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A Survey on Multi Criteria Decision Making Recommendation System using Sentiment Analysis

Gaurav Kumar

School of Computer and Systems Sciences, Jawaharlal Nehru University, New Delhi, India.

Abstract

The users usually make an essential decision in everyday life such as, either buying a product online, gathering information about movies, booking the best hotel, looking for the best tourist place, or making a reservation in a restaurant online. Social networking, users' participation in an online forum for discussion, and posting online reviews about products or services has become a popular trend among the user community. As a result, it is generating a large amount of information on the different media landscape. Today's, it has become difficult for the user in navigating through a large amount of information available on the web and find relevant information about his/her interest. Various recommender systems have been developed which mostly use collaborative and content-based filtering methods to alleviate the information overload problem. These recommender systems are usually based on the single criterion rating problem to determine the user preference. In general, there are many factors involved in making a better and informed decision. Customers' reviews and information from different online blogs, social media and e-commerce platform can be valuable information in determining the user preferences and develop a better model for decision making process. This paper characterizes the recommendation problem as a multi-criteria decision problem and provides a comprehensive survey of real-world applications of different multi-criteria decision making methods and explores the scope of customer's reviews in the decision making process.

Keywords: Recommender Systems ● Multi Criteria Ratings ● Sentiment Analysis ● MCDM ● Customer Reviews.

INTRODUCTION

Due to the recent revolution of Web 2.0 user-generated content has seen as the tremendous rise of information accessible on the World Wide Web (WWW). Its ease of accessibility facilitates customers to broadcast their knowledge and experience of products/services usage online. Social networking, users' participation in an online forum for discussion, and posting online reviews about products or services has become a popular trend among the user community. All this information can be useful in making an informed decision for buying a product online, visiting a tourist place, searching good hotels and restaurant, and so on. However, the user finds difficulty in finding the relevant information among the vast amount of information available on the web. There is a demand for some tools/software that recommend or suggest products or services to the user based on their requirements and interests to solve the problem of information overload.

Various recommender systems (RSs) based on collaborative filtering[1], content-based filtering[2] and the combination of both [3] (hybrid) have been developed in the last two decades to provide a personalized recommendation to the users. These recommender systems are being used in the various online platforms such as Netflix, Amazon, and eBay to increase their sales output. Collaborative filtering RSs majorly suffer from sparsity problem due to a limited rating of users on the item. To address such problem, content-based filtering RS has been developed. However, Content-based RS also suffers from limited content analysis problem. To address the limitations of both the approaches, hybrid RSs have been developed which combined the features of collaborative and content-based filtering to solve some of their shortcomings. However, there are several limitations still exist in these traditional recommendation approaches. All these traditional RSs usually consider a single criterion rating value for the recommendation. According to the authors [4]–[6] only rating on the item is not sufficient criterion to decide the suitable item for the recommendation because the selection of an item/service for an individual user may depend on more than one criteria. In general, selection of an item or service depends on multiple factors including the opinion of others. Integration and analysis of multiple factors in decision making model can lead to a more accurate recommendation.

In the last decade, there are a variety of multi-criteria recommendation systems [1], [4], [5], [7], [8] which have been developed to solve the problem of traditional recommender systems. In multi-criteria recommendation settings, users are being asked to rate on multiple attributes of an item/service. This additional information can help to model user's preference more accurately, and new multi-criteria based recommendation algorithms need to develop to take competitive benefits of this additional information. However, the insufficiency of rating data makes this method unsatisfactory[9]. These methods are still inadequate when target user has little historical data.

Recently, many researchers started incorporating the customers' reviews in recommendation settings to overcome the limitation of insufficient rating problems. Today, online customers reviews become a de-facto standard for measuring the quality of the product, restaurant, hotels, electronic gadgets, movies, tourist place, and so on. The continuous growth of the volume of online reviews is making it difficult for potential customers and manufacturers to extract valuable information that explain why customers like or dislike any items/services.

Researchers have used different sentiment analysis and opinion mining techniques [10]–[15] to summarize the customer's reviews to understand what customers like or dislike. The detailed information on the users' like and dislike on particular attributes of an item/service would help to analyze the users' interest more precisely.

Therefore, in this paper, we specifically emphasis on the customer's reviews, and provide a comprehensive survey on summarizing customers' reviews of multi criteria recommendation environment to solve the rating sparsity problem. We have also emphasized that recommendation problem can be considered as Multi Criteria Decision Making (MCDM) problem and reviewed real-world applications of different MCDM approaches to suggest the best item for the recommendation.

TRADITIONAL RECOMMENDER SYSTEMS

The recommender systems have been developed to help individuals in a community to find relevant items or services that they are looking for and which most likely to be attractive to them. In last two decades, various recommender systems have been developed which commonly use collaborative or content-based filtering [2] or hybrid methods (combination of both) [3], [16] to alleviate the information overload problem. Collaborative recommender system work based on the concept of patterns of collaboration among multiple people. For example, Remo and Juliet both have recently watched and enjoyed Dead pool movie. Remo has recently watched Deadpool-2 movie. Juliet has not watched yet, but the system has learned that both Remo and Juliet have similar taste, then system recommends this movie to Juliet. On the other side, a content-based recommender system is based on the concept of interacting with meta-data of the items. For example, if Remo watched a movie Avengers, and this movie has metadata tag "Action," "Adventure," and "Fantasy," then system recommend the other movies based on these metadata tags. Most of the current work on recommendation systems used by Netflix or Amazon [17] rely predominantly only on the star ratings and ignore the wealth of relevant information available in the customer's reviews. In most of the scenario [4], [6], [18], rating alone is not sufficient to decide the overall quality of an item, because the meaning of rating is ambiguous and it varies with the knowledge, experience, and understanding of the customers towards the services or products they use. For example, Rahul and his friend Karishma purchased a smartphone from Amazon. Rahul gives 5 (highest) rating (on a 1-5 scale) to a product for its quick delivery from Amazon, and his friend Karishma gives 1 (low) rating for her unfortunate experience of its usage. In the first case, the highest rating does not give any information about the quality of the product, and in another case, the lowest rating does not tell at all that the product is bad. Therefore, it is the need of the moment to incorporate additional information about the user interest on a product that may help improve the accuracy of recommendation.

MULTI-CRITERIA RATINGS RECOMMENDER SYSTEMS

There are many real-world applications which have incorporated multi-criteria rating settings in their recommendation environment to improve the accuracy. For example, Zagat's Guide provides the facility to customers to rate the restaurant ratings on three criteria, i.e., food, service, and decor. On the other side, Flipkart.com e-commerce platform provides a facility to their consumers to rate the consumer electronics (smartphone) on following attributes, i.e., camera, battery life, display, and value for money. Similarly, Yahoo! Movies ask their users to rate a movie on story, direction, visuals, and action. This additional rating information provided by users on different items/services can be helpful in determining the user's interest and thus, improving the accuracy of decision making model.

Manuselis and Costo [19] define new three algorithms, i.e., similarity per-priority, similarity-per-evaluation, and similarity-per partial-utility to evaluate the similarity between users in multi-criteria environments. The remaining steps of recommendation follow the same methodology of single criterion rating systems. Adomavicus and Kwon [4] use linear regression, and coefficients aggregation functions approach to improve the accuracy of a multi-criteria recommender system. Some researchers have also adopted probabilistic modeling approaches which have popularly being used in data mining and machine learning.

Sahoo et al. [20] extended the Flexible Mixture Model (FMM) in multi-criteria rating environment. They use two steps approach, i.e., Learning and Prediction to predict the overall rating of an unknown item. An experiment conducted using the extended FMM model on Yahoo! Movies data show the advantage of this multi-criteria rating approach over a single rating criterion despite the availability of very little training data. However, these multi-criteria rating approaches are not successful when there is limited data available for the target user. Thus, a need of incorporation of additional information is generated to overcome the rating sparsity problems.

RECOMMENDATION SYSTEM USING SENTIMENT ANALYSIS

Many researchers have incorporated the customers' reviews in the recommendation system to improve the accuracy of recommendation. Authors of [21] propose a new method called PRO which is based on adverb-verb feature extraction approach to extract the useful features and opinion from customers' reviews, and integrated with collaborative filtering methods to improve the accuracy of recommendation. The authors of [15] use sentence level classification to harness the useful information from textual reviews, and soft cluster techniques to group the like-minded users for the personalized recommendation. Authors in [12] use matrix factorization recommendation approach using Single Value Decomposition which leverages both customers rating and out-put of sentiment analysis algorithm to provide an improved personalized recommendation. Authors [4] propose two new approaches, the similarity-based approach and the aggregated function

approach to incorporate and leverage the multi-criteria information in recommenders system. Weshi Zhang [22] defines an SELC (Self-supervised, Lexicon based and Corpus-based) self-supervised sentiment classification model to determine the overall sentiment polarity of review documents and integrated with collaborative filtering methods to improve the system accuracy. All researchers have extracted valuable information from online reviews and combined with the traditional recommendation algorithm to enhance the accuracy of recommendation. Moreover, it has been observed that the new buyers mostly need an overall opinion about the product rather than fifty four-star ratings and fifty three-star ratings [21].

Many authors have developed different methods to summarize the customer reviews. In [23] the authors summarize the customer's reviews by extracting relevant aspects of services, aggregating sentiments per aspect, and selecting aspect relevant text. In [24], authors calculate the overall rating of the product using PMI-IR algorithm and generalize the customer reviews on features using feature-based classification.

Minqing Hu and Bing Liu [25], [26] propose a feature-based opinion summary of customer reviews which is summarized in the following way: In the first step, association rule mining is used to find all frequent feature set and used two methods – compactness, and redundancy pruning to filter the unwanted features. In the next step, some infrequent features are also considered while looking at the popularity of opinion words. Moreover, in the last step, nearby opinion word from feature word is identified, and bootstrapping technique and WordNet lexicons are used to measure the polarity of opinion.

Authors in [27] propose a review mining system, named OPINE, to extend the Hu and Liu's work, which uses a Point Wise Mutual (PMI) score to extract the fine-grained features and associated opinion through a web search. It uses relaxation labeling strategy to measure the polarity and strength of opinion words, and their experiment showed that result outperforms with respect to Hu and Liu's work. OPINE's system use web search engine to find the closeness of opinion words which is difficult to validate and deploy in the particular domain.

To overcome the problems of opinion polarity, Ding and Liu [28] developed a system called Opinion Observer which uses some linguistic rules to handle such type of problems. The result outperforms both FBS [25] and OPINE [27] system. However, this system is hard to apply in another language because sentence structure is language dependent. Jin et al. [29] propose a system called OpinionMiner to extract high detailed product attributes from the web on which the customer expresses their opinion. The proposed system use lexicalized Hidden Markov Model (HMM) based machine learning approach to felicitate automatic learning environment which integrates multiple linguistic features. The authors argue that their proposed rules-based system is more useful and productive than the existing rule-based system. The real difficulty in opinion mining problem is that a system is susceptive towards its domain, i.e., if we trained the classifier in one domain, its performance is often deficient in another domain.

Authors of this paper [24] propose a new similarity measure techniques, called PMI-TFIDF to assess the association of candidate features with domain entities. The basic concept of this method is to extract domain product feature through calculation of their weight in the different domain. The experiment results proved that its results outperformed with another state of art methods. Opinion feature has characteristics of word disparities across different corpora. The authors in [30] propose an innovative method to determine the opinionated features from online reviews by considering its distinct characteristics across two corpora, one is domain specific corpus, and other is independent domain corpus. The investigational results proved that the proposed method performs better than several well-established methods for identifying features. Researchers have used different supervised and un-supervised machine approach to summarize the customers' reviews and tried to suggest the best product to the potential user. There is a still a need for developing different approaches that can leverage the benefits of customer's reviews and decide/predict the best product/service to the user.

One can see that the recommendation problem involves multiple criteria to make an informed decision and defined as Multi Criteria Decision Making (MCDM) problem. In the next section, different real-world applications of various MCDM methods are reviewed, and the possibilities of exploiting the benefits of customers' reviews in the multi-criteria recommendation systems are explored.

MCDM BASED RECOMMENDATION SYSTEMS

MCDM is a most popular branch of strategic decision making model which solves the problem in the presence of a different numbers of attributes. A number of research papers present the liveliness of this field, and the different approaches have been developed to solve the real-world decision problems. SAW (Simple Additive Weighting) method was developed by Stanley Zionts [31] in 1983 for an interactive multiple objective linear programming. This method was also used to support Geographic Information System with overlay operations [32]. Rizka Ella Setyani [33] use SAW (Simple Additive Weighting) to determine the Food Prone Area of Semarang city. An outranking method called PROMETHEE [34] was developed by Brans in 1982 to rank the finite set of an alternative. There are a wide range of applications Management, Environment, Finance, Logistics, Manufacturing Designing and other areas, where PROMETHEE methods were applied. Several versions of PROMETHEE methods [34]–[36] were developed such as Partial ranking of the alternatives PROMETHEE I was developed, PROMETHEE II for complete ranking of alternatives, PROMETHEE III for ranking based on interval, for complete/partial ranking of alternatives when set of viable solution is continuous PROMETHEE IV was developed, PROMETHEE V for problems with segmentation constraints, and for the human brain representation PROMETHEE VI was developed.

Saaty [37] introduce an AHP (Analytic Hierarchy Process) in 1977 to solve the complex decision making problems of industrial engineering applications. It is based on the concept of pairwise comparison and mostly dependent on the judgment

of experts to compute the priority score. Kengpol et al. [38] propose a decision tool which combines the benefits of three different models, i.e., cost-benefit analysis, common criteria, and decision-making effectiveness model to select the advanced technology for rapid product development. Kuo et al. [39] develop a four steps algorithm which combines the basics ideas of Fuzzy set theory and AHP model to locate and select the convenience store. Authors of this paper [40] propose an optimization model for deciding the best software product among the set of alternatives.

To assist decision-makers in selecting the best alternative from the finite set of alternatives, TOPSIS method was developed by Hwang and Yoon [41] in 1981. It uses the distance measure techniques to select the alternative that is the shortest distance from an ideal solution and farthest distance from negative ideal solution. This method has been used in broad range of real-life applications across different fields such as business and marketing management, design, engineering and manufacturing systems, supply chain management and logistic, human resource management, health, water resource management and much other wide ranges of domains.

Among these areas, supply chain management and logistics have got much attention from different researchers, and application of TOPSIS is considered as a most popular approach to solving the problem of supplier selection [42]. Authors of this paper [43] integrate a Fuzzy Set Theory with TOPSIS approach and considered following factors, i.e., supplier profitability, closeness relationship, technological capability, conflict resolution factors, and conformance quality to improve the quality of the supplier selection problem. A closeness coefficient was characterized to measure the positioning order of all suppliers by computing the distance from a fuzzy positive ideal and fuzzy negative ideal solutions. However, this model is appropriate for a problem which has an only single source. Chin et al. [44] consider both tangible and intangible criteria and combined fuzzy based TOPSIS with MCGP approach to resolving the problem of single source supplier selection. Authors use linguistic value articulated in trapezoidal fuzzy number to measure the weight and rating of supplier selection criteria and then MCGP model is used to evaluate the order qualities of each supplier.

TOPSIS is also used in business and marketing management to measure the organizational performance, customer satisfaction, investment project, financial measurement, and competitive advantage. Authors [45] propose a system which combines the concept of Fuzzy TOPSIS and AHP to measure the performance of four aviation firms on five significant dimensions: quality, risk, occupational satisfaction, and usefulness. Chia and Lin [46] use fuzzy TOPSIS method to assess and rank the effectiveness of a list of shopping websites. Among several methods, TOPSIS continues to work satisfactorily in varied application areas.

CONCLUSION

We have presented an overview of traditional recommenders systems and its challenges. They mostly suffer from cold starts and limited content analysis problem. Multi-criteria rating recommender systems were proposed to overcome some of the shortcomings of traditional recommender systems, where customers were asked to give ratings on multiple criteria. However, multi-criteria recommender systems also fail when target user or naïve user has insufficient historical data. There was a need for incorporating additional information to provide an informed decision for the recommendation. Researchers started analyzing customer's reviews using different sentiment and opinion mining techniques to extract useful information from customer's reviews and integrate them with different recommendation approaches to provide an informed decision to the user. One can also see the recommendation problem as MCDM problem. The real world applications of different MCDM approaches were also presented.

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