

Using Ontological Modeling in Multi-Expert Guiding based Learning Object Recommendation

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Abstract. The Semantic Web opens up a widely used of possibility for intelligent searching and reuse of learning object by sharing ontologies and made the learning object available to potential learners on the web. This paper proposes a framework, which is the combination of the ontological modeling and the hybrid filtering method based on various designs of experts, to prevent the learner from becoming lost in course material by providing a concept map planner and recommend the most suitable learning object for learners. With linked data defined with ontological model, the learner can find other, related, learning objects in the same concept. This work specifically supports personalized learning approach to improve filtering and ranking of results from learning object search queries including learner preferences generated in the multi-agent based recommender system.

Keywords: concept map; learning object; multi-agent; ontology; recommender system; Semantic Web

1. Introduction

Nowadays, there are many learning objects distributing on various learning object repositories. This makes the learners to confuse when selecting the learning objects for their learning path. For that reason, personalized learning object recommendation is becoming more common in adaptive educational systems. Moreover, to find an optimal learning path for personalized learner is very difficult because no measure exists by which to evaluate the success of an optimal personalized learning path [1]. Although the adaptive learning system provides lots of learning objects, its application is limited for personalized learning object. This research aims at producing a guideline for learning object filtering by using the master concept map that design from various experts and the designed ontological model make it possible to personalize learning objects to specific learners.

A concept map is a description of how propositions are organized [2]. Concept maps reflect how ideas, opinions, and propositions are organized in the knowledge structure of experts who construct the concept maps, and give observations on students' states. Form observations experts can design their own concept map and will share with other. However, different characteristic of them and learners while design the same course may vary in instructional paths, contents and sequence [3]. In this work, we use the CmapTools that is the most widely used software tool for creating course concept maps [4]. This tool is intended to produce meaningful learning in approach of a "guided inquiry-model" which is based on expert skeleton maps, where instead of free form study projects the inquiry.

The remainder of this paper is organized as follows. The Section 2 provides the background knowledge in learning object on the Semantic Web, repository of learning objects and shows the need for collaborative course design in e-learning systems; Section 3 shows the our proposed model and strategy. Next, Section 4 presents the designing ontology in our system, then Section 5 the methods of learning object recommendation are presented and, finally we give the conclusion of this work.

2. Background

2.1. Learning Object on the Semantic Web

LTSC defines learning object is “any entity, digital or non-digital, that may be used for learning, education or training.” [5]. David [6] gives a definition of learning object as "Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy". The learning object needs the standard, called SCORM, which is developed by the Advanced Distributed Learning (ADL) [7]. It aims to foster creation of reusable learning content used as “instructional objects” in many courses. SCORM describes this technical framework by providing a harmonized set of guidelines, specifications and standards developed by several organizations. All of them are adapted and integrated with one another to form a more complete and easier-to-implement mode by ADL. Several organizations especially AICC, ARIADNE, IEEE LTSC, and IMS are the key contributors of SCORM.

Learning object needs the set of attributes to allow learning objects to be managed, located, and evaluated called Learning Object Metadata. The IEEE Learning Object Metadata (LOM) uses a pre-defined and common vocabulary to describe the content of learning objects. These are nine categories in the vocabulary including General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation and Classification [8].

An important topic for reusing learning object on the web is the development of appropriate technologies to provide the discovery and reuse of learning objects stored in global and local repositories. Another topic is to development of ontologies for marking up the structure of learning objects and describing pedagogical meaning to them so that the machines can understand them. A third topic is building learning objects smarter so that they can perform a more meaningful role on the Semantic Web. The important technologies for developing the Semantic Web are XML and RDF. XML allows users to insert arbitrary structure to documents without saying what these structures mean. RDF allows meaning to be specific between objects on the web by designed as a metadata modeling language. Another important aspect of semantic web is a set of ontologies that is a specification of a conceptualization. It describes the concepts and relationships of object in the world by using the well-defined ontologies. Indeed, the IMS [9] provides an RDF binding for its Learning Resource Metadata Specification (which is essentially the same as the IEEE LOM Standard).

2.2. Collaborative Course Design

In e-learning system, course concept design for web-based education is one that entails combining a variety of instructional strategies into a unique environment [10]. To our knowledge, no previous studies have explored the role of such factors in human judgments of concept importance. Most the problem of decision making for selecting the suitable concepts and paths will be happened to the new instructors who have no teaching’s experience or the instructor who want to develop their teaching strategy by sharing the knowledge with other experts. Another problem is also the question, how they do if some instructors who want to add some new concepts to the course and try to share with others. Moreover, in the situation of multiple experts, who is an experts most we can trust. All problems mentioned earlier are the reason for this work. Since our concrete approach is an interdisciplinary professional community of experts, the assumption is that the experts will be willing to share their structure designs.

2.3. Shareable Ontologies

The intelligent searching and integrating of learning objects require information not supported by the current set of elements in LOM standard. It is necessary for describing how each learning object is related in the learning concept of the domain knowledge, and which other learning object related to. With an ontology based, an agent can compare the course concept map developed by various experts with the learning object based on a common understanding of how the relate to each other [11]. This allows the agent to process the most suitable learning object to the specific learner and determine which learning objects are suitable for the concept. There have been a number of researches aimed at developing ontologies for learning object recommendation system. There have also been a few recent attempts to link elements in the LOM standard to specially developed ontologies. Ontologies about learning and teaching strategies are also helpful since they allow a learning object to specify the kinds of techniques it uses to provide learning [12]. Including with concept ontologies make it possible to personalize learning to specific learner based on learner preferences and learning design.

3. Our Proposed Model and Strategies

This system (Fig 1) includes an off-line concept modeling process, four intelligent agents and related databases. The four intelligent agents are concept map management agent, learner interface agent, feedback agent, learning object recommendation agent. Each agent has different functions; concept map management agent uses the concept map combination model (CMCM) [13] for solving various concepts map designs that is the combination of the selected concept unit from the concept modeling process, learner interface agent aim at providing learner assessment process an flexible learning interface for learners to interact with the feedback agent and the learning object recommendation agent.

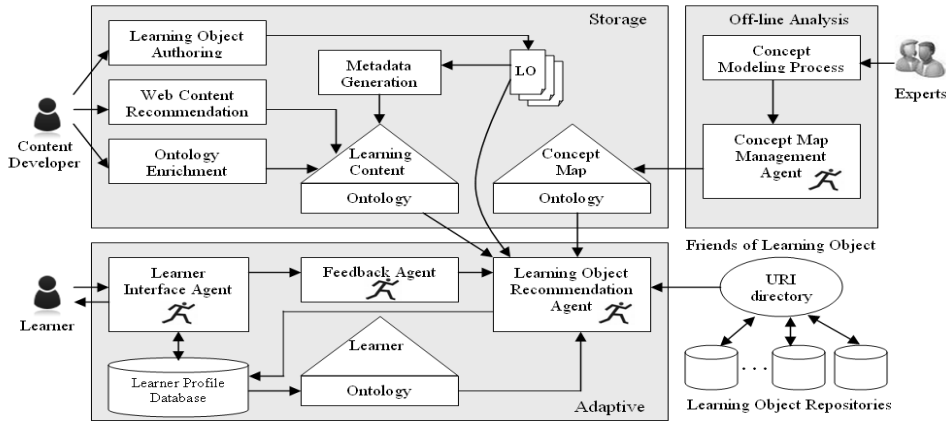


Fig 1. System architecture for creating the personalized learning object recommendations

4. Designing Ontology in the System

In our system, there are consisting of concept map ontology, learning content ontology, and learner ontology. The *concept map ontology*, shown in Fig 2, represents the concepts of a knowledge domain. Each of instances of concept class has a name and can be related to other concepts in two ways: as a pre-requisite or as a sub-concept, and has a meaning to refer to their knowledge area, author and related learning object,

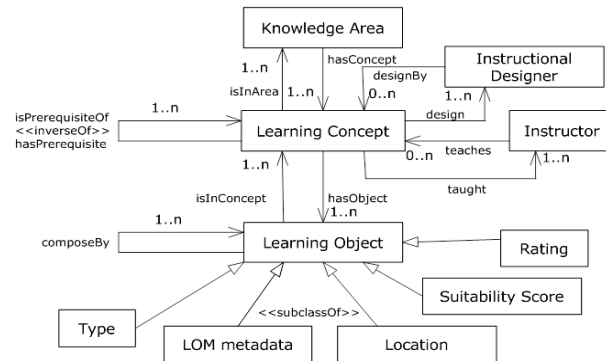


Fig 2. The Course concept ontology and its class description

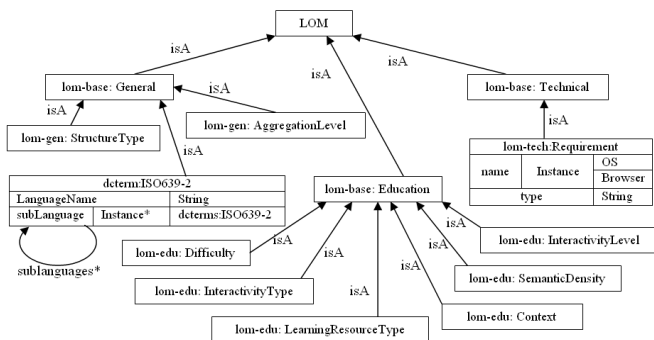


Fig 3. LOM standard ontology

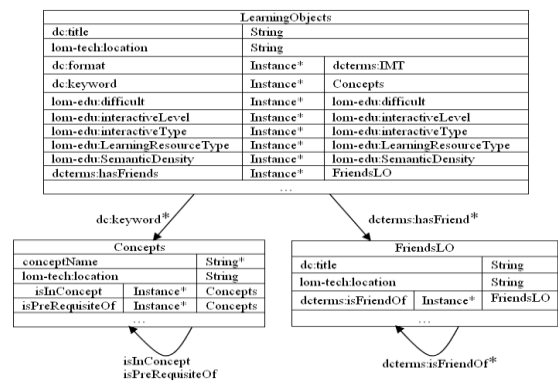


Fig 4. Learning object classes ontology

forming the domain's conceptual map. Instances of learning object class represent the learning object used in the concept. In addition some attribute of class concept also defined on LOM standard, which describe their technical and pedagogical characteristics. LOM standard ontology that shown in Fig 3 represents the

class of properties of learning objects. This ontology is based on IEEE Learning Object Metadata RDF Binding [14]. There are consists of main categories in LOM, such as, General, Educational and Technical. In each category class, it has instance to represent the characteristics of leaning object that shown as Fig 4.

This way, it is possible to compare data when selecting learning objects to the concept or course, aiming to improve the assistance to the learner's need.

5. Recommendation Model

The recommendation model consists of several processes, they are explained below.

5.1. Discovery Learning Objects and Friends by Integrated Concept Map

We generate a concept's keyword vector from the integrated concept map; keywords are noun and unfamiliar words which are extracted from the concept. Keywords list includes keywords that can reference to the learning objects. When the system generates the integrated concept map for various experts, a keyword list is generated. The keyword vector of each concept is expressed as follow.

$$CKV = (CKV_1, CKV_2, \dots, CKV_m)$$

These concept key word vectors will be use for retrieve the relevance learning object in the learning object repository. In this work we use the nine categories of LOM metadata and each category containing several fields. If a learning object is obtained with LOM ready, its feature values are automatically extracted from the field of LOM (each field is considered as feature). We define f_i to represent the feature i^{th} of learning object and L^F is the set of all learning object features.

$$L^F = \{f_i \mid \forall f_i \in LOM_f, f_i \neq f_j\}$$

We define a feature values of feature f_i as fv_k and the pair of them (f_i, fv_k) will be included to describe the learning object LO as below.

$$LO = (f_i, fv_k) \mid \forall f_i \in LOM_f, f_i \neq f_j$$

For matching process between the concept map and the related learning object, we generate the learning object keyword vector LKV of each learning object by:

$$LKV = (LKV_1, LKV_2, \dots, LKV_n) \mid \forall LKV \in LO$$

We calculate similarity of keywords (SIMkey) by COSINE method by using equation 1.

$$SIMkey(CKV, LKV) = \frac{\sum_{i=1}^j LKV_n \times CKV_m}{\sqrt{\sum_{i=1}^j LKV_n^2 \times \sum_{i=1}^j CKV_m^2}} \quad (1)$$

The result of this process is the set of learning object that relevance with concept keyword vector. We use the result of learning objects set as the material pool for finding the most suitable learning object.

5.2. Learning object recommendation based on learner

We extend the process of using set of relevant learning objects for learning object recommendation process, which is controlled by learning object recommendation agent. This agent works with the learning object recommendation algorithms, which are typically used to deliver recommendations to learners in two ways. Firstly, predictions for specific learning objects can be provided. Secondly, recommendations in the form of ranked lists of learning object can be presented to learner. With respect to prediction problem, we consider the well established learner-based collaborative algorithm. A prediction $P_{a,j}$ is calculated for a learner a on learning object j as a weighted average of k neighbors' ratings by using equation 2.

$$P_{a,j} = \bar{r}_i + \frac{\sum_{i=1}^k w(a, j)(r_{i,j} - \bar{r}_i)}{\sum_{i=1}^k |w(a, j)|} \quad (2)$$

Where \bar{r}_i is the average rating of learner a , $r_{i,j}$ is the rating assigned by neighbor i to learning object j and $w(a, j)$ is the similarity weight between user a and neighbor i . Similarity weights are computed using Pearson correlation [15].

5.3. Rank and recommend learning object

To generate a top-N recommended learning object list, the learning objects contained in all of the nearest neighbors are aggregated to form a candidate set. Learning objects that have already been rated by the active user are excluded, and a predication is made for each of the remaining candidate set learning objects using the procedure outlined above. Candidate learning objects including their learning object friend's URIs are then ranked according to predicted ratings, and the top-N set is returned.

5.4. Learner send feedback and rating to each learning object

The learner's feedbacks are the important information for the recommender system. There are two types of feedback when they receive the learning object ranked list; *content feedback* and *preference feedback*. The feedback message will be sent to the system by feedback agent. The agent reports the helpful information to the system for keeping as the learner and learning object history. The aim of this process is the system must understand whether a learner really prefers the style of learning object or not and must understand about the rating of learning object in the system.

6. Conclusion

We propose methodologies to support the multiple experts guiding" for finding the most suitable learning object and friends of them by using ontological modeling. The contribution of this research is a methodology for handling personalized learning object that specially provide for saving costs and the time of the learner. Meanwhile, the concept continuity of learning object location is also integrated by analyzing concept relation for all learning object repository while applying integrated concept ontology. To prevent the learner from becoming lost in course materials, the system provides personalized learning guidance, filters out unsuitable course concept to reduce cognitive loading, and provides a fine learning guidance based on individual user profile. These algorithms must be satisfactory to each individual learner even if learning object must be reused in order to maintain the course objectives.

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