



An evolutionary clustering algorithm based on temporal features for dynamic recommender systems



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ABSTRACT

The use of internet and Web services is changing the way we use resources and communicate since the last decade. Although, this usage has made life easier in many respects still the problem of finding relevant information persists. A naïve user faces the problem of information overload and continuous flow of new information makes the problem more complex. Furthermore, user's interests also keeps on changing with time. Several techniques deal with this problem and data mining is widely used among them. Recommender Systems (RSs) assist users in finding relevant information on the web and are mostly based on data mining algorithms. This paper addresses the problem of user requirements changing over a period of time in seeking information on web and how RSs deal with them. We propose a Dynamic Recommender system (DRS) based on evolutionary clustering algorithm. This clustering algorithm makes clusters of similar users and evolves them depicting accurate and relevant user preferences over time. The proposed approach performs an optimization of conflicting parameters instead of using the traditional evolutionary algorithms like genetic algorithm. The algorithm has been empirically tested and compared with standard recommendation algorithms and it shows considerable improvement in terms of quality of recommendations and computation time.

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1. Introduction

Recommender systems assist users in navigating through information on the web by giving suggestions regarding their preferences. This is done by generating a user profile based on their past behavior. Although RSs are chiefly applied in the area of e-commerce, their domain areas are constantly enlarging. One of the latest examples is their use in the social networking sites which are widely using recommendations. Different techniques are used in building RSs and they are mainly divided into three categories namely collaborative filtering, content based filtering and hybrid system. Collaborative filtering (CF) works by generating recommendations on the basis of similarity of interest between users. The process identifies users that have similar preferences and then from their ratings of different items it can suggest new items to a particular user. Content based filtering is the technique that uses the content knowledge of the domain of recommendation to predict items that could interest users. The domain knowledge becomes very important in such a scenario that poses as a hindrance to the overall evolution of the RSs. Hybrid techniques

combines the above two approaches, however, such a system needs to be designed carefully so that the disadvantages of the selected system are not inherited.

The most widely used technique for Recommender System is collaborative filtering [33]. The success of a collaborative filtering system is highly dependent upon the effectiveness of the algorithm in finding set of users (profile) which are most similar to that of the current user. Various data mining as well as information retrieval technique are applied for this purposed until now. The adaptability of Recommender System to predict the evolving user's needs, which are constantly changing, is a growing area of research in the sphere of recommender system. In the constantly changing environment of web, providing relevant content through a recommendation mechanism can be a difficult task and time could be one of the most important factors [23,24]. Various model based algorithms in RSs are well-known to achieve good prediction performances [23]. However, the major drawback for many such model based methods is that they all require a lengthy training period. In addition, the static nature of such models results in a progressive declining of the prediction accuracy after a period of time because new ratings are not taken into account until re-computation of whole model, which cannot be done very often because of the high computational costs. The problem of matching user profile that evolves with time can be more effectively handled by an evolving mechanism that uses temporal

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dimension. Such mechanism can precisely fulfill this gap during profile matching and thus help in dealing with the dynamics of user profile. Evolutionary clustering based methods adjust the time problem of the conventional method according to an optimization scheme [19]. Thus, the incorporation of temporal changes in user preferences can be effectively handled by an evolutionary clustering mechanism. Moreover, clustering mechanism is proven to be beneficial for removing the scalability and sparsity problems in a recommender system [15,33]. Thus, the usage of evolutionary clustering mechanism in a recommender system can be beneficial in multiple ways.

1.1. Motivation

The major focus of RSs in the real world setting is to increase the accuracy of the recommendations. To maintain accuracy of the system, relevant recommendation needs to be provided to the user. As time passes, the relevancy of items to the user shifts as his preferences changes. This shift in the user profile needs to be done periodically and it requires a constantly evolving mechanism. Thus, the biggest problem in improving the accuracy of the system comes with user changing requirements and content up gradation [23]. To handle the dynamic environment of the web, a RS needs to continuously upgrade the incoming stream of users, items and their corresponding choices. The Dynamism in RSs becomes an important factor that needs to be taken into consideration when traditional retraining methods cannot keep pace with the rate of change with respect to user preferences [31]. Maintaining accuracy together with fulfilling user changing requirements is a difficult task. The inclusion of time dimension in RSs can help in overcoming many problems. In addition to predicting changing user needs and thereby improving accuracy, temporal dimension could also help in improving the scalability of the system. This is done by reducing the number of uses and items for similarity calculation that are divided into clusters using temporal data. The question is how to add time. As Koren [23], taken a perspective where a hybrid approach with 67 parameters and lots of calculation proved time could improve accuracy and won the Netflix prize. Lathia et al. [24] on the other hand have also shown how changes over a period of time can affect the accuracy. Although a deep analysis of temporal dimension in evaluating collaborative filtering is presented in his research yet the challenge to utilize temporal dimension for the improvement and diversification of the system is not addressed. Consequently, very few people have actually tried to correlate the effect of temporal factor in the recommendation process. Even less have applied evolutionary computation to the recommendation process. Chakrabarti et al. [9] gives a very novel concept of evolutionary clustering. The process of clustering can be very effective in finding similar users and in turn better clusters that can improve accuracy in the recommendation process in addition to handling scalability. To incorporate the idea of evolving user's interest with time and the system content, an evolutionary clustering method could be employed in the recommendation system. In this paper, we have proposed an evolutionary clustering based recommendation algorithm that improves the accuracy as well as computational time.

1.2. Contribution

We propose an evolutionary clustering algorithm that could serve as the core module for matching user profiles and their evolving nature in a recommender systems. It is observed that clustering techniques often lead to worse prediction accuracy even though it improves scalability [33]. This is because, when clustering is finished, the size of a cluster that must be analyzed is much smaller. Consequently, clustering methods can solve the scalability

problem in RSs at the cost of accuracy. We propose an approach that improves the prediction accuracy as well alleviates the sparsity and scalability issue with the utilization of temporal dimension. This is done using evolutionary clustering that utilizes time dimension to produce updated groups of user in the form of clusters. In short, the detection of evolving user preferences is formulated as a clustering problem and a solution based on evolutionary clustering is proposed. The better the quality of clusters more will be the recommendation accuracy. Evolutionary clustering based recommendation algorithm will give better quality clusters and thereby improve accuracy of prediction for the users. The evolutionary algorithms that uses genetic algorithm (GA) as the basis to depict evolution are not referred here as our proposed approach uses an optimization procedure rather than a GA based approach. Instead the proposed approach is compared with other evolutionary clustering approaches and widely used model based approaches that use various optimization criteria in the area of RSs application.

The rest of the paper is organized as follows: we present related work in the area of evolutionary clustering with some reference to RSs in Section 2. In Section 3, the concept of evolutionary clustering is presented and our proposed algorithm is explained. In Section 4, the evolutionary clustering based recommendation system is presented. In Section 5, the empirical test results of the proposed algorithm on real life dataset are presented and its comparison with other standard recommendation algorithms is discussed. Finally, Section 5 concludes the paper citing future direction of research in this area.

2. Related work

The most widely used technique for RSs is collaborative filtering [8]. Collaborative filtering systems are usually categorized into two types namely memory based and model based methods. Memory-based methods store the whole rating matrix and predict recommendations on the calculations between the target user and item and the rest of the rating matrix. Model-based methods fit a parameterized model to the given rating matrix and then predict recommendations on the basis of this model. Furthermore, model based methods are becoming more popular as with increase in the number of users and items memory based methods have serious limitation in terms of computation time and accuracy. Also, there are some other major advantages in model based technique over standard memory-based methods namely higher accuracy, constant time prediction, and an explicit and compact model representation. The major model based techniques include cluster-based CF [34,40], Bayesian classifiers [28], regression based methods [41]. Recent classes of successful CF models are based on low-rank matrix factorization. The regularized RSVD method [6] factorizes the rating matrix into a product of two low rank matrices (user-profile and item-profile) that are used to estimate the missing entries. An alternative method is Non-negative Matrix Factorization (NMF) [25] which differs in that it constrain the low rank matrices forming the factorization to have non-negative entries. Recent variations are Probabilistic Matrix Factorization (PMF) [32], and Nonlinear Principal Component Analysis (NPCA) [42].

The proposed approach in this paper implements a model based techniques using evolutionary clustering. Evolutionary clustering is a very novel research area which is first postulated by Chakrabarti et al. [9]. Most of the work in evolutionary clustering focuses on developing evolving communities and clusters of users and this paper propose that such clusters could further be related to user profile and can be used in generating recommendation. To the best of our knowledge, this approach has so far not being used

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