CONTEXT AND GROUP MODELLING TO BETTER RECOMMENDATIONS

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Abstract. Users are generally overloaded by plenty of information, while accessing relevant information is more and more difficult. Researches in the digital library have to process hundreds of thousands of documents in order to find those matching their criteria. Personalized recommendations are designed to suggest such items, which should be relevant for particular user. Improving such recommendations can increase user experience by increasing user's satisfaction – which is crucial from the optimisation point of view. In this paper we summarize result of our research in the recommendation improvement field.

1. Introduction

Two basic ideas are used in order to create personalized recommendations. The content-based filtering assumes, that similar items to items liked by user will became also liked. The advanced content analysis have to be performed [1], which can result in high computation cost in some domains. On the contrary, collaborative filtering, assumes that items liked by the similar users will be also interested. These two approaches are often mixed in order to improve the result recommendation process. This section describes text and graphics formatting and layout guidelines that should be followed while writing your paper.

As the general goal of every personalized recommendation approach is to satisfy users' needs, recommendation approaches are designed to optimize user's satisfaction function (e.g. maximize knowledge level, decrease news article search time, buy specific product). The satisfaction modelling is mainly researched in the group recommendation, where the single-user satisfaction can influence other group members and thus their satisfaction with the recommended items [5]. The user context plays crucial role in the user satisfaction computation. Item liked and preferred in some context (e.g. Friday evening) can be disliked in other context. Moreover, context is not isolated influence – various context can strengthen

other context and vice versa. This is similar to the group modelling in the group recommendation, where some user moods influences other users. Incorporating the principles of satisfaction modelling from the group recommendation and using it in the context modelling can improve the performance of recommenders from the precision and rating prediction point of view.

In the digital library domain, not only single-user's preferences are helpful in order to construct recommendations. Researcher's articles, supervisor, colleagues are useful in understanding user's preferences. In other words, we can construct groups of users which represent some topic-oriented groups. These groups can be derived from the real world, or the virtual groups can be constructed based on the similarity user to user computation.

2. Virtual groups

We propose the recommendation method which uses virtual group construction to improve single-user recommendations [2]. The aggregation of single-user profiles in order to obtain one group profile combines users' preferences and also in some settings can introduce variety (in the mean of users diversity), which can be beneficial for the recommendation.

The main difference between classic collaborative recommendation and our proposed approach is that we generate recommendation not based on the user to user similarity, but based on the similarity between the user and virtual users.

Every user is assigned into one virtual group, while the virtual group preferences are represented by the virtual user. Some researchers use the aggregation strategy to fill the unknown user's preferences [4], we use the aggregations in order to create virtual users (which represent the virtual group preferences). Every user in the virtual group gets own personalized list of recommendations, which usually differs from other group members. Thanks to various settings as group size or inner-group similarity, it is possible to control and improve results in order to fulfil specific goal – to obtain various results or to focus on the specific interest area. Proposed approach consists of three basic steps:

1. virtual groups construction;
2. similarity computation between virtual users and real users outside the group;
3. generation of recommendation for specific user.

For the experiments we use the MovieLens 100k dataset, which is widely used as the gold standard dataset for recommender systems' evaluation. The dataset was split into train (80%) and test data (20%). In addition, 5 fold cross validation was performed. Various settings as the aggregation strategy used, number of similar user or group size were compared. Statistically significant improvement more than 11% for P@3 and more than 10% for P@10 was obtained, which indicated that proposed approach can be used for the task of single-user recommendation.

Similar experiments were performed over the SME.SK dataset, which refers to the news article domain. Proposed approach outperforms standard collaborative recommendation again. As the proposed approach does not consider items' content, various domains (where the content analysis is impossible e.g., music, TV) can be used for the recommendation. Results obtained from different datasets (MovieLens, news portal) support this hypothesis.

3. Single-user satisfaction

For the user's context influence modelling, we propose a method, which is based on the group satisfaction modelling principles [3]. We consider a user's context during the recommendation process and we adjust rating prediction to the actual user's circumstances. Our approach is based on an assumption that actual user's ratings are influenced by the previous experienced content and actual user's situation – user's context.

The user context is not considered as the one isolated influence, but the context itself is able to strengthen other context influence and vice versa. Our idea reflects the user's feelings intensity in the history also, which contributes to the actual predicted rating. Proposed context-based influence modelling enhances collaborative recommendation process. It consists of three basic steps:

1. predict ratings for unrated items;
2. spread activation through user's item specific influence graph;
3. combine user's ratings history and result of influence graph.

The standard prediction of ratings for unrated items is computed based on various approaches. Generally, this prediction is computed based on the ratings of similar users (similar interest in the history), e.g. the average of similar users' ratings. The cosine similarity is widely used in the task of similar users' search. We propose to enhance predicted ratings computed in this manner by proposed spreading activation based approach, which spreads the activity within a graph based on the context influence of specific user and specific item.

Not only the actual user's context influences the predicted ratings. Previously experienced items influence user's actual mood and the ability to experience the content as well. We propose considering user's rating history. These ratings are considered with the time decay factor (logarithm) – more recent item influences the user's rating stronger. Finally, predicted rating is adjusted by considering actual user rating history and his/her context as:

$$\mathrm{Rating}_{\mathrm{u,i}} = \kappa\,\eta\left(\frac{\sum_{\mathrm{j}=1}^{|\mathrm{I}|-1}\left(\left(\log_{|\mathrm{I}|-1}\sqrt{\mathrm{j}+1}\right)\mathrm{hist}_{\mathrm{u}i,j}\right)}{|\mathrm{I}|-1}\right) + (1-\eta)\,\mathrm{sp(i,u)} \qquad (1)$$

where $sp(i,u)$ refers to the result of the spreading activation in the user's $u \in Users$ influence graph for the predicted item $i \in Items$. Proposed formula is adapted to the item rating scale $\langle -5{,}5\rangle$ where $\kappa = 2.631$ (normalization to the scale). The user's rating history is considered as the η and the actual user context as the $1-\eta$ of final predicted rating (set based on the evolutionary computation approach to $\eta = 0.4$). Finally, adjusted ratings are used for the standard collaborative recommendation, where based on the highest ratings items are recommended to the user.

For the experiments we used LDOS-COMODO dataset, which includes users' ratings on movies and provides a corresponding context of this recommendation (weather, mood, emotion, day type etc.).

Our approach outperforms the average rating predictor in all settings used in experiment, while obtained improvement is considered to be statistically significant. Based on these results, we conclude that proposed approach is suitable to improve standard ratings prediction approaches and thus can be used in the recommendation process. As the proposed approach considers the context of users, next we performed training of reference

models with context-aware data. Similar pattern as when no context was used was observed. The improvement of reference approaches in MAE and RMSE metrics respectively (comparing to no context information) was very small, while proposed approach obtains the best result. Obtained results supports our hypothesis, that proposed context enhanced rating prediction approach improves the standard used approaches.

4. Conclusions

Proposed approaches for the improvement of personalized recommendations outperform standard context-aware or collaborative recommendation approaches. Construction of virtual groups can be beneficial in the digital library domain. Here the group of researcher's co-workers, supervisor etc. can be constructed and used in the recommendation process as we can expect the knowledge spread over the group. Similarly, including the context modelling can improve the single user satisfaction by considering user actual state.

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