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AN ONTOLOGY-BASED APPROACH TO STUDENT SKILLS IN MULTIAGENT E-LEARNING SYSTEMS

Anatoly Gladun, Julia Rogushina

Abstract: The main idea of our approach is that the domain ontology is not only the instrument of learning but an object of examining student skills. We propose for students to build the domain ontology of examine discipline and then compare it with etalon one. Analysis of student mistakes allows to propose them personalized recommendations and to improve the course materials in general. For knowledge interoperability we apply Semantic Web technologies. Application of agent-based technologies in e-learning provides the personification of students and tutors and saved all users from the routine operations.

Keywords: e-learning, ontology, software agents, multiagent systems, Semantic Web technologies

ACM Classification Keywords: I.2.11 Distributed Artificial Intelligence: Multiagent systems

Introduction

The growth of the information society provides a way for fast data access and information exchange all over the world. Now, a lot of materials that used for education process exist in electronic form. In many domains the results of work are plain test materials. However, human readable data resources (like student control works, reports etc.) have serious problems for achieving machine analyses.

Computer technologies have been significantly changing the content and practice of education. The consequent applications of multimedia, simulation, computer-mediated communication and communities, and internet-based support for individual and distance learning all have the potential for revolutionary improvements in education [1, 2].

Online learning (e-learning) offers new possibilities in learning: a student can et immediate feedback on solutions to problems, learning paths can be individualized, etc. Online learning is a growing business: the number of organizations working on online learning and the number of courses available on the Internet is growing rapidly. Now a lot of e-learning tools with varying functionality and purpose exist [3,4].

E-learning is a contrary concept to the traditional human tutoring system. The course tutor in a software tutoring system controls learners relatively weaker than in the traditional tutoring where it is the tutor who is charge the contents and sequence of instructions. Therefore, in order to obtain better tutoring outcomes, a software tutoring system should emphasize engaging students in the learning process and be adaptive to each individual learner.

The goal of the early software tutoring systems was to build user interfaces that provide the efficient access to knowledge for the individual learners. Recent and emerging work focuses on the learner control over the learning process such as learner exploring, designing, constructing, and using adaptive systems as tools [5].

For example, 61% of Helmut Schmidt University students that use ILIAS (www.ilias.uni-koeln.de) prefer electronic forms of learning.

With the application of more computer techniques in education and the involvement of more adults in software tutoring systems, the learner control strategy has become more appreciated than tutor control or program control.

Learning control needs the comparison means of learner's knowledge base that forms (and modifies) in learning process with the course domain knowledge base. It requires the powerful and interoperable tools of knowledge representation and analysis.

A structured information representing is required and ontologies (machine processable representations containing the semantic information of a domain) can be very useful. The ontology systems serve as a flexible and extendable platform for knowledge management. The inspiring idea to develop reusable atomic learning components and to capture their characteristics in widely-accepted, formal metadata descriptions will most probably attract learning object providers to annotate their products with the accepted standards.

The experience of the developed countries shows the technological achievement of remote training – e-learning - that opens many new opportunities in expansion of student's number with the same number of the tutors and in improving of education quality. In recent years, e-learning has been widespread, especially since standardizing initiatives for learning technologies [6] have begun.

For distant learning where the tutor works with many students without direct contacts, it is very important to provide the objectivity and automatization of knowledge examination.

An important component of e-learning is testing of student's skills and knowledge. One of the main problems arising during creation of testing systems is interoperability of created tests, opportunity to reuse these tests in different testing systems. To organize test exchange between various systems it is necessary to create some universal format of tests preservation and their processing instructions. And an important condition for this format should be its independence from the platform. Standardization of educational technologies and, in particular formats of test data preservation are working out all over the world. Now Ministry of Education and Science of Ukraine realize the Program of On-line Education Development. According to these activities the development of projects of standards for systems, methods and technologies standards of on-line education in educational institutions taking into account international standards was provided. But different test formats such as Instructional Management Systems (IMS) Question and Test Interoperability (QTI) of Global Learning Consortium are not adequate to reflect all relationships of different applied domains.

Many authors [7,8] utilize the ontology's semantic data to improve the analyses of information in unstructured documents. The domain ontology plays central role as a resource structuring the learning content [9].

One of the key challenges of the course construction process is to identify the abstract domain of information within which this course will exist. Tutor has to describe the main terms and concepts from which a course is to be constructed.

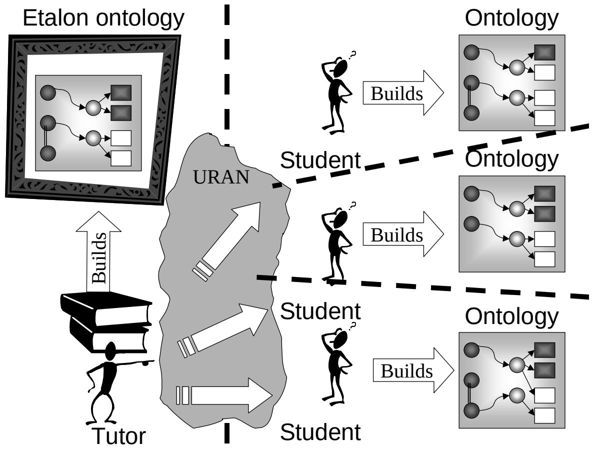
The main idea of our approach is that the domain ontology is not only the instrument of learning but an object of examining and forms by students. We propose for students to build the domain ontology of examine discipline and then compare it with etalon one.

We work on information content of Ukrainian Research and Academic Network (URAN) that is oriented in consolidation if education and scientific organizations of Ukraine [10]. Network is used to perform access to information sources. URAN provides opportunities for conducting scientific researches, distance learning, teleconferencing, etc.

Methodology for Building of Ontology

The students have to make some steps to design the ontology of domain:

1. Define the main classes and terms of domain and describe their meaning;
2. Construct the taxonomy of domain terms;
3. Define synonymy and other relations between these terms;
4. Describe the instances of constructed classes.



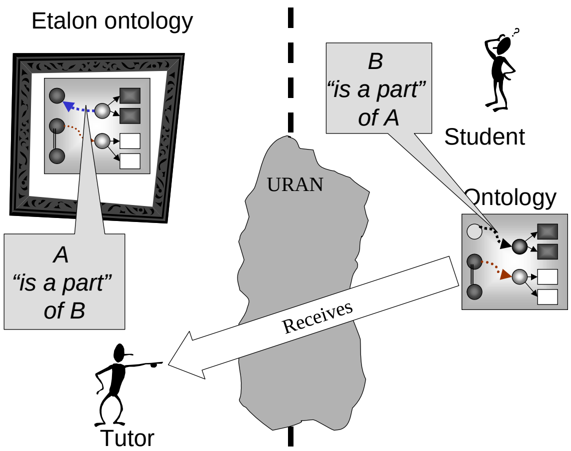
Pic.1. Ontology building process as a result of learning

For knowledge interoperability we apply Semantic Web technologies [11]. The Semantic Web project provides a solid basis for future progress in e-learning.

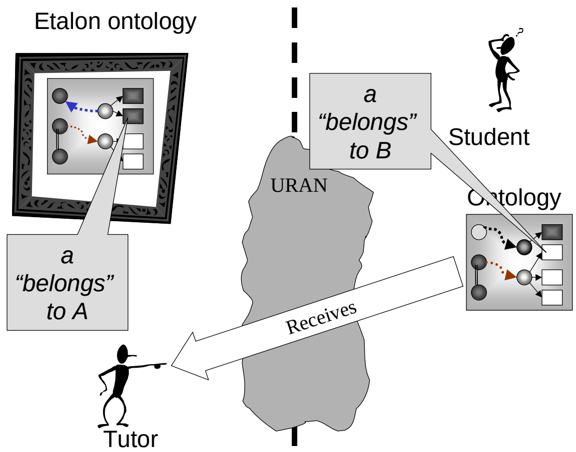
The ontologies are stored in a semantic markup language OWL [12] that is developed as a vocabulary extension of RDF [13] for applications that process the content of information. OWL is supported by many ontology visualizes and editors, like Protégé 2.0 [14]. Protégé is an integrated software tool used by system developers and domain experts to develop knowledge-based systems. Ontology in Protégé is a model of a particular field of knowledge - the concepts and their attributes, as well as the relationships between the concepts. It is represented as a set of classes with their associated slots.

Formal model of ontology O is ordered triple of finite sets O = < T, R, F > [15], where T - the domain terms of which is described by ontology O; R - finite set of the relations between terms of domain; F – the domain interpretation functions on the terms and the relations of ontology O. In process of ontology building students use relations from the fixed set that contains the most widely used relations: R={"is a subclass of", "is a part of", "is a synonym", "has attributes", "has elements"}. It simplifies the ontology building and analyses processes.

When student builds the domain ontology the tutor can compare it with etalon ontology, constructed by tutor. We use the original algorithm for automatically comparing of ontologies that provides correspondence of hierarchical levels in term taxonomy (if class A is a subclass of B in etalon taxonomy and B is a subclass of A in students taxonomy there is a mistake - pic.2) and controls affiliation of instances with classes (if instance a belongs to class A in etalon taxonomy and student describe instance a that belongs to class B is a mistake - pic.3).

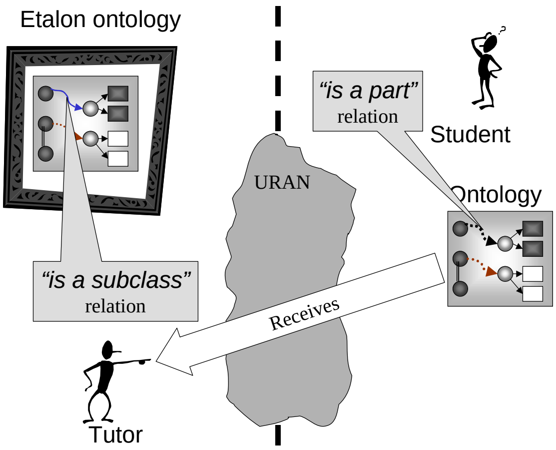


Pic.2. Hierarchical direction class error

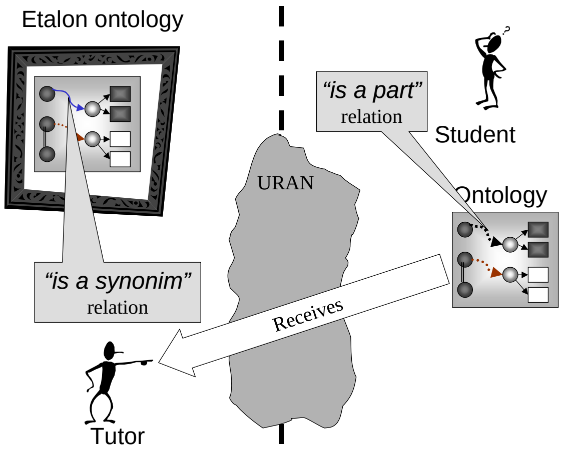


Pic.3. Instance classification error

We distinguish the mistakes of different gravity. If student uses improper relation but from group of hierarchical relations (for example, A is a part of B instead of A is a subclass of B - pic.4) it is not so important as if she or he uses hierarchical relation instead of synonymic relation (for example, A is a part of B instead of A is a synonym of B - pic.5). More serious mistake is improper direction of hierarchical relations (for example, A is a part of B instead of B is a part of A - pic.2).

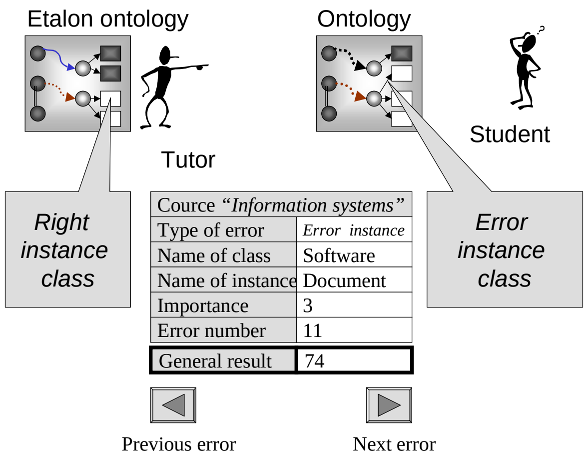


Pic.4. Class name error



Pic.5. Hierarchical class error (instead of single-level)

On base of this algorithm we grade the results of students work with 100-ball system. The experimental prototype of system that controls student's knowledge by means of ontological analyses in URAN network was developed by Java.



Pic.6. Rating of the student ontology correctness.

Intelligent Software Agents in e-Learning

Ontological representation of student domain skills can be automatically processed by intelligent software agents [16]. It is appropriate to use software agents for e-learning because they work efficiently in dynamic heterogeneous distributed environment [17].

Agent works autonomously without human direction in an actual or simulated environment. An intelligent agent may be defined as a computational process that can perform tasks autonomously. It inhabits a complex and dynamic environment with which it may interact to accomplish a given set of goals. Intelligent agents can reason in a rational manner and report back result to humans.

One of the main properties of an intelligent agent is sociability. Agents are able to communicate between themselves, using some kind of agent communication language, in order to exchange any kind of information. In that way they can engage in complex dialogues, in which they can negotiate, coordinate their actions and collaborate in the solution of a problem.

A set of agents that communicate among themselves to solve problems by using cooperation, coordination and negotiation techniques compose a multi-agent system (MAS). A lot of researchers use MAS for e-learning and e-coaching tasks.

Personalized e-learning employs an active learning strategy which empowers the learner to be in control of the context, pace and scope of their learning experience. It supports the learner by providing tools and mechanisms through which they can personalize their learning experience. This learner empowerment and shift in learning responsibility can help to improve learner satisfaction with the received learning experience.

The aims of personal e-learning agents are at increasing of information dissemination of existing courses through delivering the relevant course information offer to the right student at the right moment. For example, students of different specialties learn on different programs and in many cases have different theoretical and practical background. Their personal agents can consider it and propose them not only the universal course program but additional facts and references from allied courses that they didn't learn.

Application of agent-based technologies in e-learning provides the personification of students and tutors and saved all users from the routine operations.

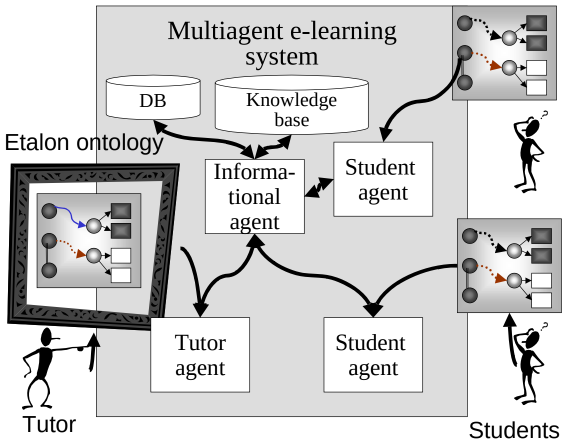
Results and Future Work

The main contribution of this paper is our architecture of e-learning MAS and methods of ontology comparing.

We use the multiagent system of e-learning. It includes personal agents of students and course tutors. Use of some agents-facilitators raises the efficiency of this system and helps to users in search of required information. Agents of students and tutors don't communicate directly. They send ontological information to informational agent that analyses them and returns the results to students and tutor.

We develop a prototype of a multiagent ontology-based e-learning system that produces automatically semantic control of student domain beliefs of learned course.

The focus of ontology analysis is on knowledge structuring (of main domain terms and their relations). We use ontologies to describe learning materials and to represent student belief about course domain. Etalon ontology is sent to MAS knowledge base by tutor personal agent.



Pic.7. Architecture of e-learning MAS.

When student forms the domain ontology in OWL format her/his personal agent connects not with course tutor personal agent but with informational agent and sends this ontology for comparing with etalon one (its last version). After the comparing, informational agent sends these results to the student and tutor personal agent. If some student or tutor usually prefers some manner of learning and information presentation then the personal agent has to provide all these requirements for new course without direct instructions of student. Student receives information in appropriate to her/him form and taking into account previous results of examination. For example, if student makes the same mistakes in some ontologies she/he receives the notification about it and advice that links with suitable course materials.

In future we plan to use the inductive inference methods to form the most appropriate personal strategy of learning for every student (for example, some students profit by theoretical materials and some other ones - from examples or practical tasks, somebody prefers graphical or text representation of information, etc.).

Use of student personal agent allows finding the situation where student makes mistakes of the same type in ontologies of different courses. She/he receives the notification about it and advice that links with suitable logical course materials. Other important advantage of multiagent technology use is deals with course tutor personal agent. If the big part of students make the same mistakes course tutor receives the notification about it and can change suitable course materials

We have been experimenting with the challenges of e-learning MAS exploiting for student beliefs control in course "Visual C++ System Programming" (European University, Kiev, www.eufimb.edu.ua) and "Modern Internet Technologies" (Kiev Slavistic University, www.mgi_ksu .edu.ua).

We create detailed domain models of these courses. Model of course "Visual C++ System Programming" contains more then 150 terms and uses 8 relations between these terms. Course is accompanied by 16 online lectures and 10 practical exercises. Model of course "Modern Internet Technologies" contains more then 68 terms and uses 10 relations between these terms. Course is accompanied by 18 online lectures and 6 practical exercises.

Table 1. Average measures of student ontology parameters

Course title	"Visual C++ System Programming"	"Modern Internet Technologies"
Number of students	22	16
Number of terms	153	68
Number of relations	8	10
Terms correctly used in student ontology K_{term}	94.2%	91.6%
Relations between terms correctly used in student ontology K_{rel}	72.0%	66,3%
Type of relations between terms correctly used in student ontology K_{type}	89.1%	81.5%
m_{term}	0.9	0.7
m_{rel}	0.3	0.5
m_{type}	0.7	0.8
Overall rating of student ontology correctness K	88,51%	80,14%

$$K = (K_{term} * m_{term} + K_{rel} * m_{rel} + K_{type} * m_{type}) / (m_{term} + m_{rel} + m_{type})$$

Conclusion

The main features of our approach to knowledge control are the following:

- all results are analyzed automatically without tutor;
- results are analyzed objectively;
- students can work with knowledge base;
- a structurization of domain knowledge simplifies the learning process;
- tutors can exchange their knowledge based on etalon ontologies.

One of the essential elements needed for effective learning is feedback. In the current generation of e-learning systems automatically produced feedback is almost only used in question-answer situation. Valuable feedback, for example produced by a human tutor via e-mail, is often possible but this introduces delays and is time consuming. We want to develop ontology-based mechanisms of feedback that use the context of education. Different student errors need different methodologies of tutor to describe their causes.

Feedback is used in many learning paradigms. The concept of feedback is very important in educational psychology. It is one of the main psychological principles that one of the essential elements needed for effective learning is feedback. Information about examining results is required to assess progress, correct errors and improve performance. Feedback describes any communication or procedure given to inform a student of the accuracy of a response, usually to an instructional question. Feedback allows the comparison of actual performance with some set standard of performance. Information that is acquired by student from feedback instruction includes not only answer correction but other information such as precision, timeliness, learning guidance, motivational messages, background material, sequence advisement, critical comparisons, and learning focus. In traditional learning students and tutors can interact directly and students can freely ask questions and tutors usually know whether their students understand concepts or problem solving techniques and relations between them. Feedback is an important component of this interaction. In e-learning systems feedback problem is much more difficult and has a lot of technological and social aspects.

In future, we plan to develop more powerful algorithms of ontology analyses that consider ontology integration and their distributed upgrade on base of multiagent technologies. Application of student and tutor agents will provide the personalization of distributed learning process. These agents will use the history of learning for feedback between student and tutor.

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