Personality-Aware Product Recommendation System Based on User Interests Mining and Meta path Discovery

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ABSTRACT

A recommendation system is an integral part of any modern online shopping or social network platform. The product recommendation system as a typical example of the legacy recommendation systems suffers from two major drawbacks: recommendation redundancy and unpredictability concerning new items (cold start). These limitations take place because the legacy recommendation systems rely only on the user's previous buying behavior to recommend new items. Incorporating the user's social features, such as personality traits and topical interest, might help alleviate the cold start and remove recommendation redundancy. Therefore, in this article, we propose Meta-Interest, a personality-aware product recommendation system based on user interest mining and metapath discovery. Meta-Interest predicts the user's interest and the items associated with these interests, even if the user's history does not contain these items or similar ones. This is done by analyzing the user's topical interests and, eventually, recommending the items associated with the user's interest. The proposed system is personality-aware from two aspects; it incorporates the user's personality traits to predict his/her topics of interest and to match the user's personality facets with the associated items. The proposed system was compared against recent recommendation methods, such as deep-learning-based recommendation system and session-based recommendation systems. Experimental results show that the proposed method can increase the precision and recall of the recommendation system, especially in cold-start settings.

I. INTRODUCTION

With the widespread of personal mobile devices and the ubiquitous access to the internet, the global number of digital buyers is expected to

reach 2.14 billion people within the next few years, which accounts for one-fourth of the world population. With such a huge number of buyers and the wide variety of available products, the efficiency of an online store is measured by their ability to match the right user with the right product; here comes the usefulness of product recommendation systems. Generally speaking, product recommendation systems are divided into two main classes.

1) Collaborative Filtering (CF): CF systems recommend

new products to a given user based on his/her previous (rating/viewing/buying) history and his/her neighbors (similar users). For example, as shown in Fig. 1(a), most of the people previously bought a football jersey, and they have also bought a football; thus, the system predicates that the user might be interested in buying a football.

2) Content Filtering or Content-Based Filtering (CBF): CBF systems recommend new items by measuring their similarity with the previously (rated/viewed/bought) products. For example, as shown in Fig. 1(b), football is recommended because it is semantically similar to the football jersey.

Far from that, with the popularity of online social networks, such as Facebook, Twitter, and Instagram,many users use social media to express their feeling or opinions about different topics or even explicitly expressing their desire to buy a specific product in some cases, which made social media content a rich resource to understand the users' needs and interests [1].On the other hand, the emerging of personality computing [2] has offered new opportunities to improve the efficiency of user modeling in general and particularly recommendation systems by incorporating the user's personality traits in the recommendation process. In this work, we propose a product recommendation system that predicts the user's needs and the associated items, even if his/her history does not contain these items or similar ones. This is done by analyzing the user's topical interest and, eventually, recommending the items associated with the theses interest.

2. LITERATURE SURVEY

In this section, we review the recent advances of personality-aware recommendation system and interest mining schemes as well.

A. Personality and Recommendation Systems

Many works have discussed the importance of incorpo- rating the user's personality traits in the recommendation systems. Yang et al. [4] proposed a recommendation system of computer games to players based on their personality traits. They have applied text mining techniques to measure the players' Big-five personality traits and classified a list of games according to their

matching with each dominant trait. They have tested their proposed system on 2050 games and 63 players from the Steam gaming network. While Wu et al. [5] presented a personality-based greedy reranking algorithm that generates the recommended list, where the personality is used to estimate the users' diversity preferences, Ning et al. [6] proposed a friend recommendation system that incorporates the big-five personality traits model and hybrid filtering, where the friend recommended process is based on personality traits and the users' harmony rating. Ferwerda et al. [7] studied the relationship between the user's personality traits and music genre preferences; they have analyzed a data set that contains personality test scores and music listening histories of 1415 Last.fm users. Similarly, in [8], they conducted an online user survey where the participants were asked to interact with an application named Tune-A-Find and measured taxonomy choice (i.e., activity, mood, or genre), individual differences (e.g., music expertise factors and personality traits), and different user experience factors. Similarly, Hafshejani et al. [9] proposed a CF system that clusters the users based on their big-five personality traits using the K-means algorithm. Following that, the unknown ratings of the sparse user–item matrix are estimated based on the clustered users. Dhelim et al. [10] discussed the benefits of capturing the user's social feature, such as personality traits that are represented as cyberentities in cyberspace. Similarly, Khelloufi et al. [11] showed the advantages of leveraging the user's social features in the context of service recommendation in the Social Internet of Things (SIoT).

B. Interest Mining

Far from personality, many previous works have discussed user interest mining from social media content. Piao et al.

[1] surveyed the literature of user interest mining from social networks, and the authors reviewed all the previous works by emphasizing the following on four aspects: 1) data collection;

2) representation of user interest profiles; 3) construction and refinement of user interest profiles; and 4) the evaluation measures of the constructed profiles. Zarrinkalam et al. [12] presented a graph-based link prediction scheme that operates over a representation model built from three categories of information: user explicit and implicit contributions to topics, relationships between users, and the similarity among topics.

Trikha et al. [13] investigated the possibility of predicting the users' implicit interests based on only topic matching using frequent pattern mining without considering the semantic similarities of the topics. While Wang et al. [14] proposed a regularization framework based on the relation bipartite graph that can be constructed from any

kind of relationship, they evaluated the proposed system from social networks that were built from retweeting relationships. Dhelim et al.

[15] discussed the usage of the user's interests to customize the services offered by a cyber-enabled smart home. Faralli et al. [16] proposed Twixonomy, a method for modeling of Twitter users by a hierarchical representation based on their interests. Twiconomy is built by identifying topical friends (a friend represents an interest instead of a social relationship) and associate each of these users with a page on Wikipedia. Dhelim et al. [17] used social media analysis to extract the user's topical interest. Kang et al. [18] proposed a user modeling framework that maps the user' posted content in social media into the associated category in the news media platforms, and based on that, they used Wikipedia as a knowledge base to construct a rich user profile that represents the user' interests. Liu et al. [19] introduced iExpand, a new CF recommendation system based on user interest expansion via personalized ranking. iExpand uses a three-layer, user– interest–item, representation scheme, which makes the recom-mendation more accurate and with less computation cost and helps the understanding of the interactions among users, items, and user interests.

3. PROPOSED SYSTEM

The proposed system is personality-aware from two aspects; it incorporates the user's personality traits to predict his/her topics of interest and to match the user's personality facets with the associated items. The proposed system is based on a hybrid filtering approach (CF and CBF) and personality-aware interest mining.

Since we have multiple types of nodes (users, items, and topics), the system is modeled as a heterogeneous information network (HIN), which includes multiple types of nodes and links. In our case, product recommendation could be formulated as link prediction in HIN. For example, in given the user's previous rating and topical interest represented in an HIN, the problem is to predict whether or not a link exists between the user and the product (the ball). One of the main challenges of link prediction in HIN is how to maintain a reasonable balance between the size of information considered to make the prediction and the algorithm complexity of the techniques required to collect that information. Since, in practice, the networks are usually composed out of hundreds of thousands or even millions of nodes, the method used to perform link prediction in HIN must be highly efficient. However, computing only local information could lead to poor predictions, especially in very sparse networks. Therefore, in our approach, we make use of metapaths that start from user nodes and end up in the predicted node (product nodes in our

case), and we try to fuse the information from these metapaths to make the prediction.

The contributions of this work are summarized as follows.

1) Propose a product recommendation system that infers the user's needs based on his/her topical interests.

2) The proposed system incorporates the user's big-five personality traits to enhance the interest mining process and perform personality-aware product filtering.

3) The relationship between the users and products is predicted using a graph-based metapath discovery; therefore, the system can predict implicit and explicit interests.

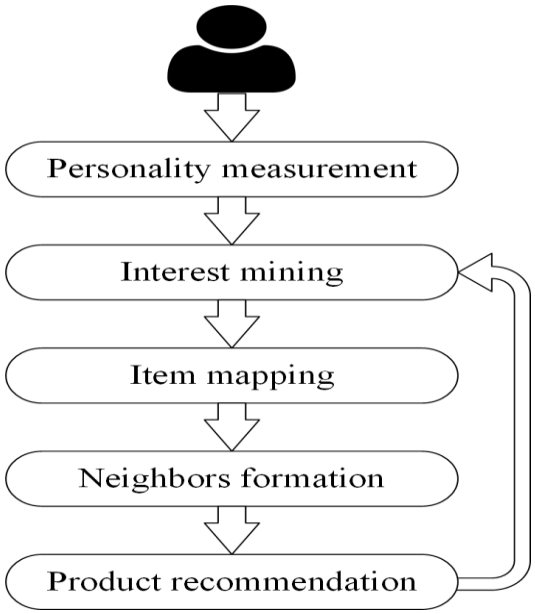

Fig: Meta-Interest recommendations process

The purpose of Meta-Interest is to recommend the most relevant items by detecting the user's topical interests from its social networking data. Fig. 3 shows the general system frame- work of Meta-Interest. The recommendation process includes five steps. Step 1 is the personality traits' measurement, which can be obtained by asking the user to take a personality measurement questionnaire or using automatic personality recognition by analyzing the subject's social network data. The personality measurement phase is the only static part of the system, which is because personality traits have been proven to be relatively stable over time. Step 2 is mining the user's topical interests, including explicit and implicit interest minings. Explicit interest mining is performed by analyzing the text shared by the user in social networks in order to detect.keywords that reflect its topical interests. Implicit interest mining involves a more complex analysis of the social network structure and other latent factors that may influence the user's topical interests. In Step 3, Meta-Interest matches the items with the corresponding topics. The matching is in the form of a many-to-many relationship that is to say that a topic might be related to many items. Similarly, an item might be related to more than one topic. In Step 4, the set of most similar users (neighbors) to the subject user is determined.

4. CONCLUSION

In this article, we have proposed a personality-aware product recommendation system based on interest mining and metapath discovery, and the system predicts the user's needs and the associated items. Products' recommendation is computed by analyzing the user's topical interest and, eventually, recommending the items associated with those interests. The proposed system is personality-aware from two aspects: first, because it incorporates the user's personality traits to predict his topics of interest; second, it matches the user's personality facets with the associated items. Experimental results show that the proposed system outperforms the state-of-art schemes in terms of precision and recall especially in the cold-start phase for new items and users.

However, Meta-Interest could be improved in different aspects.

1) In this work, the users' personality traits' measurement was conducted through questionnaires. Integrating an automatic personality recognition system, which can detect the users' personality traits based on their shared data, into Meta-Interest is one of our future directions.

2) The proposed system uses big-five to model the user's personality. Extending Meta-Interest to include other personality traits models, such as the Myers–Briggs type indicator, is a future direction.

3) The proposed system could be further improved by integrating a knowledge graph and infer topic–item association using semantic reasoning.

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