

# A Hybrid Recommender System for E-learning Environments Based on Concept Maps and Collaborative Tagging

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## Abstract

*Recommender Systems could be used to suggest the items being interested for learners in an e-learning environment. These systems can be useful to recommend learning resources or any other supportive advices to the learners. Different kind of algorithms such as user-based and item-based collaborative filtering have been used to establish a recommender system. With increasing popularity of the collaborative tagging systems, tags could be interesting and useful information which could be considered as part of a metadata to enhance recommender system's algorithms. On the other hand concept maps can be a useful means for learners to visualize their knowledge. Therefore, learners could be supported in their own learning path by recommending concept maps, tags, and learning resources, and also the learning performance of individual learners could be promoted. In this paper, an innovative architecture for a recommender system dedicated to the e-learning environments is introduced. This system simultaneously takes advantage of collaborative tagging and concept maps. By mapping the tags and concepts completed by a learner, incomprehensible facts of his/her knowledge will be identified. Therefore, recommending concept maps containing related and not being understood tags, will be helpful. In the proposed algorithm the similarity of concept maps and tags being labeled by users are computed to achieve the best suggestion.*

**Keywords:** Recommender Systems, Concept Maps, Collaborative Tagging, E-learning

## 1 Introduction

Web-based learning environments are becoming very popular. Typical E-learning environments, such as Moodle (Riordan and Marcais) and Blackboard include course content delivery tools, synchronous and asynchronous conferencing systems, Forums, quiz modules, sharing resources, white boards and etc. In these environments, educators utilize resources such as text, and multimedia to develop the learning progress. Learners are encouraged to study the resources and participate in activities. However, for learners it is very difficult and time consuming to track and assess all the activities and resources. On the learner's side, it would be useful if the system could automatically guide the learner's learning path, and intelligently recommend on-line activities or resources that would improve the learning process. "The automatic recommendation could be based on

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the instructor's sequence of navigation in the course material, or, it could be based on navigation patterns of other successful learners." (Osmar R. Zaiane 2002)

A user profile is a collection of personal data associated to a specific user, and refers to the explicit digital representation of a person's identity. A user profile can also be considered as computer representation of a user model. User profiles are constructed by different kind of information such as the user's knowledge, interests, goals, background, and individual traits. In this paper we use a collaborative tagging system in the proposed E-learning environment and utilize the tag collections of the user as the user's interest in a specific topic. We also assume that each learner in the system is capable of illustrating his knowledge with a concept map.

In collaborative tagging system the users tag the resources they've studied by labeling them with specific labels. The tag collection of each user can identify his/her interests in different topics. Concept maps are an explicit graphical representation of a human's understandings in a domain of knowledge. Concept maps represent this understanding by means of a two-dimensional network in which nodes correspond to concepts, and links correspond to the relationships between concepts. In a concept map, *concepts* are the labels used to refer to objects or events and *linking phrases* (the text on the links) are usually verbs (Novak & Gowin, 1984; Valerio et al 2008).

Given that each person's understanding of a domain is different, even if people construct concept maps on the same topic, the maps constructed by individuals are different, reflecting their personal knowledge structures (Valerio et al 2008). Hence concept maps can be used for knowledge sharing and comparison.

In this paper, we describe the architecture of an automatic recommendation system for learning environments that considers the profiles of the learners containing his/her tags and concept maps.

## 2 Related Works

**Recommender Systems:** recommender systems are a new method on the internet in which it suggests and advices the users the items that they may wish to purchase. With the large information expansion, users need a complete facility to find and navigate their needs. A recent survey of recommender systems could be found in (Maes, Guttman & Moukas, 1999).

The most popular recommender systems that are used and produced these days are the collaborative filtering type. The method is such that they aggregate information about the users and after locating the similarities between users, specific recommendation is given to them. This type of recommender systems can either be item-based or user-based. Such a system can be seen in Ringo that makes use of the user's music preferences which is calculated by taking count of albums and artists rated by the user (Shardanand & Maes, 1995).

Another well known recommender system is the content-based type, which are based on machine learning research. They have the ability to parse the content and classify it in order to make the best recommendation. "These systems use supervised machine learning to induce a classifier that can discriminate between items interesting to the user and those uninteresting."

These two kinds of recommender systems have some differences to one another. One of the advantages of collaborative filtering is that it is suitable for suggesting any kind of resource, e.g. photos, text, videos and music (Herlocker J.L et al. 2000). The algorithm is only based on the historical data and preferences of the target user.

In this article an algorithm is suggested that acts like a collaborative filtering recommender system to provide recommendations to the learners. It aggregates the learners' interests specifically tags and concept maps, and finally by locating a similarity between the resources, provides recommendations.

**Concept Maps:** Concept mapping (Novak & Gowin 1984) has been widely used by individuals from elementary school students to scientists to externalize knowledge, conduct knowledge construction (David B. Leake et al. 2003), share knowledge, and compare knowledge to advance human learning and understanding (David Leake et al. 2004). In concept mapping, subjects construct a two dimensional, visually-based representation of concepts and their relationships (David B. Leake et al. 2003) . The flexibility in constructing concept maps is commonly regarded as an advantage of concept mapping for use in many fields (Valerio .et al 2008). "The map reflects what the person knows, and for experts, the map is used to represent the idiosyncrasies of each expert" (Valerio .et al 2008). The study being done by Tarouco, Geller, and Medina's (2006) addressed that using concept maps increase the organized communication among participants (Simone C. O. et al. 2008).

**Collaborative Tagging:** " Tagging is a way to organize content through labeling." By this means we can relate meanings to different resources such as texts, URLs, photos and music. "Tags are keywords that can be associated with content as a simple form of metadata". There is no restriction in associating tags to content. We can use any word and phrase that we desire. In contrary in systems like the library we have to define specific keywords as a string on the resource. (On Kee Lee. S; Hon Wai Chun. A, 2007). The phrase Collaborative tagging is the process of sharing items and recourses so that everyone can take advantage of them. Users can organize their own knowledge such that all participants can view and benefit from the labeling.

It appears that using tags as discussed above is easy and flexible, but as it is obvious the non limitation of using any phrase to explain contents can be ambiguous and cause redundancy problems. Tags used in this way lack semantic meanings and can be complicating and miss understood. For example the phrase "apple" can refer to the fruit, and also can point to Apple Macintosh computers. In this case extracting the right meaning from these phrases can be hard to accomplish.

### 3 System Architecture

The system architecture that we have proposed in this article can be seen in figure 1. The recommendation process is composed of seven stages:

1. Users study resources
2. Users tag resources
3. Users create concept maps
4. The system finds similar tags for recommendation

5. The system finds similar concept maps for recommendation
6. Match the words of tags and concept maps of one user
7. Give final recommendation to users

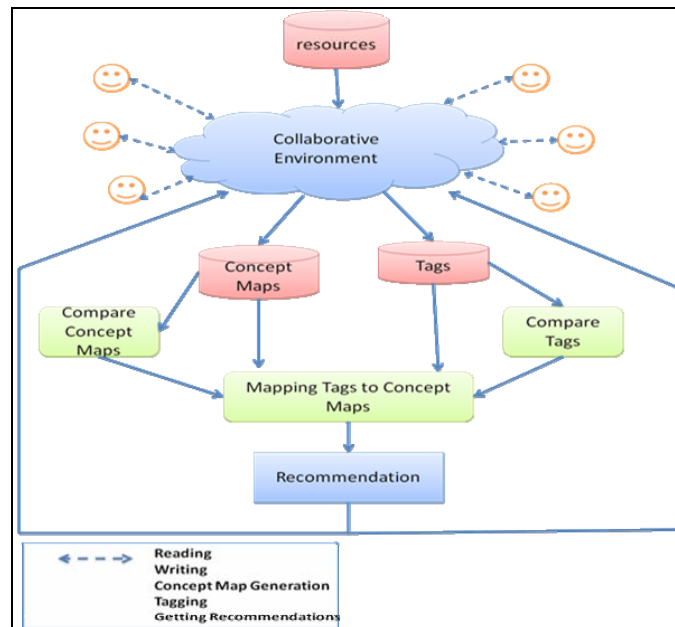


Figure 9. System Architecture

### 3.1 Detail in each Stage

**Users study the resources:** In this stage users can read from the resource repository. These resources can be contents that the educator has placed for the students. We illustrate these contents with the list of  $n$  contents and defined as:  $R = \{r_1, r_2, \dots, r_n\}$ .

**Users tag the resources:** After the user reads the content, he can tag the resource with one or more keywords to demonstrate his knowledge of that content. As discussed in (Ae-Ttie Ji et al. 2007) for a set of  $m$  tags  $T = \{t_1, t_2, \dots, t_m\}$ , tag usages of  $k$  users can be represented as a *User-tag matrix*,  $A$  ( $k \times m$ ). Each  $A_{u,t}$  represents the frequency of meaning how many times a user  $u$  has been tagging with a tag  $t$ .

**Users create the concept maps:** In this section each user can describe his knowledge about a particular subject by modeling it in a concept map. Each node of the concept map can contain a tag that user has used in the previous stage to describe a resource. The set of user's concept map is represented as  $CM_{u,i} \quad \forall u, i = 0, \dots, d$

**System finds similar tags:** In this section we present a formula which makes use of the similarity between the users tags to identify users who have similar concerns. The output of this formula is a number which illustrates the similarity between the users. As discussed in paper (Ae-Ttie Ji et al. 2007) we can calculate the user-user similarity with equation 1.

$$[1] \quad sim(u, v) = \cos(\vec{u}, \vec{v}) = \frac{\sum_{tag} A_{ut} A_{vt}}{\sqrt{\sum_{tag} A_{ut}^2} \sqrt{\sum_{tag} A_{vt}^2}}$$

Where  $u$  and  $v$  are the users and the matrix  $A$  is the matrix explained in the previous section. In order to find  $k$  nearest neighbor ( $KNN$ ), cosine similarities between a target user and each user with tag frequencies of corresponding user in *user-tag matrix*,  $A$  is calculated.  $KNN$  includes users who have higher similarity score than the other users and means a set of users who prefer more similar tags with a target user. In the next stage we find the interest of user  $u$  to a particular tag:

$$[2] \quad s_{ut} = \sum_{v \in KNN(u)} (A_{vt}) \cdot sim(u, v)$$

**Find similar concept maps:** To find the similarity between two concept maps a comparison should be made. To deal with the concept map comparison problem one method is to assume each concept map as a graph and aim to achieve the best solution that depicts the similarity between two different graphs. For this, a semantic comparator is used to calculate the correspondences among the concepts and relations, represented as attributes of both graphs. "Thus, a solution to the graph matching problem represents an association between the concepts maps compared" (De Souza et al. 2008). The difficulty is the method to find the similarities of two graphs." To do this, concept maps  $CM1$  and  $CM2$  are represented as graphs  $G1$  and  $G2$  and their attributes (concepts and relations) are extracted and compared by a semantic comparator to construct the node and edge similarity matrices". More details of the algorithm can be found in: (De Souza et al. 2008). *CmapTools* (v.4x) has a Compare-to-Cmap feature in the Tools menu that allows people to do the comparisons (Clariana et al. 2006). An alternate approach for comparing multiple concept maps is a software tool called *Pathfinder Knowledge Network Organizing Tool (KNOT; Schvaneveldt, 1990)* that has analyses capability including simultaneous comparisons between multiple concept maps (Clariana et al. 2006).

With these definitions one of the above techniques can be used to compare two concept maps in our algorithms. We suggest using the CMap tool as it is well known and its efficiency has been proven.

**Matching process:** In this part the words in the concept map and the phrases related to the tags for every user is compared with each other. This is done to know what should be recommended to the users. If tags are used in the concept maps, but are not in relationship with each other, then it is useful to suggest a concept map in which these tags are related. Otherwise, a concept map composed of more tags or a different concept map is proposed.

The algorithm for this part can be separated into three different filters. We can assume this recommender system as a collaborative filter recommender system. We briefly explain about each filter and then suggest our proposed algorithm.

**Filter 1:** In the first filter, we extract the tags and concept maps of user  $u$  as input and then the tags that couldn't be related in the concept map are filtered out. As output we find the concept maps of other users who have implemented these tags.

**Filter 2:** In the second filter, we have those concept maps which contain the unknown tags for user  $u$ . We filter out the most similar concept maps to the user  $u$ 's concept map with the algorithm discussed in 3.2.5

**Filter 3:** In the last filter, we have the most similar concept maps as input. We relate these concept maps with their constructors. Finally we can filter out tags most similar to the user's tags according to 3.2.4. So as the final output we have concept maps, tags and users who are most similar to one another.

An example of the utility of these three filters can be seen in figure 2.

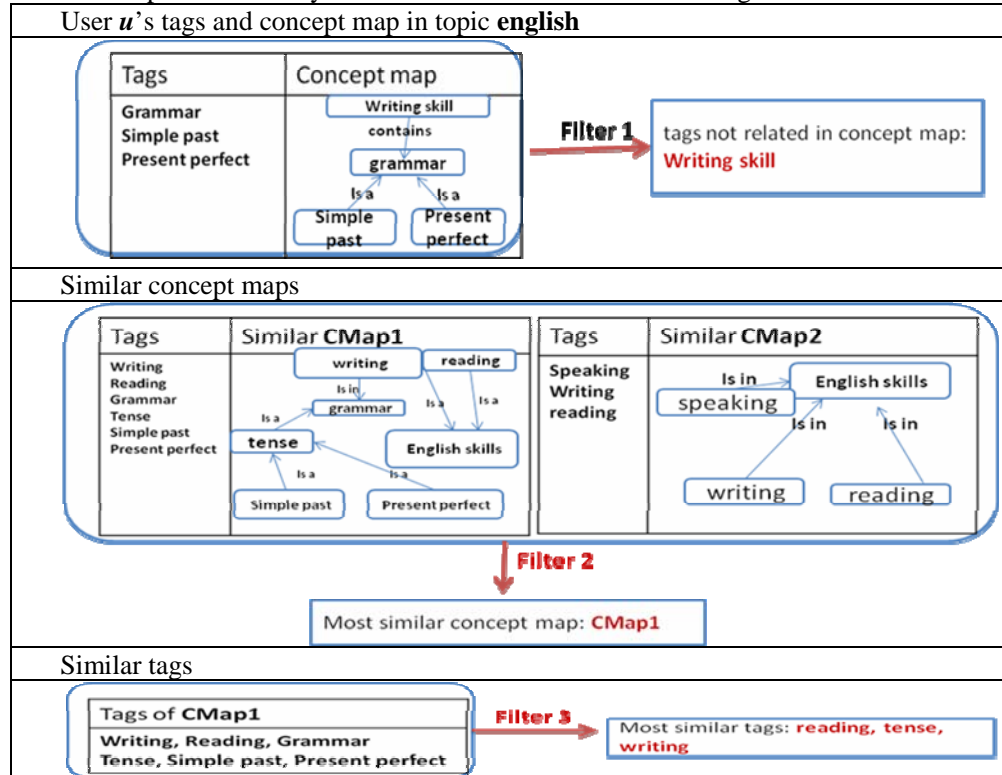


Figure 10. Example of Proposed Algorithm

In the following section we discuss the algorithm which utilizes three mentioned above filters to achieve the best recommendation for users.

**Give final recommendations to users:** As mentioned in the last line of algorithm 1 we recommend similar concept maps, tags and similar users to the user.

In figure 3 we have placed a snapshot of our work. It's a system that depicts our proposed algorithm. As it can be seen in the concept map link, an illustration of the user's concept map is presented. The tags related to the concept map are also provided below the map. Our algorithm is launched and the most similar concept maps are recommended. This recommendation makes use of the user's tags for a more efficient recommendation as discussed in section 3.1. In our belief these recommendations (both concept maps and tags) can guide the learner for a better knowledge in a specific topic.

*Algorithm 1. Hybrid Recommendation Algorithm*

$TU_u$ : The set of tags that the user  $u$  couldn't implement in his concept map  
 $CM_i$ : The Concept Maps that have implemented tag  $i$   
 $F_i$ : Friends that could implement tag  $i$  in his concept map  
 $T_j$ : Other tags that the  $j$  has implemented in his Concept map that  $i$  has not  
 For each user  $u$   
 //Compare tags to Concept maps for the user  $u$   
 $TU_u$  = extract tags that are not implemented in the Concept Map of the user  $u$   
 For each tag  $i$  in  $TU_u$   
     //search for Concept Maps in the system that have implemented  $i$   
      $CM_i$  = the Concept Maps that have implemented  $i$   
 For each concept map  $c$  in  $CM_i$   
     Find the most similar concept map to the user  $u$ 's concept map  
     //this has been done in part 3.2.5; we can Easley match  $CM_i$  with those found in 3.2.5  
      $F_i$  = the person who has implemented  $i$   
     Find similarity between  $u$  and  $F_i$  according to 3.2.4  
      $T_j$  = tags that the person has implemented in his Concept map that  $u$  hasn't  
 Recommend  $CM_i$ ,  $F_i$ ,  $T_j$  to  $u$

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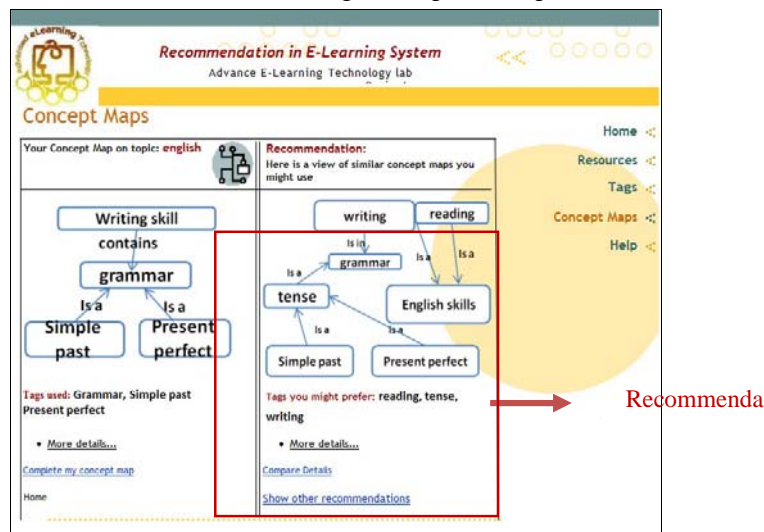


Figure 11. Prototype

#### 4 Conclusion and Future works

We proposed an original algorithm for recommender systems which utilizes collaborative filtering and uses the user's tags and concept maps as its input. The algorithm has three stages for filtering out the best recommendations. In the first filter we take out the concept maps that have implemented the tags that have not been related in a users concept map. In the second filter the most similar concept maps are extracted and finally in the last filter we match the tag space of the users to suggest the most similar tags for the user.

For future work we would experiment our results with suitable data. The data for the tags can be provided from the social bookmarking systems such as delicious.com or last.fm.com and for the concept map collection we can ask from the users to illustrate a concept map of their knowledge. Also we can ask the user if he wants to be recommended the most similar concept maps to him or the most different concept maps compared to his own. This is because the user might want to observe other users opinions about a particular topic and concept.

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