



A model to represent users trust in recommender systems using ontologies and fuzzy linguistic modeling



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ABSTRACT

Recommender systems evaluate and filter the vast amount of information available on the Web, so they can be used to assist users in the process of accessing to relevant information. In the literature we can find countless approaches for generating personalized recommendations and all of them make use of different users' and/or items' features. In this sense, building accurate profiles plays an essential role in this context making the system's success depend to a large extent on the ability of the learned profiles to represent the user's preferences and needs. An ontology works very well to characterize the users profiles involved in the process of generating recommendations. In this paper we develop an ontology to characterize the trust between users using the fuzzy linguistic modeling, so that in the recommendation generation process we do not take into account users with similar ratings history but users in which each user can trust. We present our ontology and provide a method to aggregate the trust information captured in the trust-ontology and to update the user profiles based on the feedback.

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1. Introduction

Nowadays we live in the so called Information Society, in which we are bombarded with a lot of information in all fronts of our lives. This great amount of information introduces noise in the way we access to information, which makes difficult for us to find relevant information and also affects the way we make decisions. For this reason, the Internet users increasingly need fast and effective automated systems that assist them in an easy and effective manner to access to information relevant for them according to their preferences or needs [33].

Recommender systems are examples of this kind of automated systems [10,28,53]. A recommender system attempts to discover information items (movies, music, books, research resources, images, web pages, papers, etc.) that are likely to be of interest to the user. These tools separate relevant from irrelevant information and deliver it then to users who demand it, which makes them very useful for commercial organizations too. Recommender systems are broadly used for knowledge discovery and to provide personalized items in many activities as e-commerce, digital libraries, e-marketing and so on. The delivery of personalized recommendations, requires the system to have some information available about every user, such as the ratings provided by the users about the viewed or purchased items. This need for information introduces the requirement for the system to maintain users' profiles containing the users' preferences or needs. Another aspect to take into

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consideration is which additional information is required by the system, and how this information is processed and managed to generate a list of personalized recommendations. One of the mostly used method to generate recommendations is the collaborative approach [47] in which the recommendations to a particular user are based upon other users' recommendations with similar profiles, taking into account the ratings provided by those users.

One key disadvantage of this approach consists of the need for a lot of ratings to obtain a good performance, which is usually difficult to achieve [42]. In fact, users typically provide just a few ratings, so the systems have difficulties to compute the similarity between two users. Therefore, collaborative approaches tend to fail in generating recommendations since they usually fail at obtaining groups of users with similar preferences. Thus, some improvements need to be introduced to overcome this situation and one promising direction is to focus on *trust*, which plays a crucial role in on-line social networks [17,55], so widespread and popular today. Trust networks are social networks in which users can assign trust scores to each other. In fact people tend to rely upon recommendations received from trusted users, such as friends, more than those generated by automatic systems [51]. Although the recommendations provided by a recommender system might be more precise, users we trust could make more useful recommendations for us. In the literature, we can find some proposals about the incorporation of trust models in recommendation systems [30,37,54,59]. In these systems, the recommendation engine uses in one way or another the trusted network between users. A key aspect to obtain good results in the generated recommendations is precisely storing the trusted network. For that reason, and because of the success they have demonstrated in similar scenarios, we propose to use ontologies as an efficient way to represent and exploit the information, especially trusted network.

Ontologies are very suitable to model different aspect of the world we live in. In the last decade, ontologies have been increasingly used within the field of recommender systems, allowing knowledge-based techniques to supplement classical machine learning and statistical approaches [6,57]. Ontologies have been introduced in recommender systems with different goals (see Section 2 for further details). In the collaborative approach, domain ontologies are mainly used to analyze the user behavior according to this knowledge structure, building user profiles [34,50]. There are even proposals including fuzzy logic in the ontological representations to allow for some uncertainty in them. For instance, fuzzy ontologies can be used to represent user profiles [8,16,27,40]. In the same way that fuzzy ontologies have been used to represent user profiles, we consider them suitable for modeling the trust between users, extracted from a trusted network.

In this sense, our proposal relies on a combination of these approaches to improve the recommendation process, namely trust networks along with trust propagation mechanisms, and user profiles based on ontologies. Our proposal is therefore, a new recommender system whose main novelties are listed below:

- We define an ontology that represents the degree of trust between users based on the evaluations provided according to their experiences. We are going to implement a multi-granular fuzzy linguistic modeling [32,36], to keep the maximum flexibility to manage the information by representing the different concepts of the system with different linguistic label sets.
- We use a domain ontology to establish the relationships between users and their preferences about the recommendation subject.
- We present a method to estimate the trust score between two users, because the trusted network can be huge and most users do not know each other.
- We propose a new recommendation approach in which the recommendations are taken from trustworthy users, i.e., we do not consider users with similar ratings history but users in which each user can trust.

The rest of this paper is set out as follows: Section 2 contains background information about the basics of recommender systems, the fuzzy linguistic modeling and the basics of ontologies. In Section 3 we present the new proposal. Section 4 addresses the validation of the system and in Section 5 we throw our conclusions based on the study findings.

2. Background

2.1. Basis of recommender systems

Recommender systems help users in the effective identification of items suiting their wishes, needs or preferences. They have the effect of guiding the users in a personalized way to relevant or useful objects in a large space of possible options [9]. In a recommender system, the users' preferences about research resources can be used to define user profiles that are applied as filters to streams of documents. In this sense, building accurate profiles plays an essential role in this context making the system's success depend to a large extent on the ability of the learned profiles to represent the user's preferences and needs. Then, in order to generate personalized recommendations that are tailored to the user's preferences or needs, recommender systems must collect personal preference information, such as user's history of purchase, items which were previously interesting for the user, click-stream data, and demographic information. Two different ways to obtain information about user preferences are distinguished [22], although many systems adopt a hybrid approach: the *implicit approach* is implemented by inference from some kind of observation, and the *explicit approach* which interacts with the users by acquiring feedback on information that is filtered.

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