Pair-Wise Trust Prediction Employing Matrix Factorization for Online Social Network

Rajeev Goyal, Sanjiv Sharma, Arvind Kumar Upadhyay

***Abstract:** Online social networks become popular as a medium for propagating information and connecting like-minded people. The public accessibility of such networks with the ability to share opinions, thoughts, information, and experience offers great potential to enterprises and governments. In addition to individuals using such networks connect them to their friends and families, governments and enterprises and started exploiting these platforms for delivering their services to citizens and customers. However, the success of such attempts relies on the trust level with each other also with the service provider. Therefore, trust becomes an essential and important element of a successful social network. Matrix factorization is one of the state-of-the-art recommender systems. SDV and SDV+ are used for trust-based recommender system. SDV++ is used for both internal and external factors that affect trust. This paper proposed a novel method to predict trust by Novel SDV++ Matrix factorization techniques that use both propagation and latent factor approach to predict more accurate results.*

***Index Terms:** Online Social Network, Machine Learning, Matrix Factorization.*

I. INTRODUCTION

Online Social Network (OSN) becomes a platform for several activities in the current scenario. Form students to a working adult and from housewives to the retired person, people used online social media for different activities. E-business, blogging and communicate with an online social network is rapidly increasing [17]. Trust between the users and the product is very crucial to take the decision or making relation in OSN [18]. In the Human social group, trust is based on the past experience, interaction, other's opinions, relationship, etc. in contrast of OSN users are not directly connected with one another and due to this trusting on users in the OSN is ambiguous. Trust in the online social network can be calculated by only previous experience, users profile, social status, etc. Several Online Social Networking Platform let their users give the rating or description to the product or users such as epionion.com. Online users communicate with less amount of users in very large size of the Online Social Network. As a result, there is no direct trust rating between most of the users. In Online Social Network most of the users interact the users that they don't know directly or they don't have any previous communication like in e-commerce, online shopping, etc. this nature of online social network requires an efficient and effective method to predict trust between the users that they have no direct connection.

A recommender system is used to recommend or predict the behavior or trust between users. One of the most used techniques for recommender system is collaborative filtering. The process to filter dataset and produce pattern through collaboration is called CF [21]. In Collaborative filtering, the recommendation is done based on similarity. User having similar behavior can trust similar type of users. CF is used in several recommender systems such as image processing and biotechnology. The problem with the CF used as a recommender system in OSN is the size and sparse data. As in huge size, OSN have very less trust rating or direct communication between users the new users can get a less accurate result based on the similarity.

This article is organized as follows. The next Section described the concept and method used for trust prediction and in the article. Also, describe the similar work done by researchers. The methodology describes the procedure of the study, which consist investigation, preprocessing, molding, assessment, and testing. The experimental study states the experiment results and assesses the performance of the proposed techniques. At last, conclude the article. The paper first reviews the present method for trust prediction and then compare with this the proposed method.

II. CONCEPT AND METHODS

Maintaining reliable and trustworthy Communication environment in OSN is a big concern. Trust has developed as a prominent factor for prediction or probing new friends in OSN. [1]. Trust prediction classified in two systems first supervised and second unsupervised trust prediction system.

Supervised Trust Prediction system classifies dataset in train and tests then predict the trust based on previous experiences such as trust prediction by supervised random walk [2] proposed by Bakhshandegan Moghaddam, Farshad, and Bahram Sadeghi Bigham. As OSN have huge and highly sparse data supervised trust recommender system provide imprecise result. Supervised trust recommender system does not provide accurate result due to the dynamic nature of OSN. Unsupervised Trust Prediction System is produced Trust without incorporation of the assistance [3, 4]. Trust can recommend personalizing users in Unsupervised Trust Recommender System.

Trust Recommender system classified into two categories namely Content-Based and Collaborative filtering [18]. Content-Based trust prediction

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system predicts user or product trust based on past experience of the other users. Content in OSN is image, audio, video, and text such type of content are difficult to analyze. Content-Based Recommendation System is challenging caused by specified to a particular context and evaluation of the content. Collaborative filtering (CF) is based on the similarity or related behavior of the users. Collaborative filtering Trust Recommender System recommends the trust based on similarities in user behavior or online habits of users or tendency to purchases the products. CF system provides a high rating for similar users to make the decisions. CF is considered as one of the best techniques in a recommender system for data mining and Information creation. Numerous OSN already used Recommender System like Netflix, Amazon, and Google, etc.

The process of filter the data by a collaboration of multiple keys or factor and find the pattern is called Collaborative filtering. Collaborative filtering are broad categories by memory based and model-based. In Memory based Collaborative filtering complete dataset is used for prediction. But in model-based Collaborative filtering Machine Learning Techniques are used. Through mining and ML techniques pattern produced and then the prediction is done. Due to the huge size and sparse nature of the Online Social Network,s Model-Based Collaborative filtering is best suited for Trust Prediction.

Model-based Collaborative filtering can use either Clustering or Association Rules for the Recommender System. Clustering is good in prediction for Groups and Association Rules is good practices for predicting Individual User. Since Collaborative filtering degrade due to sparsity and large size of the Online Social Network Matrix Factorization is one of the best possible options to recommend the trust between the users. Matrix Factorization Factorized the Customer-product specific matrix into Customer and product Specific metrics and then predict the missing values on the basis of both the metrics.

One of the most successful methods for recommendation is matrix factorization. This technique finds the two P and Q Matrices that multiplied and get the matrix R. R is the original matrix having all predicted values.

[R]= [P]*[Q]

Since the user has communicated very less number of users in OSN. Therefor sparsity of the matrix R is very huge. To overcome this fill the P and Q with random numbers and then optimize the error consider the rating already given.

III. PROBLEM STATEMENT

In OSN users wants to communicate with trusted users. Several OSN provides the environment to rate the users or item without any context. By using these rating trust is predicted. Trust is predicted by either propagation based or latent factor based mechanism. In propagation based method [5, 6, 7], calculate the path between source users to target user. In latent factor similarities of the users, the rating is given or received is checked. Based on that trust predicted [8, 9]. Matrix factorization is one of the most famous technique. In this technique can utilize both the propagation as well as latent factor.

The similarity between users rating can be biased. Let two user A and B gave a trust rating to the user C in the scale of 1 to 10. Both have given 6 ratings to C. but there may be a possibility that A have given 6 as highest trust rating and B has given as lowest rating. Even a user gives the rating in some pattern influenced by other factors such as the tendency to give high or low ratings. Therefore all these factors are to be incorporated for trust prediction mechanism.

There are following Observation for future trust prediction mechanism.

1. OSN is very sparse network in terms of user ratings.
2. All factors of the trust rating must be incorporated to predict accurate prediction.
3. Propagation and latent factor both factors must be incorporate in trust prediction mechanism.
4. There are factors related between users and only dependent on the user itself, these factors are also processed separately.

IV. METHODOLOGY

The section elaborates the methodology used in this work. As figure 1 present the proposed approach first prepare a trust-based dataset from a standard dataset. The dataset detail describes the following section. Second,, find the feature by applying a community detection algorithm. Third implement proposed method ie. Modified SVD++ matrix factorization with the extracted feature set. At last, we evaluate the performance of the proposed method.

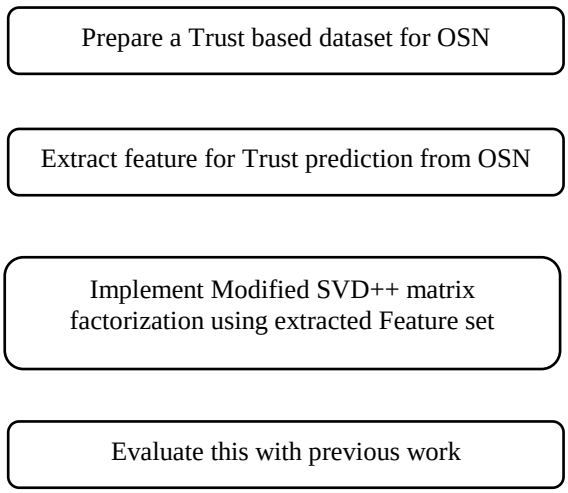


Figure1 Proposed approach for trust prediction

Trust is subjective and influenced by several factors such as trust biases, Proliferated Trust, Trust distribution similarity and trust rating similarity. To overcome the observation proposed method incorporate the following factors that affect Trust to regularization in matrix factorization [10]. Firstly trust is divided into two types of factors parts Inter-user Trust and intra User Trust.

Proliferated Trust: Human always trust more whom who are known to him or to kwon by the person that he already knows [11]. It means trust is propagated in nature. Several methods already developed for using propagation of trust for the trust prediction. Proposed method calculates the highest cost of the source user to the

destination user. Here we select the highest trust cost between the source user and the target user. C (s, t) form the multiple available paths. Is there is no path between source and target users then C (s, t) = 0. Also, the cost from source to target is not the same as a target to source. Means C (s, t) ≠ C (t, s).

Trust biasness: As each user is given the trust rating to others in a pattern that can be influenced by other external factors. Like some users give a high trust rating to all and some users give relatively low trust rating [12]. Trust biases are divided into two parts first is a user provide the trust and second a user rated by other users. Both are interdependent properties.

Trust distribution similarity: In a large OSN, some users provide trust rating in uniformly while others may provide trust with low or high rating value. The distribution of the trust rating will help to understand the user's behavior [15, 16].

Trust value Similarity: There may be the users U1 who trust the same user and gives the same rating as user U2 do [13, 14]. In the same way, two users can have the same trust rating. This similarity can be obtained by the correlation coefficient. As user CC(x, y) is the correlation that x and y provide the rating the common users.

$$CC(s,t) = \frac{\sum_{f \epsilon I(s) \cap I(t)} (b_{sf} - \overleftarrow{b}_s) . (b_{tf} - \overleftarrow{b}_t)}{\sqrt{\sum_{f \epsilon I(s) \cap I(t)} (b_{sf} - \overleftarrow{b}_s)^2} \sqrt{\sum_{f \epsilon I(s) \cap I(t)} (b_{tf} - \overleftarrow{b}_{it})^2}}$$

Where $\overleftarrow{b}_i$ and $\overleftarrow{b}_j$ shows the respective average rate of user I and j. also the correlation coefficient is regularized as [0, 1] from [-1, 1].

On the basis of the above factors, the weighted sum of the trust properties between user s and user t is formulated as below

$$PT(s,t) = a_1 prop(s,t) + a_2 CC(s,t) + a_3 RD(s,t)$$

Here a's are coefficients

To predict trust, celebration filtering can be used for a more accurate and huge dataset that is one of the prominent features of online social Network. Matrix factorization is one of the effective recommender technique. Characteristics of trustee and trustee are used for user rating as a latent factor.

As people in a social group such as OSN will trust or take suggestion form their known or relatives. As trust is an Interpersonal feature. Trust can be predicted with both explicit and implicit ratings. Most of the recommender system uses only explicit feedback. Most of the OSN does not provide implicit feedback due to privacy reason. However implicit rating can improve the accuracy of prediction as it is an additional factor for user's preference. In the proposed method, a modified SVD++ is used which used the propagation, latent factor as well as the perspective of implicit ratings.

Every trustee is associated with the vector $q_s \epsilon R^f$, each thruster is associated with $p_s \epsilon R^f$.

The exact model as following the objective function is to minimize the regularized error

$$minf(R,U,V) = min_{u,v}(R_{u,v} - b_s + b_t + p_s^T \left(q_t + |R(u)|^{-\frac{1}{2}} \sum_{j \in R(u)} y_j\right)) + PT(u,v) \|u_s - u_t\|_F^2$$

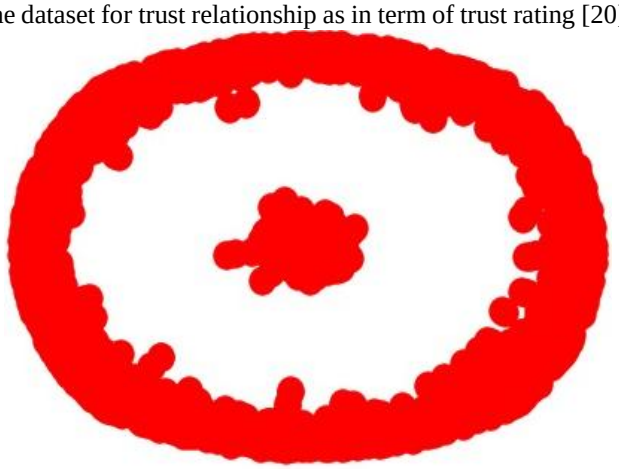
$$minf(R,U,V) = min_{u,v}(R_{u,v} - b_s + b_t + p_s^T \left(q_t + |R(u)|^{-\frac{1}{2}} \sum_{j \in R(u)} y_j\right)) + PT(u,v) \|u_s - u_t\|_F^2$$

V. EXPERIMENT

This Section analysis the results of the experiments conducted on the standard dataset available for the OSN research.

A. Data-Set

There are several datasets available for the analysis of Online Social Network such as Epinions, ciao, Avacado, etc. Out of which epinions is used as a standard dataset for the analysis of the Online social network. The epinions has a wide verity of items such as electronics, sports etc. epinions have the dataset for trust relationship as in term of trust rating [20].



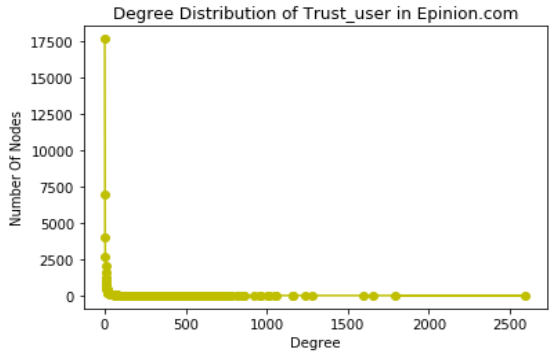


Fig 2: Distribution of epinions dataset

Table 1: Product rating table epinion_tang

S. No.	Fields
1	Userid
2	Productid
3	Catogoryid
4	Rating
5	Helpfulness
6	timestamp

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Table 2: Trust table in epinion_tang

S. No.	Fields
1	User1
2	User2
3	Timestamp

Table 3: statistics in the dataset

S. No.	File	Records
1	Product Rating	922267
2	Trust	300548

Figure 2 presents the distribution of the dataset. And table 1, 2 and 3 describe details and statistics about opinion dataset.

B. Evaluation Measures

For evaluation of prediction Mean Absolute Error MAE and Root Mean square Error RMSE are the preferred measures. Due to this MAE and RMSE is used as an evaluation measure to compare the proposed method with current techniques.

C. Result and comparison

For the validation of the proposed model, each experiment is conducted on a random subsample for 15 times. The proposed method is conducted, more than 450 times. Table 4 and figure 3 shows the result of the experiments. The result shows that the MAE is less than 0.1401 and RSME is 0.1998. That means the accuracy of the proposed model is more than 85%.

Table 4: Result of Experiments

	Training %	80%	70%	60%
MAE	Best	0.1401	0.1446	0.1487
	Average	0.1710	0.1720	0.1750
	Worst	0.1807	0.1821	0.1877
RSME	Best	0.1998	0.2026	0.2086
	Average	0.2104	0.2116	0.2176
	Worst	0.2141	0.2201	0.2240

As a result show that the proposed technique is stat of the art technique for predicting trust in OSN. Due to the use of SVD++ and personal feature which improve accuracy.

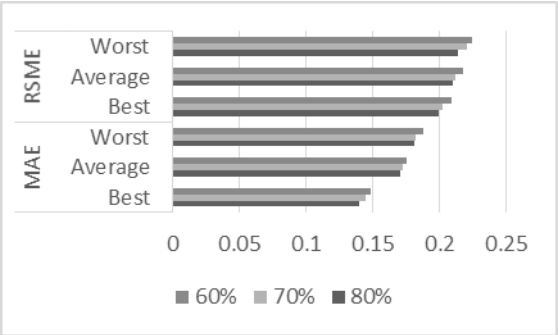

Figure 3: MAE and RSME

VI. CONCLUSION

The paper proposed a pair of a wise trust prediction model using collaborative filtering techniques. Matrix factorization is used to predict trust between the users. The technique both implicit and explicit trust rating. Implicit trust rating increase accuracy with the help of SVD++ matrix factorization. Inference and latent factor both are used for regularizing trust rating to minimize errors. These techniques achieve RSME= 0.1998 and MAE=0.1401. In the future, these techniques can be improved for context-sensitive trust prediction. In Future, this technique can be modified in the context of Trust prediction with context sensitivity. That can improve accuracy.

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