Applying of Ontological Technology of Semantic Search in E-learning

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***Abstract*—The AI in education has become the most challenging area in the last several years. Knowledge management in the lot of the modern Web-oriented applications of AI is based on ontologies. In this paper, we focus on ontological model of retrieval interaction of users and informational resources. Represent model can be used in various intelligent application.**

***Keywords*—Artificial Intelligence, ontology, Semantic Web, semantic search, competence management.**

I. Introduction

Artificial intelligence (AI) in computer science is an ideal "intelligent" machine wich is a flexible rational agent that perceives its environment and takes actions that maximize its chance of success at some goal. The goal of the AI field's is to deliver knowledge-based systems, which can be used in real teaching, learning and training situations. The main AI technologies include: general problem-solving, expert systems, natural language processing, vision, robotics, and games.

Researchers have been used AI field of research in education to develop a new generation of intelligent tutoring and learning systems [1, 2]. The main two components in developing an efficient and robust intelligent tutoring and learning systems in any domain are the "knowledge base" and the "inference engine". Concerning the knowledge base there are many knowledge representation and management techniques, e.g.; lists, trees, semantic networks, frames, scripts, production rules, cases, and ontologies. The key to the success of such systems is the selection of the appropriate technique that best fits the domain knowledge and the problem to be solved. That choice is depends on the experience of the knowledge engineer. Regarding the inference engine, there are many methodologies and approaches of reasoning e.g.; automated reasoning, case-based reasoning, commonsense reasoning, fuzzy reasoning, geometric reasoning, non-monotonic reasoning, model-based reasoning, probabilistic reasoning, causal reasoning, qualitative reasoning, spatial reasoning and temporal reasoning [3]. In fact these methodologies receive increasing attention within the AI in education community [4-6].

II. Ontological engineering in e-learning from the artificial intelligence perspective

A. Ontological Engineering in e-Learning

During the last decade, increasing attention has been focused on ontologies [7]. At present, there are applications of ontologies with commercial, industrial, medical, academicals and research focuses [8-11].

The main objective of using ontologies is to share knowledge between computers or computers and human. Computers are capable to transmit and present the information stored in files with different formats, but they are not yet compatible to interpret them. To facilitate communication and intelligent processing of information, it is necessary that all actors of the digital space (computers and humans) have the same vocabulary. Ontologies are the foundation of cooperation and the semantical understanding between computers (running a lot of nonhomogeneous software programs) and of the cooperation between computers and humans.

Most of the usages of ontologies in the field of computer science are related to knowledge based systems and intelligent systems. These types of ontologies include a small number of concepts and their main objective is to facilitate reasoning.

B. Artificial Intelligence Perspective

Ontologies' usage in educational systems may be approached from various points of view: as a common vocabulary for multi-agent system, as a chain between heterogeneous educational systems, ontologies for pedagogical resources sharing or for sharing data and ontologies used to mediate the search of the learning materials on the internet[12].

The The abstract specification of a system is composed of functional interconnected elements. These elements communicate using an interface and a common vocabulary. The online instructional process can be implemented successfully using artificial Intelligence techniques. Sophistically software programs with the following features give the intelligence of the machine: adaptability, flexibility. Learning capacity, reactive capacity, autonomy, collaboration and understanding capacity. This approach enables to solve the complexity and the incertitude of the instructional systems. An intelligent learning system based on a multi-agent approach consists in a set of intelligent agents, which have to communicate. They collaborate through messages. Software agents can understand and interpret the messages due to a common ontology or the interoperability of the private ontologies.

III. Artificial Intelligence in Education and Learning

Conferences on "Artificial Intelligence in Education "which held during the period 1993 – 2007, figure 1 shows the main areas of the AI in education [4].From this figure it can be seen that the research in the field of AI-EDU consists of seven main areas, namely: Intelligent Educational Systems (IES), Teaching Aspects, Learning Aspects, Cognitive Science, Knowledge Structure, Intelligent Tools, Shells and Interfaces. The main systems of the IES are Intelligent Tutoring Systems (ITS), Educational Robotics and Multimedia Systems.

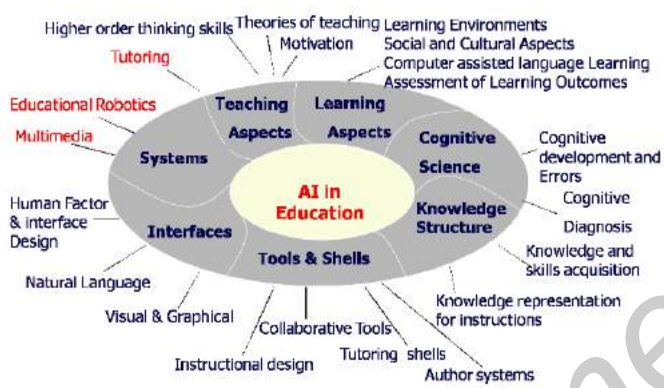

Figure 1. The main areas of artificial intelligence in education

In what follows, a brief a account of the AI-based areas of research, namely:

1) intelligent tutoring systems;
2) intelligent e-learning systems;
3) intelligent authoring shells and tools [13,14].

Intelligent Tutoring Systems (ITSs). ITS is a knowledge based software that act as an intelligent tutor used in real teaching. ITS is also used in learning, and training situations. From the technical point of view, ITS is composed of the following software components:

1) expert model;
2) student mode;
3) instructional module;
4) interface;
5) knowledge acquisition module.

ITS components are complex to build and complex to maintain. For more technical information, see [1]. The main features and characteristics of the ITS are:

- Adjust its tutorial to the student's knowledge, experience, strengths, and weaknesses.
- Generates exercises and test.
- Generates programs for illustration purposes
- Carry on a natural language dialogues and explanations.
- Organize its knowledge in a lesson-oriented manner according to student models.
- Evaluates students results for tests, and develop a student's model.
- Tireless teacher which adapts to the learners cognitive particularities and his individual progress.
- Based around a large amount of knowledge from the teaching domain.
- Learner's particularities and his progress are stored in the "student model"
- Use of pedagogical knowledge.
- Use of rhetorical knowledge (or rules) for natural language text generation
- Addition of new knowledge is simple due to the structured object-oriented knowledge representation language.
- Generate a highly structured collection of web pages.

The main benefits of ITS are:

1) enhances instructor and student productivity;
2) provides tailored instruction and remediation;
3) allowing flexibility in teaching methods.

In addition the web-based ITS provides the following benefits:

1) a unique opportunity to distribute training across multiple sites (reducing travel-related training costs;
2) provides realism and authentic learning;
3) create a new kinds of learning experiences;
4) distribute of multimedia materials;
5) disseminate work publicity [15].

IeLSs are AI-based systems that imitates the human mind. The main characteristics of these systems are the ability of inference, reasoning, perception, learning, and knowledge-based systems. To a limited degree, AI permits IeLS to accept knowledge from human input, then use that knowledge through simulated thought and reasoning processes to solve problems. Many types of IeLSs are in existence today and are applies to different domains and tasks, e.g., geology, biological sciences, medical sciences, health care, commerce, and education [2, 13].

The main stage in developing IeLS for any specific task is to build a "knowledge base" in that domain of interest. The knowledge of that domain must be collected, codified, organized and arranged in a systematic order. The process of collecting and organizing the knowledge is called knowledge engineering. It is the most difficult and time-consuming stage of any IeLS development process. Although a variety of knowledge representation techniques have been developed over the years, these techniques share two common characteristics. First, they can be programmed with certain computer languages and tools. Second, they are designed so that the facts and other knowledge contained within them can be manipulated by an “inference system”, the other major part of an IeLS. The inference system uses search and pattern matching techniques on the knowledge base to answer questions, draw conclusions, or otherwise perform an intelligent function.

Intelligent authoring shells allow a course instructor to easily enter domain and other knowledge without requiring computer programming skills. The authoring shell automatically generates an ITS/IeLS focusing on the specified knowledge. It also facilitates the entry of examples/exercises, including problem descriptions, solutions steps, and explanations. The examples may be in the form of scenarios or simulations. It allows organized entry of the course principles and the integration of multi-media courseware (developed with well-known authoring tools) which includes descriptions of the principles or motivational passages. In addition to course knowledge, the instructor specifies pedagogical knowledge (how best to teach a particular student), and student modeling knowledge (how to assess actions and determine mastery) [16].

The most common authoring shells are DIAG, RIDES-VIVIDS, XAIDA, REDEEM, EON, INTELLIGENT TUTOR, D3 TRAINER, CALAT, INTERBOOK, and PERSUADE [1]. Some tools were meant for select authors or students and others were designed for a wide set of authors. Some tools were designed to work with a limited area of domain expertise, and some were designed for a wide range of domains. Some tools had one main instructional strategy, but others had many. Each tool had their own way of representing the student’s knowledge and understanding of the material being taught. Some tools generated instruction directly from domain knowledge. Some relied on pedagogical knowledge about the domain to create instruction. Some provided simulation environments for practice and exploration [17-22].

IV. Ontological analysis as an instrument of the distributed knowledge management

Every domain has phenomena that people allocate as conceptual or physical objects, connections and situations. With the help of various language mechanisms such phenomena contacts to the certain descriptors (e.g., names, noun phrases). Professional activity is a characteristic of a domain. A domain is considered as a set of the tasks, which are solved by specialists of this domain. A domain ontology is the part of domain knowledge that restricts the meanings of domain terms, a set of agreements about the domain.

A. Formal model of ontology

The formal model of ontology O is an ordered triple

$$O = \langle X, R, F \rangle$$

Where X - finite set of subject domain concepts that represents ontology O; R - finite set of the relations between concepts of the given subject domain; F - finite set of interpretation functions of given on concepts and relations of ontology O. An ontology is a specification of a conceptualization.

Now a lot of the Web applications is intelligent and uses knowledge about some subject domain or produce some new knowledge. In such applications knowledge is represented in interoperable form and can be reusable. For such representation ontological approach is widely used because ontologies have a fundamental theoretical foundation (descriptive logic).

An ontology is commonly defined as an explicit and formal specification of a shared conceptualization of a domain of interest. Ontologies formalize the intentional aspects of a domain, whereas the extensional part is provided by a knowledge base that contains assertions about instances of concepts and relations as defined by the ontology.

The creation of intelligent informational systems based on ontologies, in environment of continuous organizational and technological changes requires methods and tools not only for ontology creation, but also for the whole complex of related problems - change management, estimations, personification, separation, mapping and integration etc.

In the context of knowledge sharing, I use the term ontology to mean a specification of a conceptualization. That is, an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents. This definition is consistent with the usage of ontology as set-of-concept-definitions, but more general.

B. Formal model of thesaurus

The thesaurus can be considered as a special case of ontology. A thesaurus is a networked collection of controlled vocabulary terms. This means that a thesaurus uses associative relationships in addition to parent-child relationships. The expressiveness of the associative relationships in a thesaurus varies and can be as simple as “related to term” as in term A is related to term B [23]. The formal model of thesaurus is a pair

$$T_h = \langle T, R \rangle$$

Where T – finite set of the terms; and R – finite set of the relations between these terms.

A formal definition of a thesaurus designed for indexing is: a list of every important term (single-word or multi-word) in a given domain of knowledge; and a set of related terms for each term in the list.

At the present stage of IT in the majority of cases intelligent Web applications use standards and technologies of knowledge management developed by Semantic Web project. Ontologies are an important building block of knowledge in the Semantic Web [24-26]. They provide a shared and common understanding of a domain that can be communicated across people and applications.

Ontologies of the Semantic Web consist of Semantic Web Terms (SWT) – building blocks that play the role of the natural languages words. The set of SWT associates the RDF statements with formal semantics that are defined by RDF(S) with OWL statements. The social Web provides the knowledge about persons and communities that can be represented also as an ontology.

C. Information recourses

Information recourses (IR) represented in the Internet can be classify on textual and multimedia ones, static and dynamic, structures and not structured etc., but every IR has some semantics and is concerned with some subject domain. In process of information retrieval is very important to discover IR concerned with the domain interested to user [27-29].

Structures textual information in the Internet is mainly given in HTML and XML formats. The subject domain of textual IR can be defined by two ways:

- analyzing of IR textual content and
- considering metadata of these IR.

The challenge is to create consistent terminology labels for each element in the public resources that would allow the identification of all elements that relate to the same type at a given level of granularity.

Metadata can be built in IR or be stored and updated independently of resources. With the help of RDF one can describe the structure of a IR and connect it with appropriate domain. RDF describes IR in a form of oriented marked graph - each IR can have properties that also can be IR or their collections. Most widespread set of elements for metadata specification of the Internet IR is Dublin Core Metadata Elements.

Processes of global informatization of the international community focus on the construction and use of multidisciplinary knowledge. It requires the development of knowledge engineering and knowledge management tools. A relatively new trend in this area is the ontological engineering, providing re-use and interoperability accumulated in the knowledge society.

Ontologies are used in the knowledge processing for their structuring and integration. Therefore, questions of automated creation and updating of ontologies based on heterogeneous and dynamically changing information resources Web, their integration and mapping, as well as the development of methods for inference on them are very actual now.

V. Ontological Model of Semantic Search

A. *Ontology-based semantic search*

In the most general understanding search is a complex problem of:

1) matching of user conception about relevant for his problem knowledge with content of available information resources; and
2) building of the specific data object (with a finite number of specific values of properties that are mined from the analysed resources) based on this matching.

The main difference of the semantic search from the traditional one is the usege of the knowledge (related to the search objects, users, information resources (IRs), domain of retrieval etc.) to improve the pertinence of retrieved information to user‘s task.

Ontologies can be useful in all these problems. But we have to keep in mind that the use of ontologies, despite such advantages as an explicit representation of semantics and a strict mathematical basis (descriptive logic), has significant shortcomings relating to the complexity of ontology processing and inference. Therefore, the appropriateness of the use of ontologies and their particular cases for knowledge representation in the semantic search is the subject of a separate study [30,31].

B. *Ontological model of search*

Ontological model of semantic search formally defines the main subjects of retrieval process and relations between them.

Ontological model of interaction between users and IRs describes the following classes:

- domain ontology, which describes the sphere of the user‘s information needs;
- lexical domain ontology which contains information about the lexical element of natural languages appropriated to ontology terms;
- task thesaurus – set of pairs where the first element is the domain ontology terms, and the second – the weight (positive or negative) of the term for user‘s problem;
- request – set of keywords describing one of their information needs of the user (associated with a particular task by using of the task thesaurus);
- theme – the set of requests related to the same information needs that can combine the needs of different users, based on different ontologies and thesauri, and allows you to combine semantically related queries;
- query result – a set of pairs where the first element is a reference to IR, and the second – the user evaluation of this IR;
- user – a class that has a more complicated structure and having the following attributes, which can be divided into several groups: registration information, user information imported from external sources, IPS experience of interaction with the user etc.,
- information resource;
- informational object – result knowledge with structure fixed by external ontology (for example, Web service, learning organization, human).

Knowledge about particular users, IRs and other search elements is represented by ontology individuals and their properties.

VI. Qualification Management as a Particular Case of Semantic Search Task

This model of semantic search quite easily can be adapted for various applications.

Here we consider the case of the problem of matching competencies, which is an integral part of such tasks deal with education as:

- finding of suitable contractors employer;
- comparison of specialists with different specialties (in particular, relevant to standards of different countries);

- selection of an applicant institution, offering him the necessary set of disciplines;
- valuation of the possibility of student transfer from one institution to another (what disciplines from a previously studied can be take into consideration), etc.

Model of this search domain deals with main terms of educational activities and describes the basic concepts (“discipline”, “speciality”, “competence”, “student”, “learner”, “qualification level” etc.) and the relationships between them, as well as the structure of a data object, which is the result of the search – human, educatinal organization, speciality (Fig.2).

These strict definitions based on OWL support the relevant formalization of various requests such as comparison of the values of properties from one class of different class instances.

For example, if we want to find the professor for some University hen we have to match the informational object classified as an individual of “Educational organization” that values of property “Discipline” include the values from the set defined by values of property “Discipline” of individual of class “Learner”.

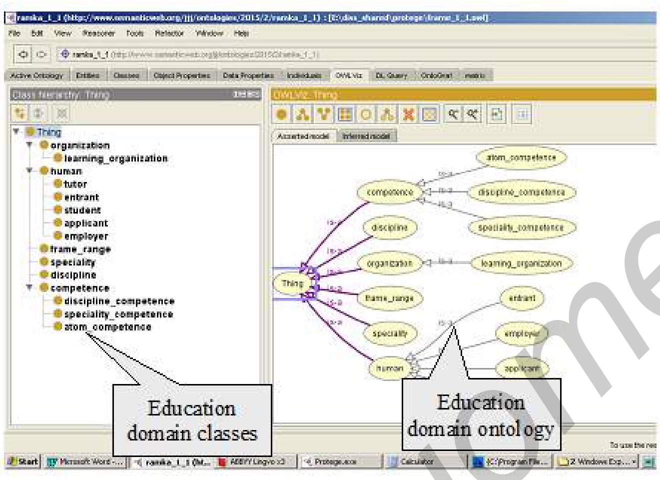

Figure 2. Education domain ontology

The main element of this model is a hierachy of competences deal with various disciplines, specialities, organizations and humans.

For comparison of specialties, skills and competences of people and organizations of different countries, it is advisable to use a set of standard atomic instances of each class.

An instance is considered to be atomic if any other instance of this class is not it‘s subset.

If two competence A and B are overlapping, then we have to build three potentially atomic competences – A_1, B_1 and C, such that

$$A \cap B = C, A_1 \cup C = A, B_1 \cup C = B$$

This process is repeated iteratively until all sets become disjoint.

Class "Atomic competence" is a subclass of class "competence", so that $\forall a \in$ "atomic competence" exists at least one element b of class "Competence", such that $a \subseteq b$, but for any element of the class "atomic competence" there is no other element c of this class "atomic competence" such that $c \subseteq a$, $a \not\subset c$. Class "Atomic competence" has a property "part of the" of class "discipline" and the property "to enter the" of class "competence".

In this case, the user describes his need in information by indicating the class of desired information object from the domain ontology A, – a human, institution, specialty etc. – and conditions imposed on it – the set of instances of the class "atomic competence" that are associated whith the selected object by relationships from the ontology that describe the links between instances (object properties).

An important advantage of the proposed search model is the fact that in this description semantics is clearly indicated the information needs. It provides the differentiated search for various relationships between the desired information object and a set of competencies.

For example, some different subsets of atomic competencies can be associated with the same instance of the class "person" by such relations as "has", "certified", "can teach", "has experience with." This differentiation allows for much more accurately satisfy user’s demand in the information by finding of the information objects that meet all requirements.

The most important task deals with competence management can be divided into two subgroups:

- building of the set of atomic competencies by the set of discipline competencies;
- updating the knowledge base by information about the domain instances.

VII. Conclusion

Artificial Intelligence is a powerful methodological and theoretical foundation for various knowledge-based applications. Integration of the AI algorithms and approaches with the up-to-date semantically enriched Web technologies provides high-efficient information processing and analysis.

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ПРИМЕНЕНИЕ ОНТОЛОГИЧЕСКИХ ТЕХНОЛОГИИ СЕМАНТИЧЕСКОГО ПОИСКА В ОБЛАСТИ ЭЛЕКТРОННОГО ОБУЧЕНИЯ

Гладун А. Я. Хала Е. А. Абдель-Бадех М. Салем

Искусственный интеллект в образовании стал самым сложным направлением, в последние несколько лет. Управление знаниями во многих современных веб-приложениях, ориентированных на ИИ базируется на онтологиях. В данной работе мы ориентируемся на онтологическую модель поискового взаимодействия пользователей и информационных ресурсов. Представленная модель может быть использована в различных интеллектуальных приложениях.