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Empowering recommender systems using trust and argumentation

Punam Bedi, Pooja Vashisth *

Department of Computer Science, University of Delhi, Delhi, India

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ABSTRACT

Recommender systems (RSs) use the opinions of members of a community to help individuals in that community identify the information most likely to be interesting to them or relevant to their needs. These systems use the similarity between the users and recommenders or between the items to form recommendation list for the user. We believe that, various interactions and arguments exchanged in favor or against are responsible for the eventual result of a recommendation process. Therefore, besides recommendations it is vital to determine the users' response on such interactions to determine more accurate trust estimates for users in the system. Hence, this paper proposes a novel fuzzy and argumentation based trust model which is also integrated within the practical reasoning of agents in the multi-agent recommender systems. This integration allows the agent to take trustworthy decisions and reason about them as well. The user is also able to make a wiser selection in case there are conflicting opinions related to a specific product or the user comes across a new, unseen product and is indecisive about it. As a result it improves recommender's persuasive power and user's trust in the system resulting in an increase in the user's acceptance of the recommendations. The experiments performed with a Book Recommender System (using a hybrid recommendation approach), confirms that the variant implemented with the proposed approach performs better than those using conventional methods. Results obtained from evaluation metrics showed that the recommendations were more accurate, relevant and novel.

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1. Introduction

A recommender system (RS) attempts to discover information items (like movies, music, books, news, etc.) that are likely of interest to a user [25]. Recommendation systems are used widely in suggesting products in e-commerce [36], recommending courses in learning environments [35], and advising research resources in digital libraries or in a technology transfer office [25]. These personalized systems are especially useful when they identify information that was previously unseen by the user. Current recommendation technologies can be enriched by developing intelligent systems with the ability to qualitatively exploit data from users and service providers. Such systems should be able to perform inference on data, explore the reasons beyond user preferences and resolve conflicts [11]. They should also allow the user to evaluate reasons behind recommendations. The most appropriate paradigm for designing such complex systems is the Multi Agent System (MAS) technology [45]. A multi-agent system is comprised of multiple agents working together to solve a problem. These

* Corresponding author. Address: L-37, Street No. 22, New Mahavir Nagar, New Delhi 110018, India. Tel.: +91 09971696984; fax: +91 11 27662553.
E-mail addresses: punambedi@ieee.org (P. Bedi), poojavashisth@rediffmail.com (P. Vashisth).

agents can communicate with each other and assist each other in achieving larger and more complex tasks [4,5,15,29,45]. Traditionally, the three main techniques used in literature to compute recommendations have been content based [26], collaborative filtering [34] and hybrid approaches [7]. Over the years several inter-disciplinary techniques have been applied to these methods to improve efficiency of the recommender systems [2,3,6,11,14,24,29]. We now describe a couple of such influential practices.

Trust can play a crucial role in the multi-agent recommender systems where various agents work in the interest of their owners, carrying out their owners' wishes while interacting with other entities. In such interactions, agents will have to reason about the amount that they should trust those other entities. The basis of these systems is trust relationships that exist between users to users due to which users thus become explicitly connected in a network. This inferred trust network also known as "web of trust" is highly dynamic and evolving, and mimics the real world "friend of a friend" recommendations.

The argumentation approach can be used to enhance performance of the trust mechanisms by combining trust with argumentation [17]. Argumentation system is simply a set of arguments and a binary relation representing the attack-relation between the arguments. The integration of argumentation and trust in a system can prove to be promising in a number of ways. One can use trustworthiness of an agent as value of the argument it provides. Parsons et al. [22] have considered the use of arguments for computing and combining trust from different sources. Trust and argumentation can be combined to compute the trustworthiness of an agent based on arguments generated by it. Argumentation can also be used to improve communication about trust [17].

As both trust and argumentation can play a major role in enhancing recommendation technologies, a novel argumentation based fuzzy trust model is proposed in this paper which is integrated within the agent's reasoning mechanism. The motivation behind this research work is to provide a solution to some of the several research issues faced by present day RSs. The first issue under consideration is "*Exposing underlying assumptions*", by tracing the evidence used to provide suggestions to the users; recommenders can expose the underlying assumptions for the user. Moreover, people trust recommendations more when the system can explain why this recommendation was generated [43]. This can be handled well by using argumentation to explore the underlying structure of a given piece of information [11]. However, the second issue which arises is "*Proving rationally compelling arguments*". Usually, there is not an explanation about the reasoning process that has been followed to come up with specific recommendations. By providing a formal model, users will get appropriate justification of why certain recommendations should be trusted or preferred. This may resolve conflicts between user desires and recommendations [2]. Lastly, the issue related to, "*Trust and trustworthiness*", is of umpteen importance in recommendation technologies [3,32,43]. Trust plays a vital role in the agent based RSs as the agents maintain a trust network of their acquaintances and each agent keeps information about how much it trusts them. Therefore, it is desirable to consider these trusty acquaintances in recommendation process.

In light of the above mentioned research issues, we put forward the main contributions of this paper as follows: (1) We develop a trust model that keeps track of all the interactions carried during a recommendation process. Trust determination depends on final user feedback as well as the intermediate communications between agents. (2) This work is pioneer in investigating the integration of fuzzy and argumentation based trust measures with the agent's reasoning mechanism. This ensures that the recommendations do not just come directly from the recommendation algorithm (using a hybrid approach) but also from the acquaintances that a user has in his trust network. (3) Using argumentation, agents are able to detect conflicts between varied opinions. These are resolved interactively by agent communication and taking user's feedback over the interactions.

The paper is organized as follows. Section 2 briefly describes work done in the field of trust and argumentation. Section 3 defines the proposed argumentation based fuzzy trust model. Section 4 deals with the integration of trust in the reasoning mechanism using argumentation. In Section 5, we demonstrate use of the proposed approach giving an example where argument attacks are resolved using acceptability analysis. Section 6 briefly describes the hybrid recommendation approach used to implement the proposal. It also presents experimental study and the results were found to be encouraging. Finally, we close this paper with conclusion in Section 7.

2. Related work

In recent years, several models of trust have been developed [5,6,12,38,42]. Much of the work on trust in computer science have concentrated on dealing with specific scenarios in which trust has to be established or handled in some fashion. There have been studies on the development of trust in e-commerce through the use of reputation systems and studies on how such systems perform [32]. Another area of concern is the reliability of information, and its sources on the web, like the one provided by the recommender systems. For example; in [42], the authors relate information reliability with the length of the paths that connect users. They evaluated several path length incorporating aggregation strategies in order to generate more and highly accurate predictions. Dong, Berti-Equille and Srivastava [12], have investigated mechanisms to determine which sources to trust when faced with multiple conflicting information. Bedi and Vashisth in [4] extended this idea to rate the individuals who provide information, by looking at the history of the arguments they have provided.

Computing trust is a problem of reasoning under uncertainty, requiring the prediction and anticipation by an agent (the evaluator) of the future behavior of another agent (the target). Therefore, argumentation approach can be used to improve performance of the trust mechanisms. Despite the acknowledged ability of argumentation to support reasoning under

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