DESIGN OF INTELLECTUAL DIALOGUE LEARNING SYSTEM BASED ON ONTOLOGY

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Abstract

The study considers the current actual problems related to the individuality, difficulties and perspectives of design of intellectual dialogue learning system based on ontology. The study formalizes architecture of educational server and formal model of ontology. Special attention is given to the steps of creating ontology for the design of intellectual interactive learning system. This study considers the details of integration and merging stage of the existing ontologies, in which the author proposes to use a special algorithm. The article also provides an overview of different programming languages, which can be used to describe the ontological knowledge bases. Via using object-oriented programming, the author proposes a procedure for the creation of architecture ontological intelligent interactive learning system.

Keywords: *ontology, artificial intelligent, architecture, declarative description.*

Introduction

At present, in all areas of education there are tries to find ways to improve the efficiency and quality of education. As known, a technical equipment and computerization are characterized as being basic features of modern education process. As a result, the traditional approach to learning has descended significantly. Modern automated learning systems are means for providing information, the assimilation of knowledge and skills, testing, help, on the level of the program and the subject equally [1]. The systems are adapted to the student's knowledge level, speed, subjects sequence, etc. They collect and process statistical information about each student, group and flows; they also accumulate error information of the system, as well as of the students.

Problem definition

The key problem which appeared is the process of designing those systems and at the same time it is seen as one of the main unsolved problems in computer science and artificial intelligence. This problem can be concluded in providing knowledge about the subject area and as a consequence in establishing a dialogue with the information system on a natural language. The importance of the designing of e-learning systems is on continuance growing. Only the intellectual learning systems can partially replace the traditional attendance of the teacher. By this way, when the person is in contact with the information system, he sends queries to intellectual learning systems using the natural language and receives replies in the same language [2].

To overcome the above mentioned problems in the field of software engineering, different types of declarative descriptions become wide spread [3].

Methodology of solving problem

One kind of declarative programming is ontological, based on the usage of ontologies, which confirms the actuality of the chosen research topic and its practical and theoretical significance.

Considering the discussion above, the purpose of the study is to analyze the design stages of intellectual dialogue learning system (IDLS) based on ontologies.

Ontology (in artificial intelligence) is an attempt to understand comprehensive and detailed formalization of a field of knowledge with the help of a conceptual scheme. Typically, the scheme consists of a data structure containing all the relevant object classes, their relationships and rules (i.e. theorems, limitations) adopted in this field [4].

There are a plenty of recommendations, advices and guidance on the creation of ontologies, but at the moment there is no general algorithm creating ontologies.

In fact, these platforms reflect the relationship of the teacher and listener with educational servers using pedagogical agents. Intellectual pedagogical agents provide the infrastructure for the flow of knowledge and information between clients and servers [4].

Pedagogical agents access the educational content on the server using high-level educational services (Fig. 1), and the server has sufficient intelligence for replenishment (i.e. personalization) learning tasks, which the server supports.

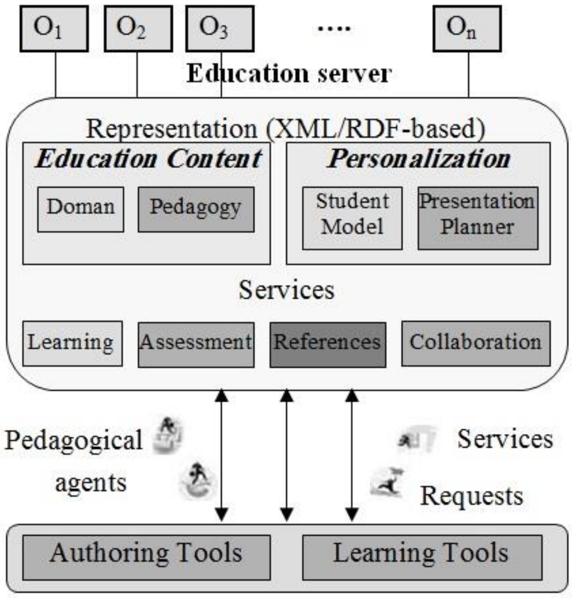

Fig. 1 - Architecture of the educational server
(**O**$_i$ - ontology)

In the student's point of view, the server is an intellectual tutor with subject and pedagogical knowledge to enable the student to carry out a training session. It uses presentation planner for the selecting, training and adapting materials subject for the student. It also gradually builds a model of the student during the session, in order to (a) keep the student's history of actions and educational progress, (b) identify and correct his mistakes and misunderstandings, and (c) may thus readdress (redirect) session.

On this basis, to enable the model to well work, first, it is required to develop a suitable subject and pedagogical ontology. In the ideal case, the creation of educational web-content with ontological annotation should be supported authoring tools and classes ontological hierarchy. Moreover, the ontology should be linked with an archive of intervals, and linked to the possibility of the repeated use or the modifying of intervals.

It is obvious that the ontology should be designed and developed to adapt the tasks of intellectual dialogue learning system. Efficiency is determined by adaptation laid down in the structure and function of the knowledge base by mechanisms setting of ontology in the process of software system, that is, with the self-study. [5] The concept of ontology implies the definition and use relationships and mutually agreed set of three components:

(i) taxonomy of terms;
(ii) definitions of terms;
(iii) rules for their processing.

To understand ordered triad in the formal model of ontology O_i, it can be shown as follows:

$$\mathbf{O_i = (C, R, F)}$$

Where, C - a finite set of concepts (concepts, terms) field of subject, of the given ontology O_i;

R - Finite set of relationships between concepts (concepts, terms) of a given domain;

F - Finite set of functions of interpreting (axiomatization, restrictions) defined on the concepts and relations of the ontology.

Now consider the more detailed steps involved in designing ontology for designing IDLS.

(1) Defining the scope and scale of the ontology. To do this, we must answer the following key questions:

- What subject area will cover ontology?

- Which ontology will be used for?

- What types of questions can be answered by information in ontology?

Ontological knowledge representation about the courses that are part of the IDLS, can be used to integrate information resources of one area of knowledge into a single information space (see. Fig.2).

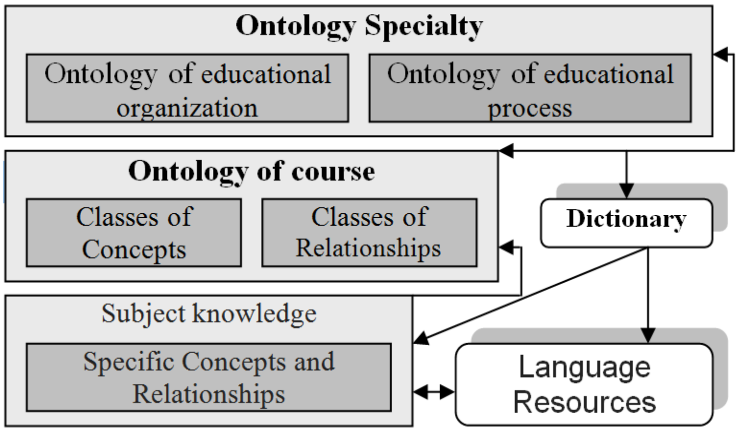

Fig. 2 - Ontological knowledge representation in IDLS

As shown by Fig. 2, the subject area of IDLS represents the whole terminology used for the organization of the training course: theme, lectures, practice, laboratory work, test questions, examples, and all the smaller components of each of the objects.

(2) Considering options for re-using the existing ontologies. Plenty of ontologies are already available in electronic form and can be imported into used environment of an ontology design. At this stage, the developer can face a problem of integration and merging of existing ontologies.

The task of merging of ontologies is formulated as follows: given two correct ontologies, it is necessary to establish a third correct ontology, which is the concept of the input ontologies and the additional restrictions and relationships, if they are needed. Researchers of different scopes of computer science work on automatic or instrumentally supported merger of ontologies, but these researches and studies are still the early stages and require further development.

Let us consider in more details the work combining subsystems of ontology. Ontology is considered as graph classes. Each concept is the apex, and the relationships class - subclass is the arcs. A class without a based class is the peak of the graph. It enables multiple inheritances.

Considering the ontologies, they represent unique graph concepts with a single primitive peak. Graph has no links to external ontologies.

To join the ontologies, author suggests the following algorithm which consists of these actions:

1) Aligning ontologies orders.

2) Permitting the conflict of names.

3)Combining classes, their properties and relationships.

The sequence of the ontologies refers to the number of levels of graph hierarchy. The suggested algorithm can work with executing two requirements that lay to merging ontologies:

- The number of hierarchy levels should be the same [6];

- There should be no repeated names of concepts in the ontologies at different levels of the hierarchy, that is, there should be no naming conflict.

In the algorithm, one of merged ontologies is considered basic, while the other one is complementary. The algorithm will work more effectively if the basic ontology is larger than the complementary one. The probability of combined ontologies that have different hierarchical structure is large enough. To work correctly, the proposed algorithm is necessary to align ontologies orders. Alignment is implemented by adding fictitious hierarchical levels to the hierarchical structure. The names of concepts on fictitious hierarchical levels are not considered when the algorithm is working.

Realization of the proposed algorithm supposes the following steps:

Step 1: forming a list of converging names of concepts of ontologies, which they are in different levels of hierarchy.

Step 2: forming a list of converging names of concepts of ontologies, which they are at the same levels of hierarchy.

Step 3: forming a list of names concepts of ontology, for which no synonymic concepts in the basic ontology at the same levels of hierarchy.

The list obtained in the first step which is prior to combining ontologies, should be considered by an expert in order to resolve existing conflict of names. That is, a conflict of names should be eliminated to the algorithm of step 2 and 3. In step 2, synonymic concepts of ontology are analyzed by module of *verification of compliance*. In step 3, divergent concepts are processed by the module of *analysis of elements* that they are different.

(3) Selection of knowledge representation technology. This includes:

a) Hierarchical model (frames, semantic networks, databases, OOP);
b) Knowledge representation in the form of hierarchy of structured objects, which are interconnected by relationships;
c) First order logic (FOL) is a formal theory which allows statements about variables, fixed functions and predicates;
d) Descriptive logic is formed by combining the semantic networks and FOL. Descriptive logic combines the ability to represent knowledge as a hierarchy of concepts on the one hand, and the possibility of machining knowledge on the other hand.

(4) Selecting language for the description of ontological knowledge bases such as:

a) Resource Description Framework (RDF) is a simple way to describe instances of the data in the format of the subject-object relationship, in which any member of the trio is used only by resources identifiers.
b) Semantic-extension of RDF. This language provides mechanisms for describing groups of related resources and the relationships between these resources.
c) Ontology Web Language (OWL) is designed for use in the software, which must process the content of the information, not only to present the information.
d) OIL is language designed specifically for ontology with formal semantics and output means, submitted by descriptive logic. OWL provides full processing information and it is best suited for creating ontologies of IDLS.

(5) Selection of software tools for developing ontology. Table 1 provides a brief description of the software tools and a list of supported languages.

Name	Short description	Language
Protégé	Create, view ontology. Free for use.	RDF/RDF, OIL, OWL
OntoEdit	Development and maintenance of ontologies.	RDFS, OIL
OilEd	The development of ontologies, support the logical output.	OIL

Table 1 - Comparison of Ontology Editors

(6) Definition of all important terms. It is necessary to identify all the important concepts in an academic discipline. The set of terms is individual to each academic discipline in universities, because in most cases the same concept in different areas of knowledge is defined differently.

(7) Determination of classes and hierarchy classes. This stage is crucial and the most difficult to develop ontology. It is necessary to choose the method of dividing it into classes (i.e. top-down, bottom-up, combined) and for disciplines the more suitable method is top-down. Initially we define the general concepts, then they are concretized, but the final choice depends on the ontology developer. It is also necessary to determine the list of relationships between

concepts. For disciplines, the best suited main types of relationships are: is-a, has-a, a-kind-of and have-value.

(8) Defining the properties of classes. Each property can be set to a specific value or method (e.g. formula implemented with the associated procedures) calculating the value of this property.

(9) A formal interpretation of the axioms. The axioms give rules for the use of terms in the context of other terms. Axioms can also describe the new intervals by using the already defined simple terms of the current ontology.

(10) Creating instances. Defining instances begins with a definition of the desired depth of detail in their presentation. The depth of detail depends on the purpose of creating ontology, in which this should be made by the future IDLS.

(11) Refinement and Verification of established ontology. Any ontology is created by permanent additions to the established model. To check the ontology is necessary to prepare a number of questions that must be answered to create ontology, and using the model created to construct an answer to them.

Now, after the creation of ontology, we focus on designing of IDLS.

First, we need to design a tool for creating and sending inquiries to the ontology by the user. Designing and developing of such tool is quite nontrivial task. Therefore, we should use the standard protocol of queries SPARQL to ontologies, which is standardized by the consortium W3C. The main element of the SPARQL query protocol template is a triple pattern. Triple template is a triple in the RDF model in which in the places of predicate (subject, object) there are constants or variables.

Researches show that in such these systems SPARQL [select and describe-queries] are often used whereas ask-questions are less frequently used.

Results and Discussion

The main job of searching answers to queries is performed by OUTPUT machine (SPARQL reasoner). Development of output machine is fairly complex task, so it is easier to use existing output machine.

To implement the IDLS, we offer a choice of Jena library. Selecting this library determines the choice of programming language for the implementation of IDLS. Thus, the system design must be implemented in terms of the OOP Java language.

In designing the system, as it is advisable to take the concept of basis information system architecture based on the ontology described in Patent Document fundamental [7].

Thus, as a result of this study, method of constructing ontologies of IDLS was developed. Using OOP proposed procedure for the establishment of the ontological architecture educational system, which it aims to provide flexibility and to further the transition from IDLS that works with a single ontology, to framework for developing classes of systems.

Conclusion

This study described the algorithm of intellectual dialogue learning system based on ontology-development methodology for declarative frame-based systems. The study listed the steps in the ontology-development process and addressed the complex issues of defining class hierarchies and properties of classes and instances. It has been also mentioned the steps of developing the architecture of the educational server based on ontology. We finally, developed a suitable subject and pedagogical ontology by creation of educational web-content with ontological annotation, authoring tools and classes ontological hierarchy.

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تصميم نظام التعلم التفاعلي الذكي يستند إلى الأنطولوجيا

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الملخص

تتناول هذه الدراسة المشاكل الفعلية المرتبطة بالخصوصية، التحديات والآفاق الخاصة بالنظم التفاعلية الذكية على أساس انطولوجيا (هندسة البرمجيات)، في هذا البحث يتم تصميم هيكل رسمي للخادم التعليمي، وتصميم نموذج رسمي للأنطولوجيا. ويولى اهتمام خاص إلى خطوات تهيئة الأنطولوجيا لتصميم نظام التعلم التفاعلي الذكي. يتم عرض تفاصيل تكامل ودمج الانطولوجيا الموجودة، وذلك باستخدام خوارزمية خاصة بها. كذلك تعطي الدراسة لمحة عامة عن مختلف لغات البرمجة التي يمكن استخدامها لوصف قواعد المعرفة الانطولوجية. باستخدام البرمجة الكائنية الموجهة، يقترح المؤلف في هذه الدراسة إنشاء بنية هيكلية لنظام التعلم التفاعلي الانطولوجي.

الكلمات المفتاحية: انطولوجيا، الذكاء الاصطناعي، المعمارية، الوصف التصريحي.