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Friend Recommendation System by Using Context-Awareness

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Abstract: In current scenario, everybody is busy but still wants to be socially active to share their knowledge. Recommendation of friends with similar interest is the biggest challenge for the social networking applications. This can be accomplished by user's lifestyle that plays the major role in identifying user nature and interest. Lifestyle with contextual information based friend recommendation system is different and more precise approach. Moreover, users' interests are not static, it may be varied with time.

Keywords: Recommendation System, Machine Learning, User Interest, Friend Recommendation.

1. Introduction

In current scenario, with the popularity of Social Media Sites, most of the social sites attracted the users to actively participate in all types of social activities. Approximately, 4021 million people are the active internet users, 3722 million people are the unique mobile internet users, 3196 million are active social media users and 2958 million are active mobile social media users [36], they want to connect with each other.

A recommendation system generally interacts with its users in a most possible friendly way and recommends doing something in its user's favor [38]. Social networking sites, such as Facebook and Twitter getting popularity in the last few years. Friend recommendation being an important component of social networking sites may help to expand its dimensions through recommending new and more potential friends to users. There are plenty of commercial opportunities when taking the online friendship into considerations.

Traditional friends, on one hand, usually have face to face interactions frequently because they

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live near each other, or work, or play in the same place. On the other hand, when they have a chat, the topics are usually about things that happen in their surroundings. Traditional friends also share some similar social characteristics such as age, place, etc. Friends can also share their experiences, photos, achievements, views, etc. Friend recommendation helps to find online friends that share similar personal interest, no matter who they are and from where they are. For example, a man who has an interest in stitching new clothes, no matter where he is, might make online friend with those who share many designs, photos and their views about the clothes and the design. The friend recommendation is based on individuals' interest.

In friend recommendation, the user can search for friends by name, mobile number, tagging, their mutual friends, locations, etc [39]. Friendbook identifies lifestyle and day to day activities of users and recommended friends to user with higher similarity scores. It presents the recommendation score withusers.

The appearance of several social networking sites has given a novel mechanism of making friends. There can be so many ways to become friends with someone on social networks. People can easily and freely make friends on social networks. But some of the time recommendation is not as per user's choice. Generally, habits or lifestyle or behavior or activities are the major feature between two users friendship, but is not broadly used by most of the social networking sites recommendation systems because the user's lifestyle is hard to confine by web actions. Several times user's lifestyle is based on the activities that carried out in their regular life. Our daily life is designated by so many activities. This recommendation system permits users to share lifestyle on the social network. By using this lifestyle system, recommends the suitable friends to the user, which definitely helps users to get their friends on the social network.

Recommendation of friends with the similar interest is the biggest challenge for the social networking applications. This can be accomplished by user's lifestyle that plays the major role in identifying user nature and interest. Moreover, users' interests are not static, it may be varied with time. A computer system that makes suggestions is called a .

Lifestyle-based friend recommendation for knowledge-management can be a different and simple approach. Knowledge-management is one of the ways of creating, sharing, using and managing the knowledge and information. For example, if the user shares same native place and

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same school during childhood time, they may have a common interest behind friendship. In order to extract more information about recommendation system and data mining approach a study the relevant algorithm for both has been performed and observe that mining can be a good approach to filter out the group of similar users whereas recommendation can help to extract the list of most similar users [40].

Social networks provide an easy and interesting way for people to connect with each other and make new friends to be more social. Similarity or feature input is always expected in a recommendation system which can be derived from mining algorithms. Study of data mining observes that clustering approach can be a good approach for social networking sites to prepare a group of similar users and reduce effort of recommendation.

2. Literature Review

Following section contains the existing work proposed in the related area. Kacchi et al. [1] presented a solution model which is based on filtering and recommendation system. The proposed solution is based on data collection and analysis method with friend matching graph and ranking steps. Wang et al. [2] suggest that machine learning and data mining approach can be used as recommendation purpose and can effectively perform the role of friend recommended on social networking sites and applied semantic analysis for the recommendation. Bian et al. [3] developed a solution based on personality of users by using collaborative filtering for recommendation purpose.

Linden et al. [4] assumed that every user has a unique nature and style which can be obtained from user previous transactions or nature of the products selected during shopping and recommend products based on their characteristics. Kanungo et al. [5] represented the broad view of understanding and implementation of K-mean algorithm and strongly justice use this approach for social networking sites. The only problem with this proposal is, it cannot be used for recommendation purpose and can only able to prepare a group of similar elements.

Kwon et al. [6] proposed a friend recommendation approach based on matching graph. The authors addressed that lifestyle may be an innovative approach to find similarity among social networking users. This work attempted to propose a hybrid approach to recommend user based

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on clustering and filtering approach. Du et al. [7] proposed an explainable and efficient Friend-of- Friend based friend recommendation algorithm in a campus social network system for better performance in complexity and scalability.

Yang et al. [8] gave a hypothesis for friend recommendation based on content, social relations and the filtering recommendation to get an improved and sequenced algorithm for a more comprehensive recommendation method. For Friend Recommendation, Zhao et al. [9] used a hybrid friend recommendation framework which is not only based on friend relationship but also on user's location information using collaborative filtering approach.

Raghuwanshi et al. [10] proposed a methodology for friend recommendation system based on similar interest by using k-mean clustering algorithm and calculate similarity factor by using formula of Closeness factor. Deng et al. [11] proposed a new recommendation method by combining the existing FOF algorithm and content-based algorithm to get more meaningful and accurate recommendation outcomes and calculate more quickly in the large amount of data and also solve the problem of accuracy.

Farikha et al. [12] developed a trusted friend's calculation method for friend recommendation by analyzing user's profile and also represented the user's model as an ontology that consider all trusted friends' preferences and the degree of trust between friends.

Yu et al. [13] proposed a system to improve amount of information on users' preferences through FR (Friend Recommendation) and gave a definition of Friend Recommendation considering Preference Coverage Problem (FRPCP) and it is one of the NP-hard problem. Author proposed the greedy algorithm to solve this problem. Zhang et al. [14] proposed a recommendation model called feature extraction-extreme learning machine (FE-ELM), where friend recommendation is estimated as a binary classification problem. This proposed system uses some approaches for the extraction of the spatial-temporal feature, social feature and textual feature.

Zhou et al. [15] presented a friend recommendation mechanism using a user's information of total attributes which is based on the law of total probability. Nguyen et al. [16] presented a way for friend recommendation in social networks based on user's perception in each of his/her friend groups by using genomes to represent friend group perception.

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Guo et al. [17] proposed a trust-based privacy-preserving friend recommendation system for online social networks (OSNs). Huang et al. [18] correlated different social role networks to find their relationships and make friend recommendations and known as NC (Network Correlation) based SFR (Social Friend Recommendation).

Zhang et al. [19] introduced a friend recommendation system which used user's total attributes information (FRUTAI) that is based on the law of total probability. Abbas et al. [20] described various components of trust such as friend-of-friend, credibility and the kind of social spot where trust evaluation is performed and then calculate these parameters to compute the final trust value.

Kumar et al. [21] proposed two algorithms to recommend a new friend in online social networks. The first algorithm is based on the number of mutual friends and second is based on influence score and these recommendation algorithms use collaborative filtering. Pingate et al. [22] presented Friendbook, a new semantic-based friend recommendation scheme for social networking sites, which suggests friends to users on the basis of their lifestyles regardless of social graphs. Rottentomatoes [24] recommend various videos, movies, games, etc. according to user's interest and previous search histories.

Youtube [25], the world most well-known online video group. This recommends personalized record of videos to users based on the previous activity. Jeff Naruchitparames et al. [26] emphasized that by combining network topology and genetic algorithms, better recommendations can be achieved.

Jiang et al. [28] designed a safe friend recommendation system which is based on the user behavior, called PRUB to achieve elegant recommendation to friends who share some same features without exposing the actual user behavior. Ramteke et al. [29] proposed a model that

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will execute on the Android-based System or Smartphone's. The results will illustrate that the recommendations correctly return the users' preferences in choosing friends.

Guy et al. [30] studied personalized item recommendation within an enterprise social media application suite that includes blogs, bookmarks, communities, wikis, and shared files. Recommendations are based on two of the core elements of social media–people and tags. Zheng et al. [31] proposed a temporal-topic model to analyze user's possible behavior and predict their potential friend in microblogging. The model learns user's latent preferences by extracting keyword on aggregated messages over a period of time with the help of topic model and then the impact of time is considered to deal with interest drifts.

Kang et al. [32] proposed LA-LDA, a latent topic model which incorporates limited, non-uniformly divided attention in the diffusion process by which opinions and information spread on the social network. Pennacchiotti et al. [33] gave a friend recommendation system by using LDA with high recall, outperforming existing strategies based on graph analysis.

Huang et al. [34] proposed a more precise friend recommendation system with two stages i.e. possible friends chose in first stage and further refine the recommendation by using topic model.

Table 1: Comparative table of different recommendation methods available

Method	**Year**	**Domain**	**Feature**	**Learning Approach**	**Analysis Approach**	**Dataset**
K-mean Algorithm	2010	Data Mining	Similar Group	Friend Matching Graph	Clustering [5]	Netflix
Matching Graph	2010	Clustering	Lifestyle	Hybrid (Clustering & Filtering)	Matching Graph [6]	Real Data
Collaborative Filtering Model	2011	Feature Extraction	Personality	Matching Network	Personality Extraction [3]	Real Data

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Network Topology & Genetic Algorithm	2011	Network-Based	Personal Interest & Network Based	Link Recommendation	Network-Based Approach [26]	Facebook Data
LDA	2011	Machine Learning	Feature Extraction	LDA	Topic Model [33]	Twitter Data Set
FOF & Content Based Method	2012	Clustering	Content Based	DBSCAN	Content Based Approach [11]	BYR (500 User's data)
Trust-Based Privacy-Preserving FR	2013	OSN	Trust-Based	KNN, Secure Social Coordinate Matching	Security Analysis [17]	Facebook, Infocom
LA-LDA	2013	Limited Attention & Diffusion	Attention-Based	LDA	Probability Distribution [32]	Social News Aggregator Digg
Filtering Approach	2014	Data Mining	Feature	Clustering	Based on nature of product selected during shopping [4]	Amazon

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FOF Algorithm	2014	Relationship Based Approach	Community (Group)	Clustering	Generation of Incremental Relationship Data [7]	Real Data
FR Based on User Perception	2014	Perception System	Multi-Group Based	Markov Clustering Algorithm	Feature Extraction [16]	Facebook Data
Latent Dirichlet Allocation	2015	Machine Learning & Data Mining	Features and Activity	Topic Model, Friend Matching Graph, User Impact	Semantic Analysis [2]	Real Data (8-Users by using sensor network)
FRUITA	2015	Path-Based & FOF	Total Attributes	Social Network Graph	Law of Total Probability [15]	RenRen Data
NC-Based SFR	2015	Multiple Network Correlation	Multiple Network Based	Network Correlation	Feature Extraction [18]	Flickr Network
FRUITAI	2015	FOF & Path-Based	Total Attributes	Social media Relation	Law of Total Probability [19]	RenRen Data
Temporal Topic Model	2015	Micro blogging System	Time-Based	LDA	Topic Model [31]	Real Data
Filtering and Recommendation System Model	2016	Hadoop Technology & SQL	Lifestyle	Friend Matching Graph & Ranking System	Reverse Indexing [1]	Real Data

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PMSN Based FR	2016	MSN	Trust-Evaluation Based	Trust-Evaluation Protocol	Mutual Friend [20]	Real Data
PRUB Based FR	2016	Security & Behavior Based	User Behavior Based	Same Characteristics based Approach	Privacy Protection [28]	Chinese-ISP
Multiple Classifier Combination Method	2017	Location Based System	Location Based	Supervised Learning	Collaborative Filtering Approach [9]	Twitter (New York & Sidney for 1 month)
K-means Clustering	2017	Machine Learning	Attributes (52)	Clustering & Friend Matching Graph	Similar Interest [10]	Real Data (200 Users)
User-Interest Extraction	2017	Semantic Social Recommender System	Trust Based	TF-IDF	Similarity Measurement [12]	Face book Data
Greedy Algorithm for NP-Hard Problem	2017	LBSN	Point-Of-Interest	FRPCP	Preference Similarity [13]	Real Foursquare & Gowalla Dataset
FE-ELM	2017	Clustering & Learning	Spatial Temporal, Social & Textual Feature	Classification	Feature Extraction & Training [14]	Real Data (New York City)

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Topic Model	2017	Feature Extraction	Preciseness	LDA	Probabilistic Topic Model [34]	Flickr Data Set
Recommendation Based on Content & Social Relationship	2018	Micro blog System	Social Relation	Clustering	Filtering [8]	Military People Data
Topological Structure of Social Networks	2018	Social Networks	Mutual Friend & Influence Score	Content Based & Collaborative Filtering	Collaborative Filtering [21]	Facebook & Twitter Data

3. Research Gaps

There are some of the research gaps in this area, as:

- Most of the existing friend suggestion mechanisms rely on pre-existing user relationship to recommend friends.
- The previously proposed models don't ensure its effectiveness on those users who have less friends and followers [31].
- Some of the previous models perform much better when a user has small number of friends otherwise its performance is less impressive [19].
- It is needed to extend a model which works on other several attributes to recommend a friend to users.
- Contextual information is usually not included for the recommendation.
- More precise and accurate results are also an important requirement for social sites.

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4. Proposed Algorithm

Feature extraction:

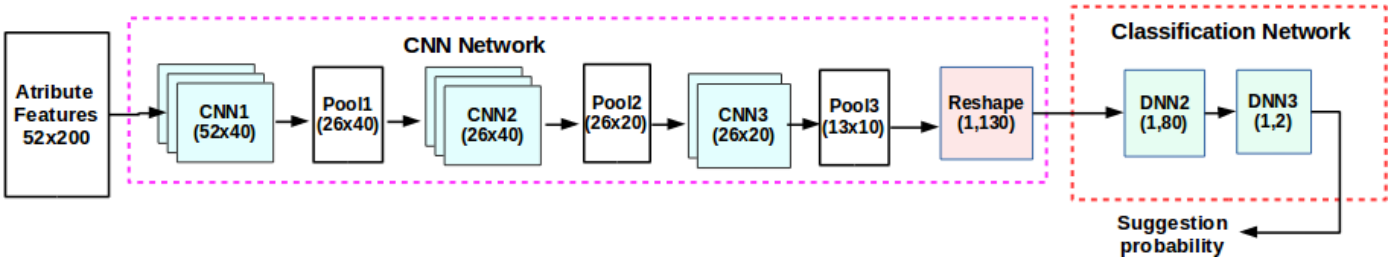
In this section, we propose a similarity feature vector of dimension 52x100, which consists of 52 attributes similar to [10]. For each person, we extracted 52 attributes data, then representing each attribute using a unique 100-dimensional vector, a 52x200 feature for each person is obtained by combining 2 persons feature vectors.

The proposed architecture is shown in the block diagram.

It consists of 2 major parts, that is

1) CNN network and

2) classification network.



Block Diagram of proposed network

1) CNN network:

In this network, we consider 3 1D convolutional layers alternatively with pooling layer. In the first CNN layer, it considers the feature vector of size 52x200. Using padding with 40 filters the output size is reduced to 52x40, then it is passed to first pooling layer to make the size 26x40. In the second CNN layer, it considers the output of first pool layer as input. Then it is transformed to output size 26x40 using 40 filters with padding and stride zero. Then it is passed to pool2 layer to make the size 26x20. The pooling applied in the first dimension. In the next CNN layer, it will consider the second pool layer output as its input, and by using 20 filters with padding and stride zero, its output size is 26x20.

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then it is passed to pool3 layer to apply to pool in the first and second dimension to make the size 13x10.

Then we have used a reshape block to make the size of the feature to 130. So each person is represented by 130-dimensional vector depending on his interests.

2) Classification network:

Here we use two dense neural network layers to make the decision of whether to recommend a friend or not. Now the 130-dimensional vector is passed to the first neural network layer to convert it into an 80-dimensional feature vector. Then it is passed to 2 nodes dense layer with softmax activation to give the probability of whether to recommend a friend or not. So if the final output probability is greater than 0.5 then friend suggestion will be given among them. Else not.

Training:

First we consider the K-means clustering algorithm among feature vectors inspired from [10] then we use two persons from the same cluster to give at time to do training. For training, we consider a set of 200 persons, with limited connections among them. If two persons of training data are friends then the final label is 1 otherwise it is zero. In this way, training data is used to train the above network. Before training available data is split into training and testing.

5. Result and Discussion

Method	Accuracy on predefined network
K-means	62.33%
Proposed Method	81%

Comparison of proposed and k-means algorithm method

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The above table shows the results of correct prediction of friend suggestion on predefined people network. It clearly shows that applying the proposed network after the K-means clustering will improve the performance by ~20%. It is also clear from the table that just applying K-means clustering does not ensure the similarity between the persons.

This networks also helps us to understand, on what basis people are becoming friends on social network sites. This also helps us to investigate the reasons for social likeness.

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