International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 13 (2017) pp. 3724-3729

F2F: Friend-To-Friend Semantic Path Recommendation

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Abstract

Recently, services of social network applications especially location services have been enhanced to meet the advancements in positioning devices and internet of things technologies. In addition, the explosion in the number of web users led to incorporating new properties in these applications to match their new desires and needs.

Inspired by the new digital era needs, an activity semantics approach is presented in this paper that utilizes location semantic features along with friends' activities semantics to enhance recommendation process results.

In this paper we propose a Friend-To-Friend (F2F) semantic path recommendation which aims at discovering the best path (trajectory) that satisfies the target user's desired set of activities taking into consideration target user's preference and location rating attributes, (i.e. quality, price, service, etc.) which is performed based on similar friends trajectories satisfying the same set of activities that are desired by the target user.

F2F is experimented and evaluated using real data that is obtained from Foursquare and Gowalla social applications. The accuracy of the resulting recommendations is also presented to show the effectiveness of the proposed approach.

Categories and Subject Descriptors: [Database Applications]: Spatial databases.

General Terms: Recommendation System, Location Based Services, Semantic-based Recommendation.

Keywords: Semantic Activity Search, Friend Based Recommendation, Location Attributes.

INTRODUCTION

Traditional location recommendations were designed to retrieve the most relevant venues based on spatial attributes for example current location, distance, etc. [1], however, with the increased use of Global Positioning Systems (GPS) and location based services new recommendation systems that take into consideration user reviews, user connections, check-ins data, ratings, and preferences are highly needed to improve the accuracy and quality of recommended results [2] [3].

During the last few years several location recommendation approaches were proposed. Collaborative filtering [4], content based filtering [5], location aware recommendation [6], which is a special type of context aware recommendation [7], knowledge based recommendation [1], semantic information [8] and hybrid recommendations [9] are all different approaches for location recommendations.

Recently, the authors in [10] [11] introduced trajectory similarity search that aims at finding the most similar trajectories that fulfill users' requirements.

In this paper we employ features from both semantic based and location aware recommendations along with collaborative filtering. We aim in our model to enhance the recommendation process by merging the traditional approaches to propose a hybrid approach to recommend the best path(s) that satisfy users' needs along with meeting the required users' venie attirbutes.

The proposed F2F model makes use of spatial characteristics along with friends' profiles, in addition it takes into account contextual information related to each venue (price, quality, service, etc.) with another pillar representing the kind (degree) of relationship between different users (i.e. either friends or not friends).

In addition, F2F is characterized by the ability to recommend a complete path that satisfies the required set of activities taking into account the semantic dimension of those activities.

Contributions in this paper mainly focus on: 1) presenting F2F model that satisfies target user's needs, 2) combining traditional recommendation approach, 3) testing the resulting recommendations using real data.

The rest of the paper is organized as follows. First, we focus on previous works in recommendation systems especially location based recommendation systems. Then, we introduce the F2F model, we define the main concpets and introduce the model architecutre. Next, experiments using real data are conducted and evaluated with other similar approaches. Finally, we conclude our proposed model discussion and propose dorections for future work.

RELATED WORK

In this section we highlight the main contributions related to our problem. We divide those contributions among a set of domains as follows.

1) Location Recommendation

Location recommendation aims to recommend venues based on different features as presented in [12] [13], in those works the constructed recommendation models are based on traditional spatial features (i.e. current location, and travel distance). Then the authors in [14] showed the importance of the check-in service in location recommendation as the users became able to share their current location likewise attach geotagged information (i.e. picture, comment, company, etc.) and how it affected recommendation performance.

In addition, in [15] the authors proposed location aware recommendation system that takes into consideration suitable features to ensure user satisfaction. In [16], the authors discussed the issue of recommending new venues to target users, they proved that target users most likely tend to try new locations that were previously tried by other users, and the possibility of trying this new location increases based on the relation degrees between these users (i.e. friend, relative, etc.) as the authors highlighted in [17].

2) Trajectory Similarity Search

Trajectory search was introduced in [11] [18] to propose a path recommendation system, the authors aimed to analyze trajectory data to match target user's desires through discovering top k similar trajectories that achieve user's needs. Similarity search is considered a major challenge in the field of trajectory search, hence, lots of efforts concentrated on finding different similarity search techniques in trajectories as proposed in [19].

Then, in [20] the authors presented similarity searching in spatial data through tree structure, also the authors in [21] introduced similarity search in trajectory based on activity data using grid activity stechnique to find the most similar path(s) that satisfies a set of activities desired by the active user. Nevertheless, in [22] the authors extended the current activity trajectory to enhance the recommendation model, they proposed big data framework based on Hadoop structure with map–reduce multi-hub system. Lately, the authors in [23] brought into consideration the concept of rates values to be applied in recommendation system to show its effect on the resulting recommendation for better user satisfaction.

3) Semantic Recommendation

Previous works in recommendation systems based on semantic information was investigated, regrading users' behaviors and preference similarities. The authors in [16] focused on discovering new social relations between users based on the similarities in their profiles. In [24] the authors proposed an ontology model that studies user behaviors based on the target user trajectory data to conclude the user semantics from his movements.

Also, semantic based location was defined by the authors in [8] for matching indirect users' interests with venue semantic attributes to recommend the most suitable venue(s).

Moreover, the authors in [25] focused on understanding the semantics behind check-in spatial data, for better knowledge about target users and how they tend to visit new locations

PROBLEM STATEMENT

Determining the best path that satisfies target user's list of desired activities to fulfill his needs taking into account venue attribute and user's preference is a challenging problem. Employing spatial attributes along with semantic knowledge concerning required activities and rating values help to enhance the quality of the recommendation process. Our goal in this paper is to build a path recommendation system that explores historical check-ins data belonging to target users' friends' list specially those who previously visited venues satisfying the required set of activities

In this section we aim to discuss the proposed F2F model, first we list important annotations and definitions to be taken into consideration, then, the used procedures are presented and discussed. Table 1. lists all used symbols along with their corresponding description.

Table 1: Symbols and Definitions

Symbol	*Title*
POI	Place of Interest
U	Target User
Uid	User id of Current Point
UV	User Preference
QA	Query Activities
RA	Place Activities
S	Similar Candidates
V	Venue Attributes
F_L	Friends list

Q	User query
Cƚ	Similar Candidates
x	Latitude
y	Longitude
A_L	Activities list in Current Point
β	Distance threshold
CA	List of activities in each check-in
CPA	List of activities in each similar Candidates

PROPOSED SOLUTION

Figure 1. shows the architecture of the proposed F2F model, the main phases of the architecture are defined as follows:

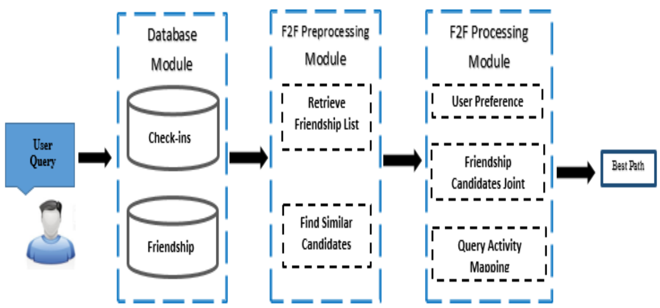

Figure 1: F2F Proposed Approach

1) Phase1: F2F Database Module

This phase provides real data about historical check-ins data set that describes users' check-ins processes attached with rating values which describe venue attributes, and friendship data set which clarifies the degree of relation between users (friend, not-friend).

2) Phase2: F2F Preprocessing Module

This phase aims to traverse the database model to retrieve friendship list which contains the list of friends of the target user and retrieve the list of similar candidates S that satisfies users' required activities as shown in Algortihm 1.

We first highlight some definitions that need to be considered before we proceed to the algorithm.

Definition 1. (Venue Activities) Let A_L denotes the set of activities offered at a certain point P where A_L={A_1,…,A_n}.

Definition 2. (User Query) Let Q represent desired requirements from U where Q= {POI, QA, UV, β}.

Definition 3. (Similar Candidates) Let S represent a list of S={ CP_1,…, CP_n} where P is said CP if and only if its A_L have at least one activity from QA.

Definition 4. (Distance Threshold) Let β denotes desired threshold and D(POI,CP_i) represents Euclidean distance between user target desired location POI and similar candidate where ∀ CP_i∈ S.

Definition 5. (ExistFriend) Let ExistFriend (F_i, U) denotes a if there exist arelationship between Fi and U whether they are friends or not.

Definition 6. (Friendship List) Let F_L denotes the retrieved list which contains all the target user's friends in the friend data set where each Fi in Friendship list can be a friend to U through ExistFriend (Fi, U).

```
Input:POI,QA,β,Check-ins, Friendship.
Output: S, F_L

S → null
F_L → null
F_L → getFriends()
ForEach CPi in Check-ins
{
  distance → D (POI, CPi)
  While distance ≤ β
  {
    A_L → getActivities()
    ForEach Ai in A_L
    {
      IF (Ai ∈ QA)
      {
        S → S U CPi
      }
    }//END FOR
   }//END WhILE
  }//END FOR
Return S, F_L
```

Algortihm 1: F2F Preprocessing Module

```
F_L → null
ForEach Fi in Friendship
{
  IF  ExistFriend (Fi, U)
   {
      F_L → F_L U Fi
   }// END IF
}//END FOR
Return F_L
```

Procedure 1: getFriends

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 13 (2017) pp. 3724-3729
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```
A_L → null
ForEach Ai in CPi
{
  A_L → A_L U Ai
}// END FOR
Return A L
```

Procedure 2: getActivities

3) Phase3: F2F Processing Module

Based on venue attributes that are required by target user (i.e. high rated) in terms of place, quality, type of service. We filter S to retrieve venues according to target user's preference, after that friendship list is joined with similar candidates to obtain candidate set of friends. Finally, each activity in query activities list QA is mapped through an inverted index list with the friends similar candidates that satisfies this activity and is sorted based on highest rating value from venue attributes that matches the target user's preference UV.

We introduce the definitions and symbols used to implement the F2F processing module as shown in Algorithm 2.

Definition 1. (Venue Attributes) Let V denotes the ratings values for each attribute that describes the location represented as each location P_i has V_i= {Price, Quality, Service, Over All}.

Definition 2. (Friendship Candidate Joint) Let FS denotes each Si in S which is performed by a friend from F_L

Definition 3. (Query Activity Mapping) Let QA_L denotes every activity A_i that belongs to A_L in target users' query QA with all similar candidates from S but only done by friends which achieve current A_i.

Definition 4. (User Preference) Let UV denotes the location feature which is desired by U whether he needs high rated venue in one of the following V = {price, Quality, Type of Service, Over all}.

Definition 5. (Path/Trajectory) Let ƫ represents the path or track which satisfies user needs as a set of Points $\{P_1, \ldots P_i\}$ where $1 \leq i < n$ and each trajectory point $P_i \in$ ƫ = {Uid, X, Y, A_L, V}.

Definition 6. (Friendship Join) Let Exist(V_i , UV) checks the required target user preference UV with each location attribute in the current Cp_i, when Exist(V_i , UV) have a match then $R(V_i)$ gets the rate value of V_i.

```
ForEach Vi in V
{
  IF Exist( Vi , UV)
  {
    r → R(Vi)
  }// END IF
}//END FOR
Return r
```

Procedure 3: RelatedRate()

```
Input: S, F_L, UV, QA, V
Output: ƫ
ForEach Ai in QA
{
    Points → null
    Rates → null
    Points → getPoints(Ai)
    ForEach Pi in Points
    {
      IF (F_L Contains Uid )
      {
        Rates → Rates U RelatedRate(Pi)
      }//END IF
    } // END FOR
    index → IndexOf(Max(Rates))
    ƫ → ƫ U Points.get(index)
}// END FOR
Return ƫ
```

Algortihm 2: F2F Processing Module

```
Points → null
ForEach CPi in S
{
  IF( A_L Contains Ai)
  {
    Points → Points U CPi
  }// END IF
}//END FOR
Return Points
```

Procedure 4: getPoints()

EXPERIMENTS AND EVALUATION

A. Configuration

The experiments in this paper are performed on Microsoft Windows 8.1 operating system, a 6 GB RAM with processor of Core i5 using java programming language, data used in this research are derived from Foursquare [26]and Gowalla [27] samples of used data are shown as in Table 2. that describes relation degree between users where they are friends or not. Also, Table 3. shows a snapshot of available check-in data set where each tuple describes each user location at certain time doing set of activities associated with venue attributes and corresponding rates from 1 to 10.

Table 2: Sample of Friendship Data Set

User A	User B
1200	15
200	600

Table 3: Sample of Check-ins set

Id	1200
X	45.4343434
Y	-73.0002
Activity	A1,A2
Quality	5
Price	6
Service Type	8
Over All	7

B. Evaluation

Experiments on the F2F model proved the effectiveness of the proposed model against other replated approaches namely, Tree structure [20], and Grid Index Search [21]. Results show that F2F out performs comparing these approaches in satisfying target users' query.

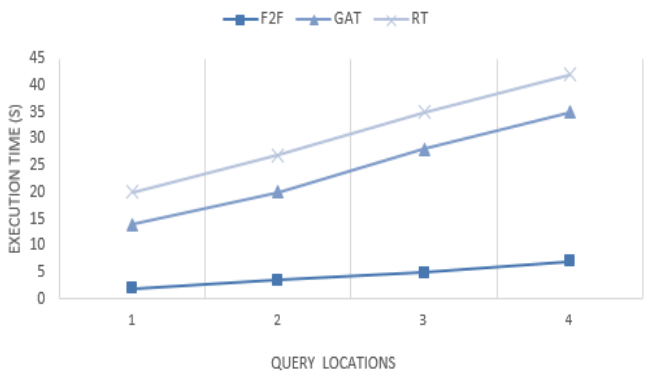

Figure 2: Effect of query location numbers

Figure 2. Shows the effect of changing the desired number of point of interest by the target user. F2F model was supported with a distance function with the friendship check that succeeded to limit the number of possible candidates where it helped F2F proposed solution to deal with the increase in the number of needed locations against other approaches for recommending new venues.

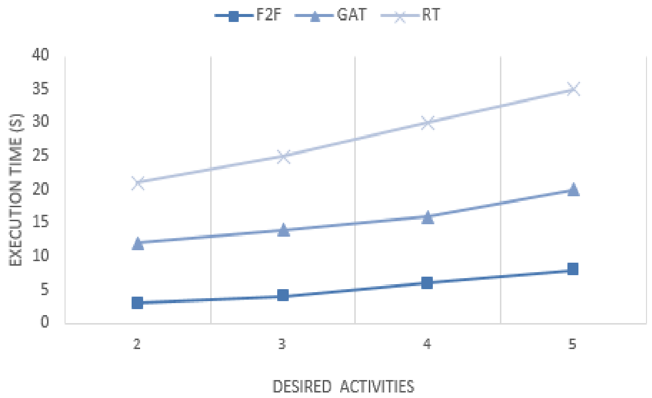

Figure 3: Effect of activities desired number

Figure 3. Shows the effect of changing the number of desired set of activities by the target user. Inverted index in F2F proposed model shows significant results with the effectiveness of the resulted recommendations as it helped in the process of mapping each desired activity with semantic features for satisfying target user's requirements.

CONCLUSION AND FUTURE WORK

The importance of recommendation systems has been recently increased because of the tremendous amount of data produced from Global Positioning systems GPS and social networks applications, not to mention spatial features which are recently added to most of positioning technologies.

In this paper Friend-To-Friend semantic path recommendation (F2F) model has been introduced to satisfy users' query to retrieve best path that achieves desired activities.

Experiments are based on real social networks showed that F2F model outperforms with other comparable recommendation approaches.

For future work we believe that expanding this framework to work for big datasets is a potential research direction. Migrating the proposed F2F model to work on Hadoop or similar parallel processing frameworks is a possible direction for future research.

REFERENCES

[1] M. Sridevi, R. R. Rao and M. V. Rao, "A Survey on Recommender System," *International Journal of Computer Science and Information Security,* vol. 5, no. 14, p. 265, 2016.

[2] J. Bao, D. Wilkie, Y. Z. Zheng and M. Mokbel, "Recommendations in location-based social networks: a survey," *GEOINFORMATICA,* pp. 525-565., 2015.

[3] C. Hongbo, C. Zhiming and M. S. Arefin, "Place Recommendation from Check-in Spots on," in *Third International Conference on Networking and Computing*, 2012 .

[4] K. W.-T. Leung, D. L. Lee and W. C. Lee, "CLR: A Collaborative Location Recommendation Framework based on Co-Clustering," in *Proceedings of the 34th international ACM SIGIR conference on Research and development in Information Retrieval*, 2011.

[5] A. Felfernig, M. Jeran, G. Ninaus, F. Reinfrank, S. Reiterer and M. Stettinger, "Basic Approaches in Recommendation Systems," in *Recommendation Systems in Software Engineering*, Berlin Heidelberg, Springer , 2014, pp. (pp. 15-37).

[6] M. Sarwat, "LARS*: An efficient and scalable location-aware recommender system," in *Transactions on Knowledge and Data Engineering*, vol. 26.6 , IEEE, 2014, pp. 1384-1399..

[7] G. Adomavicius, B. Mobasher, F. Ricci and A. Tuzhilin, "Context-aware recommender systems," in *Recommender systems handbook*, Springer US, 2011, pp. 217-253.

[8] X. Wang, Y.-L. Zhao, L. Nie, Y. Gao, W. Nie, Z.-J. Zha and T.-S. Chua, "Semantic-Based Location Recommendation With Multimodal Venue Semantics," *IEEE Transactions on Multimedia ,* vol. 3, no. 17, pp. 409-419., 2015.

[9] J. S. Chauhan, "Survey on Hybrid Recommendation System," *International Journal of Advance Engineering and Research,* vol. 3, no. 5, May- 2016.

[10] Z. Chen, H. T. Shen, X. Zhou, Y. Zheng and X. Xie, "Searching trajectories by locations: an efficiency study," in *Proceedings of the 2010 ACM SIGMOD International Conference on Management of data*, 2010.

[11] Y. Zheng, Z. Chen and X. Xie, "Searching Similar Trajectories by Locations". US Patent 12/794,538, 8 December 2011.

[12] C. Hongbo, C. Zhiming, M. Arefin Shamsul and Y. Morimoto, "Place recommendation from check-in spots on location-based online social networks," in *Networking and Computing (ICNC), 2012 Third International Conference on*, 2012.

[13] J. Bao, Y. Zheng, D. Wilkie and M. F. Mokbel, "A Survey on Recommendations in Location-based Social Networks," *ACM Transaction on Intelligent Systems and Technology.,* 2013.

[14] H. Wang, M. Terrovitis and N. Mamoulis, "Location recommendation in location-based social networks using user check-in data," in *Proceedings of the 21st ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems.*, 2013.

[15] H. Yin, Y. Sun, B. Cui, Z. Hu and L. Chen, "LCARS: a location-content-aware recommender system," in *Proceedings of the 19th ACM SIGKDD international conferenceon Knowledge discovery and data mining*, 2013.

[16] E. Cho, S. A. Myers and J. Leskovec, "Friendship and Mobility: User Movement In Location-Based Social Networks," in *ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD), .*, 2011.

[17] S. J. Fusco, R. Abbas, K. Michael and A. Aloudat, "Location-based social networking: impact on trust in relationships," *IEEE Technology and society magazine,* vol. 2, no. 31, pp. 39-50., 2012.

[18] S. Shang, R. Ding, B. Yuan, K. Xie, K. Zheng and P. Kalnis, "User oriented trajectory search for trip recommendation," in *Proceedings of the 15th International Conference on Extending Database Technology*, 2012.

[19] O. Osama and H. M. O. Mokhtar, "Similarity Search in Moving Object Trajectories," in *Proceedings of the 15th International Conference on Management of Data*, 2009.

[20] M. Hadjieleftheriou, Y. Manolopoulos, Y. Theodoridis and V. J. Tsotras, "R-trees: A dynamic index structure for spatial searching," Encyclopedia of GIS Springer , US, 2008.

[21] K. Zheng, . S. Shang, N. Jing and . Y. Y, "Towards efficient search for activity trajectories," in *29th International Conference In Data Engineering (ICDE)*, 2013.

[22] M. M. Hasan and H. M. O. Mokhtar, "An Activity Based Trajectory Search Approach," *International Journal of Computer, Electrical, Automation, Control and Information Engineering,* vol. Vol:10, no. No:12, pp. 1857-1862, 2016.

[23] W. Chen, L. Zhao, X. Jiajie, K. Zheng and X. Zhou, "Ranking Based Activity Trajectory Search," in *International Conference on Web Information Systems Engineering*, 2014.

[24] H. Wagih and H. Mokhtar , "HBTOnto: An Ontology Model for Analyzing Human Behavior Trajectories," in *11th International Conference on Semantics, Knowledge and Grids (SKG),. IEEE*, 2015.

[25] X. Long, L. Jin and J. Joshi, "Towards Understanding Traveler Behavior in Location-Based Social Networks," in *Global Communications Conference (GLOBECOM)*, 2013.

[26] [Online]. Available: https://archive.org/details/201309_foursquare_dataset_umn.

[27] [Online]. Available: https://snap.stanford.edu/data/.