User Cold Start Recommendation System Based on Hofstede Cultural Theory

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ABSTRACT

The main function of recommendation systems is to help users select satisfactory services from many services. Existing recommendation systems usually need to conduct a questionnaire survey of the user or obtain the user's third-party information in the case of cold start users; this operation often infringes on the user's privacy. This article is aimed at providing accurate recommendations for cold start users without infringement on user privacy. Therefore, in response to this problem, this manuscript per the authors proposes a recommendation algorithm based on Hofstede's cultural dimensions theory. The algorithm uses Hofstede's cultural dimensions theory to establish a connection between two cold start users, thus ensuring the stability of QoS prediction accuracy. Then, the prediction results and the dynamic combination of the matrix factorization algorithm are used to obtain a more accurate prediction. The verification results on the real dataset WS-Dream show that the prediction algorithm proposed in this paper effectively alleviates the user cold start problem.

KEYWORDS

Cold Start, Cultural Distance, Matrix Decomposition, Service Recommendation

INTRODUCTION

The number and types of services continue to increase due to the development of technologies like cloud services, internet of things (IoT) services, mobile services, and microservices. Service recommendation technology emerged to identify a service that meet individual users' needs (Qi, 2023; Zhang, Y., Yin, C., et al., 2021). Service recommendation is generally used to model a user's interest by analyzing their historical behavior. Thus, a service can be recommend that meets a user's preference requirements (Zhang, Y., Cui, G., 2021). In a service recommendation system, the quality of service (QoS) should be predicted when identifying a service that meets a user's quality requirements. Therefore, accurate prediction of the QoS value (Zhang, Y., Wang, K., He et al., 2021; Qi et al., 2020; Qi et al., 2022) prior to the user call is an important step in service recommendation (Zhang, Y., Zhang, Yan, 2023; Zhang, Hu, Zhang, 2021; Cui et al., 2020).

Edge computing (Zhang, Pan et al., 2021; Zhang, Cui, Zhao et al., 2016; Zhang, Zhao, Deng, 2018) has introduced new problems to existing recommendation technology. When an emerging technology

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attracts new users, a recommendation system is often used to provide personalized recommendations for new users. The user cold start problem is monumental in recommendation systems (Wang, 2021; Seth & Mehrota, 2021; Amamou et al., 2016). Existing methods to address the cold start of users can be divided into three types. The first, statistical methods, includes the mode method and average method in statistics. These can alleviate the user cold start problem to a certain extent. This type of method is easy to implement; however, it has poor prediction accuracy. The second, demographic methods (Rashid et al., 2008; Liu et al., 2018), uses new users' completed questionnaires to profile users. This type of recommendation method achieves better prediction accuracy than statistical methods; however, it involves user privacy and may lead to a decline in user favorability and user viscosity. The third includes methods based on foreign information sources (Wang et al., 2017; Sahebi & Brusilovsky, 2013). These have good prediction accuracy and recommendation effects. Still, the foreign information sources infringe more on user privacy.

This article focuses on the cold start problem in web services and edge services, including at the protection of user privacy. A recommendation algorithm is proposed based on matrix factorization to solve the cold start problem of users. There is a certain correlation between user preferences and cultural background; therefore, this study introduces Hofstede's cultural dimensions theory (Hofstede et al., 2010). First, it establishes the connection between two users. Second, it ensures QoS for cold start users' stability of prediction accuracy. The experimental results show that the proposed method largely solves the problem of predicting the accuracy of cold starts by users. The main contributions of this article are presented as follows:

1. Using the location information of the user and service, the cultural distance between the user and service is calculated through Hofstede's cultural dimensions theory. The connection among the cold-start user, old user, and service is established without infringement on user privacy.
2. The preliminary prediction of new users is conducted by searching for heuristic services. The preliminary prediction results are dynamically integrated with the matrix decomposition technology. The model parameters are updated by continuously fitting the training set. The final trained model is used to complete the prediction of new users.
3. Several experiments were conducted on the real dataset (WS-Dream). The experimental results show that this method has better prediction accuracy than existing recommendation technology for solving the user cold start.

The remaining content of this article is arranged as follows. The next section introduces the current cold start recommendation methods. Then, it discusses the prediction framework and implementation process proposed in this article. This is followed with a verification of the effectiveness of the algorithm framework via experiments. Finally, the article provides a summary and prospects for follow-up work.

RELATED WORK

Before introducing the proposal, the article introduces solutions to the cold start problem. A direct method to alleviate the user's cold start problem is the mode recommendation method in statistics (or popular recommendation method). The most popular method, as proposed by Park and Chu (Park et al., 2009), is based on this idea. Their method ranks services according to popularity. It provides the same recommendation to all users based on the ranking results. This method is easy to implement and the recommendations are obtained quickly. However, the algorithm disregards the subjectivity of users. In addition, it cannot make personalized recommendations. Moreover, the long tail effect is not conducive to the long-term development of recommendation systems.

Another way to alleviate a user's cold start is by collecting user information. This type of method can be subdivided into two types. The first method obtains the preferences of new users in the form

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