A Graph Neural Network-Based Algorithm for Point-of-Interest Recommendation Using Social Relation and Time Series

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ABSTRACT

POI recommendation has gradually become an important topic in the field of service recommendation, which is always achieved by mining user behavior patterns. However, the context information of the collaborative signal is not encoded in the embedding process of traditional POI recommendation methods, which is not enough to capture the collaborative signal among different users. Therefore, a POI recommendation algorithm is presented by using social-time context graph neural network model (GNN) in location-based social networks. First, it finds similarities between different social relationships based on the users’ social and temporal behavior. Then, the similarity among different users is calculated by an improved Euclidean distance. Finally, it integrates the graph neural network, the interaction bipartite graph of users and social-time information into the algorithm to generate the final recommendation list in this paper. Experiments on real datasets show that the proposed method is superior to the state-of-the-art POI recommendation methods.

KEYWORDS

Algorithm, Contextual Information, Graph Neural Network, Location-Based Social Networks, Point-of-Interest Recommendations

1. INTRODUCTION

In recent years, a large amount of user information has been generated in location-based social networks (LBSN). For example, in 2016, Foursquare has more than 500 million active users and more than 800 million check-ins POI records, while Yelp has about 21 million active users and 102 million geo-coordinate related reviews, which received extensive attention from related researchers (Liu et al., 2017). Compared with traditional social networks, location-based social networks provide an unprecedented opportunity for the study of human mobile behaviors through contextual information such as space, time and social relations (Gao et al., 2013). These spatio-temporal characteristics, combined with the user’s social relations, constitute the user’s context and provide a method to study the user’s behavior pattern. Such as points of interest (POI) recommendation (Lian et al., 2014; Ying et al., 2017; Ren et al., 2017; M, Aliannejadi et al., 2020; Hossein et al., 2020; Hossein et al., 2019; Huang et al., 2020), friend recommendation (Xin & Wu, 2020; Xu-Rui et al., 2017) and so on. In the above LBSN services, users can share their life experiences on different POIs in the form of check-ins. This shared lifestyle brings a lot of information, which can help users understand themselves and explore potential interests. It can also help enterprises find more potential users and enhance their profits.

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POI recommendation is an important application in LBSNs, which can help users filter out the POI that they are not interested in from the mass information and find the valuable POI related to their preferences. Different from the tasks and challenges of the traditional recommendation system, POI recommendation is more complex, personalized and contextual. POI recommendation has the following unique characteristics: (1) Contextual factors: Previous studies have shown that contextual factors, such as geography, social relations and time, have an important impact on users’ behavior patterns (Gao et al., 2013; Ying et al., 2017; Hossein et al., 2020; Huang et al., 2020). (2) Implicit feedback: There is no explicit user rating in LBSN, so only positive samples are included in the POI recommendation system, which is called single-class collaborative filtering (Pan et al., 2008). To solve these problems, researchers have carried out studies from different perspectives. Some scholars have studied users’ behavior patterns (Lian et al., 2014; Ying et al., 2017; Ren et al., 2017; Hossein et al., 2020;) from the perspective of context by analyzing contextual information such as users’ geography, social interaction and time. There are also some scholars who combine deep learning techniques to enhance the learning of user feature representation vectors. For example, RBM, CF-NADE and denoising auto-encoders (Salakhutdinov et al., 2007; Li et al., 2015; Zheng et al., 2016; Wu et al., 2016), etc. However, the coding of the collaborative signal of User-POI interaction is not explicitly introduced in the above research method, so the results may not be sufficient to capture the collaborative filtering effect. Therefore, from the perspective of graphs, some scholars began to explore the structural information of graphs through the combination of graph convolutional neural network and collaborative filtering. It enhances the learning of feature representation vectors by explicitly encoding collaborative signals into the embedding process (Wang et al., 2019; He et al., 2020). However, most of the existing recommendation methods based on Graph Convolution Network (GCN) use binary values to represent the interactive binary graph structure of user-POI. Furthermore, they do not integrate the information of users in different contexts into the embedding process. In order to solve the above problems, a graphical convolutional neural network model with mixed social relations and time series (LGCN-STC) is presented to help users find potential points of interest. First of all, it uses a new approach that mixes social relations and time series to calculate the similarity of user preferences and temporal behavior in different social contexts. Then, inspired by LightGCN (He et al., 2020), it not only explores the high-order connectivity of the interactive binary graph between users, but also integrates the check-ins confidence vector, social relations and time series similarity. Eventually, a top-N POI list is provided for target users through the trained model.

The contributions of this paper are listed as follows:

First of all, we propose a POI recommendation algorithm based on graph convolutional neural network, which mixes social relations and time series (LGCN-STC). Compared with the existing recommendation algorithms, combining the user’s context information with deep learning can not only greatly improve the recommendation efficiency, but also alleviate the problems of data sparsity and cold start.

Furthermore, the algorithm based on graph convolutional neural network in the recommendation domain only uses binary to indicate whether the user has visited POI, ignoring the influence of user preference and situational factors. Therefore, on the basis of LightGCN, we integrate confidence vectors and contextual factors to complete the overall processing of implicit user feedback data, which has achieved remarkable success.

Finally, the LGCN-STC has been verified by the two real-world datasets Gowalla and Brightkite. Experimental results show that the proposed LGCN-STC model has better performance.

The rest of this article is organized as follows. Section 2 introduces the relevant work. Section 3 lists the relevant definitions and describes the general framework of the LGCN-STC model. Section 4 elaborates the influence of social relations and time series, and gives the calculation method of the similarity of social relations and time series. Section 5 gives the LGCN-STC model of this paper. Section 6 describes the experiment and analysis. In the final section, we summarize our work and present the future research.
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