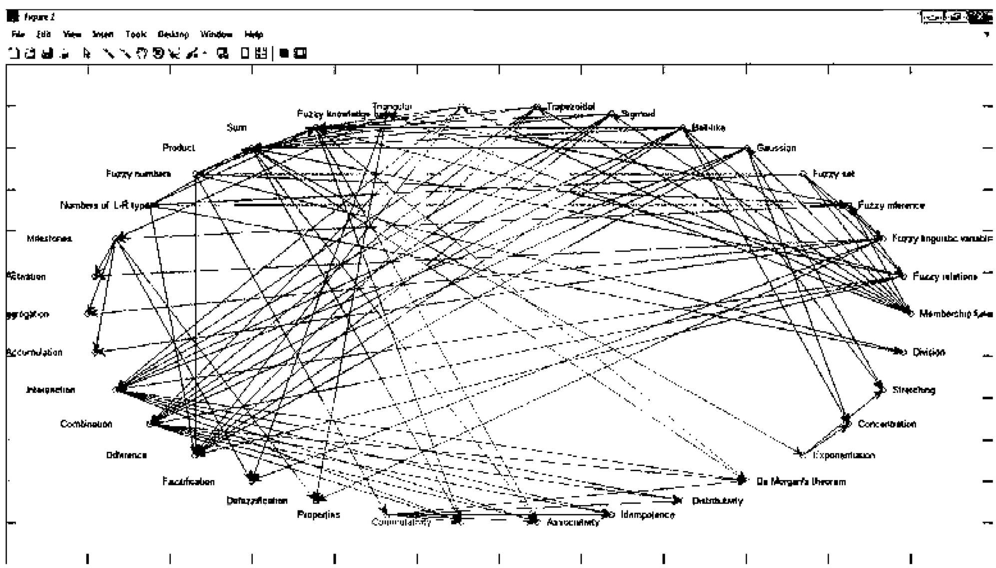

Figure 2. Circular arrangement of nodes

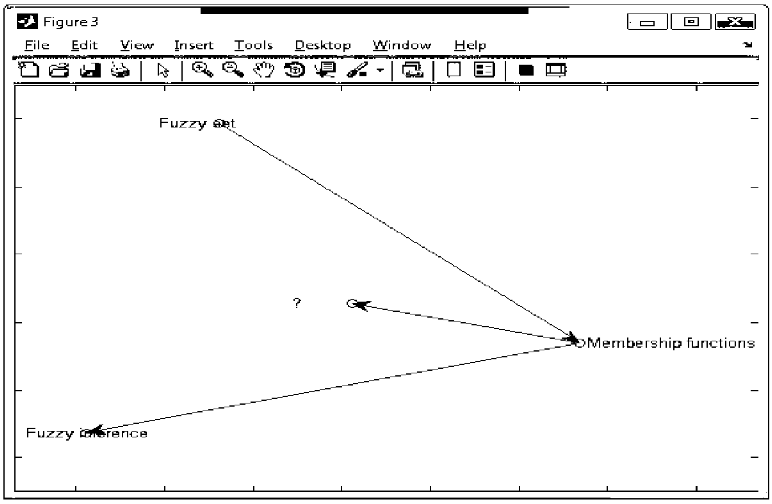

Figure. 3. Request network

An analysis of knowledge in a SS is possible only when there is a declarative specification of terms. A formal analysis of terms is extremely valuable both for trying to re-use the existing ontologies, and in the case of their expansion [14, c. 9]. The knowledge described in the ontology can be used in other applications, databases and more. In addition, the efficiency of both the intelligent systems and traditional information systems is significantly increased, which in turn substantiates the relevance of creating ontologies.

Conclusions. The formal approach to the model of ontology of the content module allows to structure and generalize the knowledge of a SS. The user of the system may disagree with its recommendations and make his/her own decision on the basis of additional new knowledge which has not yet gotten into the model. Other people can also use the developed model of ontology in their SSs. In addition, to create a large ontology some elements of the developed one as it describes a part of a large SS. Moreover, the present model of ontology will make it possible to organize effective procedures for processing the information received as a result of testing with the help of automated systems of knowledge control.

See prospects for further research in building models of ontology semantic modules for the study of neural networks and genetic algorithms, which will allow to describe large reductions – intelligent technologies of decision-making management.

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