Towards Learning Knowledge Objects

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Abstract. In this paper, we present an ontology-based approach, The Knowledge Puzzle approach, that aims to exploit principles from the AIED and Intelligent Tutoring Systems fields to produce e-Learning resources more tailored to learner’s needs. We present a semi-automatic process to annotate learning material from different points of view: domain, structural and pedagogical. We then use this knowledge to generate dynamically learning knowledge objects based on instructional theories.

Keywords. Ontology, Intelligent Tutoring Systems, e-Learning, Learning Knowledge Objects

Introduction

The concept of learning object (LO) and particularly the concept of the reusability of LOs is one of the main research topics in the e-learning community. In fact, many initiatives for constituting learning object repositories (LORs) have been realized to facilitate the retrieval and reuse of LOs. However, LORs suffer from their lack of adaptability to a learner model as well as from the black box structure of learning objects. We believe that concepts from the AIED and ITS fields can help to overcome these shortcomings.

The paper is organized as follows: First, we present the main conceptual points of our approach. Then we detail it by presenting the learning modelling, the adopted knowledge representation and the learning knowledge object generation and standardization. We end with a conclusion.

1. The Knowledge Puzzle Approach

We propose an ontology-based approach that aims to reduce the gap between e-Learning and ITSs by dynamically aggregating learning objects on demand and according to a competence-oriented approach. Our contribution is articulated around the following main axes:

- First, we think that a competence-based approach should be adopted to allow training adapted to particular needs. In fact, the lack of adaptability to individual learners is one of the main shortcomings of traditional e-Learning approaches.
- Second, we consider that richer knowledge representations, based on ontologies, must be adopted to reflect learning object content.
Third, we strongly agree with the fact that the pedagogical framework of learning objects is implicit and is left to the human expert [1], thus reducing the possibility to dynamically compose interesting resources. Our goal is to enable an explicit representation of the instructional framework through the creation of Learning Knowledge Objects.

Finally, we recognize the importance of standards in the e-Learning community. Hence, we propose to produce learning knowledge objects that are compliant with the SCORM standard.

1.1. Learner Modeling: a Competence-Oriented Approach

First of all, learning objects must be adapted to fit individual needs. We developed a Competence Ontology that describes a competence as a set of skills on domain concepts. Skills are classified, in our system, according to the Bloom taxonomy [2]. Instructional objectives or competencies must be linked to learning objects or parts of them to enable their reusability efficiently. This can be done through an effective knowledge representation.

1.2. Knowledge Representation

We developed an ontological model to represent learning object content. We used the Protégé Ontology Editor [3] and the Web Ontology Language (OWL) to express the ontologies. We also developed a content model, the Knowledge Puzzle Content Model [4], that allows to annotate learning materials according to domain, structure and pedagogy:

  **Domain Annotation (Domain Ontology):** We use machine learning (KEA-3.0 [5]) and natural language processing (Stanford Parser [6]) to generate a domain ontology from learning objects content and thus to explicit this content through concepts and relations between them. This allows for a more focused search of learning resources based not only on metadata but on the learning object content itself.

  **Structural Annotation (Document Structure Ontology):** This ontology describes the relevant structural assets that can be found in a learning object (such as sentences, paragraphs, sections, images, tables, figures, etc). A learning object annotation using these assets is performed through a Knowledge Extractor based on IBM’s UIMA [7].

  **Instructional Annotation (Instructional Role Ontology):** The Instructional Role Ontology models pedagogical roles (e.g. Definition, Example). This is done manually, through a Knowledge Annotator.

  All these ontologies are stored into an **organizational memory (OM),** which is a dynamic knowledge prosthesis whose content is created through a knowledge management process and exploited through a learning process. We believe that an OM represents an alternative to static learning object repositories.

2. Generating Learning Knowledge Objects

An essential part of effective learning resources is the use of a clear pedagogical framework that enables a software to understand it thus helping the reuse of these
resources. In fact, we believe that an automatic approach for learning object generation should follow instructional theories. So we developed an instructional theory ontology that models an instructional theory as a set of Instructional Steps stated in the form of rules combining assets and predefined methods. These rules express a mapping between the theory’s principles and the instructional role ontology. We use SWRL (Semantic Web Rule Language) as the rule formalism.

The learning knowledge object (LKO) generation follows the following path: an instructor defines a competence in term of skills on domain concepts. Starting from this definition, the system compares the learner’s knowledge with the competence requirements. Then it produces an updated competence definition based on this analysis. A learning Knowledge object is generated for each skill to be mastered and according to an instructional theory chosen by the instructor. By default, the system uses the Gagné’s theory, which is represented as an instance of the instructional theory ontology. Each step of the theory is attached to a set of rules that describe the assets able to fulfill the objective of the step. The final learning knowledge object takes the form of a hierarchy of activities, with each step attached to a learning resource. In order to make the learning knowledge object compatible with e-learning standards (especially SCORM), a similar structure is generated as a SCORM Content Package with a manifest describing the learning knowledge object composition and a sharable content object for each instructional step. We use a linear sequencing strategy to teach each skill.

3. Conclusion

In this paper, we presented an approach to generate dynamically learning knowledge objects (LKOs) based on instructional theories. We also showed that we are able to export such LKOs into standard formats (SCORM). We succeeded in building a bridge between fine-grained knowledge representations like the ones in ITSs and more wide-scale knowledge representations as the ones used in e-Learning. Our next goal will be to automate the process of instructional role annotation as well as to export our LKOs into the IMS-LD specification.

References.