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論文の内容の要旨

Recommender systems (RSs) have been developing rapidly since they were introduced in 1990s; and in practice, these systems have been applied in a variety of e-commerce applications. Usually, RSs provide rating domains representing as finite sets and allow users (customers) to evaluate items (products or services) with hard ratings which are known as single values in the sets. However, user preferences are subjective and qualitative; therefore, in some scenarios, representing user preferences as hard ratings is not suitable. Moreover, most previous studies on recommendation techniques have unfortunately neglected the important issue of imperfect information which may be present due to ambiguities and uncertainties in user ratings.

More recently, using soft ratings represented as subsets of a rating domain is considered to be a strategy to model not only subjective and qualitative information but also imperfect information about user preferences in RSs. According to the literature, RSs offering soft ratings are developed based on Dempster-Shafer theory (DST) which is known as one of the most general theories for modeling imperfect information. Furthermore, these days, communication and collaboration in social networks have become more and more convenient and frequent, and social relations in social networks can naturally influence individual behaviors as well as decisions including the ones on buying items. In this research, we have developed two novel collaborative filtering RSs based on DST, which exploit community context information and community preferences extracted from social networks for improving accuracy of recommendations. One of the developed systems is able to deal with the sparsity problem, and the other can overcome both the sparsity and cold-start problems.

In RSs based on DST, context information, community context information or community preference is employed for predicting unprovided ratings, and then both predicted and provided ratings are used for computing user-user similarities. As predicted ratings are not one hundred

percent accurate, while the provided ratings are actually evaluated by users, in this research, we have proposed a new method for computing user-user similarities, in which provided ratings are considered more significant than predicted ones.

As observed, Dempster's rule is currently applied for combining information about user preferences in RSs based on DST. However, when using this method, the combined results usually contain many focal elements with very low probabilities and a few focal elements with high probabilities. The focal elements with very low probabilities can lead to unsatisfactory results in case of combining highly conflicting mass functions. Therefore, in this research, we have developed two new combination methods, called 2-probabilities focused combination and noise-averse combination, which are capable of reducing the focal elements with very low probabilities. Moreover, Dempster's rule does not allow to combine totally conflicting mass functions which are common in RSs based on DST due to the diversity of users; thus, we have also developed two new mixed combination methods that support combining totally conflicting mass functions. In fact, the new combination methods developed in this research can be employed as useful tools for fusing information about user preferences from different sources in RSs based on DST.

Keywords: Recommender System, Dempster-Shafer Theory, Social Network, Information Fusion, Uncertain Reasoning.

論文審査の結果の要旨

With the rapid growth of e-commerce and other Web applications, recommender systems (RS) have received great attention and been actively studied during the last two decades. Most previous RS studies assume that user's preference on items is represented as a hard rating chosen out of a finite set of discrete rating values. However, user ratings are mostly subjective and qualitative in nature and additionally uncertain due to the ambiguity of rating values. Recently, Dempster-Shafer theory of evidence (DST) has been used for modeling uncertainty in user ratings in RS. In RS based on DST, user preferences are modelled using soft ratings (i.e., subsets of rating domain) instead of hard ratings as in conventional RS and then allow to capture subjective and qualitative nature of user preferences. In addition, DST also provides a powerful tool for information combination which can be used for integrating user preferences from different sources in order to improve the quality of recommendations.

The research of this dissertation is focused on RS based on DST with the following goals: 1) to exploit information about user preferences from social networks so as to integrate into RS for improving the quality of recommendations 2) to develop methods of fusing information about user preferences extracted from different sources capable of handling conflict in RS based on DST. The dissertation also provided a comprehensive overview of relevant literature related to the research problem proposed. The main

contributions of this dissertation are as follows: (1) it proposed to integrate RS based on DST with social networks and use community context information about user preferences and community preferences extracted from the networks for handling the imperfection of information and dealing with the so-called sparsity and cold-start problems in RS; (2) it developed a new method for computing user-user similarities in which provided ratings are considered more significant than predicted ones; (3) it developed new rules of information combination capable of handling conflict and noise in user preferences in RS based on DST. Also, comprehensive experiments have been conducted on real-world datasets such as Movielens and Flixster to evaluate the effectiveness and efficiency of the developed methods. Finally, several important suggestions for future research on RS based on DST have been also highlighted in the dissertation.

This dissertation has made a significant contribution to theoretical and experimental developments within the area of RS based on DST. The research work presented has eventually resulted in three journal papers, one of which was published in *International Journal of Approximate Reasoning*, and six refereed conference papers.

In summary, Mr. NGUYEN, Doan Van has completed all the requirements in the doctoral program of the School of Knowledge Science, JAIST and finished the examination on February 1, 2017. All the committee members unanimously decided to pass the candidate.