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# Ontology Based Personalized Recommendation Model for Learning Objects in a Service Oriented E-learning Environment

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**Abstract.** This paper proposed the ontology based personalized recommendation model for learning objects in order to increase the reusability of the learning objects. The model will assist the users to select the "best fit" learning objects by referring to their preference history. The search keywords inputted by the users will be processed and the semantic similar terms of the keywords will be captured from WordNet. Both users input keywords and semantic similar terms are considered for searching the suitable learning objects. The recommendation model will rank the learning objects based on the user's preference history and similar users' preference history. The target users are considered as similar users of the user if they are having similar preference history with the user. Different with other existing ideas, the proposed model considers the personalization based on user's preference history and ontology based searching in the recommendation process. A prototype system will be created in future to show the contribution.

**Keywords:** E-learning, Recommendation Model, Service Oriented Architecture (SOA), Ontology

## 1. Introduction

The e-learning technology is one of the most important topics in the computer science field nowadays. Researchers are always doing their best to improve the e-learning technologies. In the researches, the reusable e-learning concepts would be highlighted always, especially the ideas of the reusable content in e-learning system. Meanwhile, the reusability of the contents is on focus.

To allow the learning contents to be reused, the concept of learning objects (LOs) has been applied into the e-learning system. Learning objects are also defined as "*any entity, digital or non-digital, that may be used for learning, education or training*" [1]. The learning contents are packaged together in a learning object. Other than that, the concept of separating the components (Context, Content and Presentation Layer) of the digital repositories (LOR) of the e-learning system is proposed. As the result, the learning objects can be reused in another system. To increase the reusability, accessibility, adaptability and interoperability, the standardization of the learning objects are important. Hence, the Advanced Distributed Learning (ADL) proposed the standard of SCORM (Sharable Content Object Reference Model) [2]. Every SCORM compatible learning objects are able to be reused in every of SCORM compatible e-learning system.

The Service Oriented Architecture (SOA) approach is applied in the e-learning system. In the SOA, all functions are defined as services while all services are interconnected with each other via well-defined interface by using web technologies [3, 4]. The SOA supports software reusability as all services are independent of hardware, operation system and programming languages [3]. Hence, the services can be reused in another SOA system.

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The e-learning systems are now able to allow the developers to reuse the learning contents (e.g. SCORM learning objects) and learning functions (e.g. services in SOA). In the other hand, the users can also reuse the learning contents of the system. To improve the reusability degree of the learning objects, the e-learning system should be able to assist the users to select and reuse the "best fit" learning objects based on their profiles and history records.

## 2. Ontology Concept

Ontology is defined as "*a specification of a conceptualization*" [5]. In the other words, ontology is a specification of a shared conceptualization in a formal way. In ontology, there are three important components which are objects, concepts and the relationships that hold among them. In ontology, the objects, concept and other entities are explicitly defined. The ontology is machine readable and stores the consensual knowledge that is agreed by group but not individual.

Ontology defines the shared meaning of vocabulary in a formal way. Each concept consists of a set of objects. The related concepts are mapped together with each other and defined by a set of relations. The structure of the ontology can be viewed as a hierarchy tree. In the tree, there are parent concepts and child concepts. The relationship between the parent concepts and child concepts is defined by the *is-a* relation. The parent concepts inherit the objects of the child concepts in the ontology. WordNet is one of the most popular ontology tools. It is an online lexical reference system [6]. In WordNet, semantic similar terms are grouped into same synonym sets (*synset*).

## 3. Ontology in E-learning

In e-learning system, different authors or different users may use different term in the process of searching for learning objects. For example, the students in United States may search the learning objects by keyword of "Automobile" while the students in United Kingdom may search with the keyword of "Car". As we know, both terms are semantic similar. As the result, the system should consider both keywords in the searching process. Hence, ontology concept is a powerful mechanism to solve this situation.

A semantic web based e-learning model which is using the well known standards, which are Resource Definition Framework (RDF) data model and Web Ontology Language (OWL) are proposed [7]. The model is also able to help users to find the learning objects by providing a hierarchical concepts structure and semantic relationships of the concepts.

Another model is proposed which is applied with Formal Concept Analysis (FCA), Self-Organizing Map (SOM) and k-means clustering in the ontology based e-learning system [8, 9]. FCA is able to manage the knowledge ontologically and discover the conceptual structures of data. SOM is the tool to reduce the size of the neutral networks. K-means clustering technique links the related ontological concepts together to form a relationship view of the concepts.

A semantic-aware classification algorithm is proposed to search for sharable learning objects in local learning object repository and heterogeneous learning objects repository [10]. The searching is processed based on the semantic similar concepts or meanings but not just by keywords.

Then, an idea of the ontology mapping method is proposed [11, 12]. The mapping will first compute the similarity measurement of the ontology structures by using the Jaccard's coefficient formula then the structures are classified with Fuzzy Logic.

The design of learning objects model that supports personalization in a semantic web based e-learning system is then proposed [13]. The personalization is considered based on prior knowledge aspects, learning style aspects and student performance aspects of the learner.

Several different approaches are then applied on the semantic web based personalized recommendation model. In [14]'s idea, only four parameters in learner profiles are taken into consideration for the personalization, which are learning level, level of mastery, learning style and the current learning knowledge point ID. Based on the matched ontology items and four stated parameters above, the learning objects and learning path will be recommended to the learners.

In the idea of [15], the similarity of different users is calculated by using the relationship between the concepts in domain ontology. It is the semantic similarity between core concepts of different user evaluation. Then, the resources are recommended to the learners based on interest of similar users.

Some of the approaches above, for example [7, 8, 9, 10, 11, 12], are mainly focusing on the mapping and organization of the resources or learning objects based on the ontology. Semantic similar resources or learning objects is linked together in the system. As the result, the approaches help the users to search and reuse the related learning objects in the system. However, the problem is the system will show only semantic similar learning objects without considering the user interests.

The case is solved with the researches of [13, 14, 15]. The three approaches are focusing on semantic web based personalized recommendation model. For the personalization, [13] implemented a Student Model Ontology. In the other hand, [14] considers four parameters in user profile and [15] considers similar users interest. In the other words, all three approaches are focusing in user’s properties or similar user’s interest but not the learning history records of the users.

Learning history records are sometimes helpful to make the personalization be more accurate. However, the most ideal is to consider the learning history records of the users, the properties of the users (for example learning style, learning level and etc.) and similar users’ interest.

## 4. Ontology Based Personalized Recommendation Model

According to the statements above, the ontology based personalized recommendation model is proposed. The recommendation will be done based on the metadata files of the LOs. Each LO will have an associated metadata to present the properties of the LO. The metadata files are normally created under Learning Object Metadata (LOM) standards. In our model, the metadata are stored in Metadata database while physical LOs are stored in Learning Objects database. It is to make the recommendation process be faster. Since both database are separated, whenever the new LO is created, the LO has been registered to the system. The metadata and its associated LO will be recorded. In the model, only 9 features are considered in recommendation, which are *Title, Language, Keyword, Coverage, LearningResourceType, IntendedEndUserRole, TypicalAgeRange, Difficulty and TypicalLearningTime.*

### 4.1. Feature Extraction

Before the recommendation is started, the metadata files are extracted. Each feature of each metadata will be stored in a set. The forms of the sets are shown at Eq. 1 and Eq. 2.

$$LO_i = \{(Title), (Language), (Keyword), (Coverage), (LearningResourceType), (IntendedEndUserRole), (TypicalAgeRange), (Difficulty), (TypicalLearningTime)\} \quad (1)$$

$$LO = \{(LO_1), (LO_2), (LO_3) \dots (LO_i)\} \quad (2)$$

### 4.2. Keyword Processing

The users will input some keywords in order to search for the LOs. The keywords will be processed before the searching is started. The stemming process is undergoed to reduce the inflected words to their stem, such as the words ended with, "-ed ", "-ing" or "ly ". It is done by Porter’s Stemming Algorithm [10].

### 4.3. Ontology Match

The semantic similar terms of the processed keywords will be taken from WordNet database. The semantic similar terms are located in the same synset in the WordNet database with the keywords. They are under same concept and same object in ontology. For example, in the synset of {automobile, autocar, motor car, car}, each of the terms in the synset are included in users searching keywords, another terms are going to be included also. Only same level terms of the keywords in the ontology tree are considered in our model.

All of the terms (both users input terms and semantic similar terms) are stored in a keyword set, *O*. In the set of *O,* the semantic similar terms will be stored in a same subset.

### 4.4. History Extaction

As the personalization is done based on the used history of the users, the Learner Preference History (LPH) which is stored in User Profile database will be extacted and stored in the set of *usedObject(l).l* shows the *userID*. The LOs that are used by *l* will be stored in *usedObject(l).*

### 4.5. Search for Matched Objects

The model will search for the matched objects with the keywords set of *O*. Any terms in any features of metadata of any LO are matched with any terms in *O* will be stored in the set of *matchObject(l)*.

### 4.6. User's Preference

Each features of each of the LOs in *matchObject(l)* will be compare with each features of each of the LOs in *usedObject(l)*. For example there is $LO_1$ and $LO_2$ in *matchObject(l).* The *Keyword* feature of $LO_1$ is *Car* while the Keyword feature of $LO_2$ is *Bus*. In the *userObject(l),* the user, *l* has previously used $LO_3$, $LO_4$ and $LO_5$. The *Keyword* features of $LO_3$, $LO_4$ and $LO_5$ are *Car*, *Automobile* and *Bus* respectively. Hence, the Preference Score (*Pscore*) of the *Keyword* feature of $LO_1$ is 2/3 because the *Keyword* feature of $LO_1$ is *Car* and appears 2 times (*Car* and *Automobile* are semantic similar in ontology) in total of 3 LOs in *userObject(l).* The *Pscore* is calculated with Eq 3. In Eq. 3, *j* shows the order of features and maximum is 9.

$$Pscore\left(matchedObject_i(l)\right) = \sum_{j=1}^{9} \frac{\sum_{x=1}^{\max(x)} \left(matchedObject_i^{\,j}(l) \text{ exists in } \mathrm{usedObject}_x^{\,j}(l)\right)}{number\ of\ usedObject(l)} \tag{3}$$

### 4.7. Similar Users' Preferences

The similar users are the users who are having high similarity of usage history with the user. The similarity degree counts the precentage of LOs that are used of user *l* is used by target user *sl* (Eq. 4). If the similarity degree is over a particular variable (*similar_threshold*), the *sl* is considered as similar user. For every similar user, their used objects will be extacted and the matched objects with keyword set of *O* will be found. Based on that, the Similar User Preference Score (*Sscore*) will be calculated (Eq. 5).

$$sim(l, sl) = \frac{\sum_{x=1}^{\max(x)} \left(userObject_x(l)\ exists\ in\ LPH_{sl}\right)}{number\ of\ usedObject(l)} \tag{4}$$

$$Sscore\left(matchedObject_i(l)\right) = \sum_{j=1}^{9} \frac{\sum_{x=1}^{\max(x)} \left(matchedObject_i^{\,j}(l) \text{ exists in } \mathrm{usedObject}_x^{\,j}(sl)\right)}{number\ of\ usedObject(sl)} \tag{5}$$

### 4.8. Recommendation Score

The Recommendation Score (*Rscore*) of each LOs in *matchObject(l)* will be counted (Eq. 6). In Eq. 6, both $\alpha$ and $\beta$ are predefined. The ranking of the LOs will be based on the *Rscore*.

$$Rscore\left(\left(matchedObject_i(l)\right)\right) = \alpha\ \mathrm{Pscore}\left(\left(matchedObject_i(l)\right)\right) + \beta\ \mathrm{Sscore}\left(\left(matchedObject_i(l)\right)\right)$$

$$while\ \alpha + \beta = 1 \tag{6}$$

### 4.9. Exclusion Case

If the user $l$ is the new user who does not have any records and history in the system, the LOs in *matchObject(l)* is ranked based on the overall citation number. The LO that is used by most users will be ranked at first.

## 5. Future Work and Conclusion

To examine the efficiency and completeness of the proposed recommendation model, the exact system should be implemented, including the recommendation model. A number of learning objects with different properties (for example different topics, with different learning time, different language and etc.) should be created. After examining the model with the learning objects, the recommendation results should be analyzed. Statistical data would be collected.

However, a theoretic idea of the ontology based personalized recommendation model for learning objects in SOA e-learning system is proposed. By providing an ontology based recommendation model, it is easier for the users to search and select the LOs that are suitable for them. Indirectly, it is to increase the probability of the LOs to be reused in the system. As the result, the reusability degree of the LOs will be increased in the e-learning system.

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