Poster: When Friends Move: A Deep Learning-based Approach for Friendship Prediction in Mobility Network

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ABSTRACT

Considering location data for friendship prediction has become prevalent due to the huge success of online social networks. However, few studies have focused on investigating the possibility of using mobility information in a dense place such as a campus. The research direction for those mobility networks should be treated differently. We propose a CNN-based noble framework for friendship prediction, which starts from collecting location data to a classification model to learn their relation between friendships and mobility. From the experiment, we show that our system outperforms empirical supervised learning techniques and also can be useful for friendship prediction of the future.

CCS CONCEPTS

• **Information systems** → **Social recommendation**; • **Human-centered computing** → **Social networks**; *Social network analysis*; • **Networks** → Mobile ad hoc networks.

KEYWORDS

link prediction, recommendation, datasets, neural networks, bluetooth low energy

ACM Reference Format:
Hyungho Byun and Chong-kwon Kim. 2019. Poster: When Friends Move: A Deep Learning-based Approach for Friendship Prediction in Mobility Network. In *The 17th Annual Int'l Conference on Mobile Systems, Applications, & Services (MobiSys '19), June 17–21, 2019, Seoul, Korea.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3307334.3328604

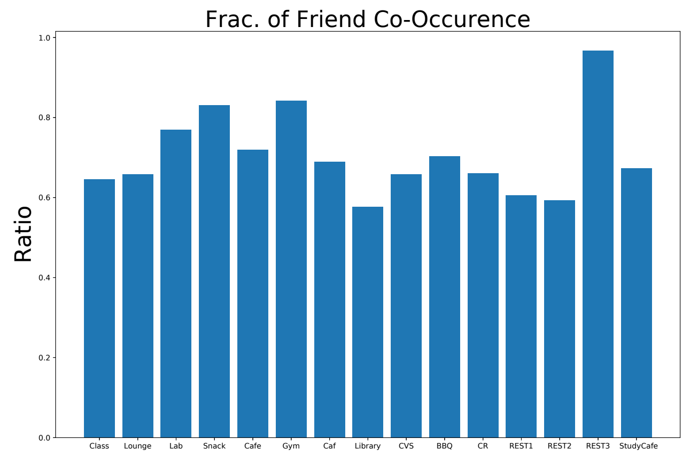

Figure 1: Different ratio of friends' co-occurence according to locations

1 INTRODUCTION

Usually, we know someone whom you have seen many times, but have no relationship with. Regardless of your intention, you and she were in the same classroom, or on the same floor of the office, or just in a same bus stop. It would not be correct if someone think you and that guy as friends, though it is commonly known that friends tend to do things together and move along. Therefore, link prediction utilizing mobility information has to be performed well based on the situation and environments.

Considering mobility data has become prevalent due to the huge success of online social networks [1, 2]. Those researches utilizes users' check-in data in the social network [1]. However, few studies have focused on investigating the possibility of using mobility information in a dense place, such as a campus or an office. Furthermore, the research direction for those mobility networks should be treated differently due to following reasons.

- People are more likely to move around the place according to their own fixed routine, so co-occurrences of users in same places are much more frequent.
- Many co-occurrences do not imply the relation between peoples' friendship. They have different correlation depending on the location and time.

[Figure 1] depicts aforementioned points in our collected real-world data. To handle those differences, we propose a noble framework for friendship prediction, which starts from scanning to actual deep learning models to learn their relation between friendships and mobility. From the actual campus students, we gathered location data by scanning the signal of personal beacons which are given to them. Beacons advertises their designated IDs using BLE protocols, and scanning devices catch their signals and store relative signal strength indication (RSSI) with the information of signals. We chose to use BLE because of its connectivity and universality. Furthermore, it is proved that using BLE can provide more accurate result in the localization tasks [3]. Also, [4] is a notable research which measures proximity using BLE devices. Our dataset is a fine-grained mobility data from actual experiment, which are available online[1].

ACM ISBN 978-1-4503-6661-8/19/06.
https://doi.org/10.1145/3307334.3328604

[1] https://github.com/NotoriousH2/WhenFriendsMove

Figure 2: BLE devices for data collection

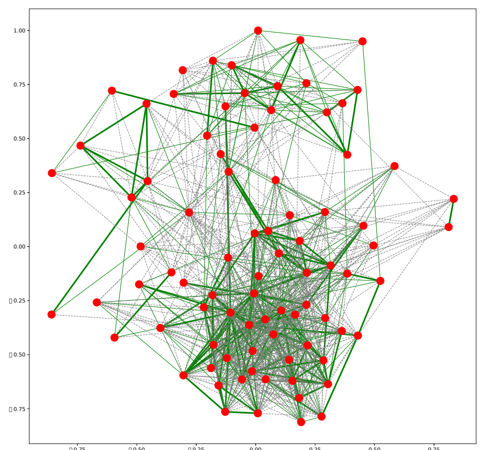

Figure 3: Friendship network of our dataset

2 DATA COLLECTION

We collected 85 undergraduate course students in a same department of a university from Sep 22, 2018 to Dec 6, 2018 (46 days in total). In that period, we installed 30 Raspberry Pi 3 devices in 20 locations to scan BLE signals from students' beacons and communicate with a server. We used Raspberry Pi 3 devices for scanning signals, and Estimote Stickers[2] for advertising signals as depicted in [Figure 2]. Selection of locations for installation was based on surveys of participants' visitation, which are depicted in [Figure 1].

As a ground truth, users are required to participate in a survey which is about answering friendship with every participant. Participants had to choose the relationship between each other among 0 (complete stranger), 1 (acquaintance), 2 (friend), and 3 (close friend). After that, we could gain 381 unique edges of friends. [Figure 3] is a distribution of friend relationship among students. Bold line depicts close friends; gray dashed line depicts acquaintances of average score 1(acquaintance).

3 FRIENDSHIP PREDICTION

In this section, we constructed a CNN-based model to classify each student pair's behavioral data into friends and non-friends. From the preliminary survey, we defined a pair of students are friends when the average score between them is at least 2. To convert each student's mobility data as sequences, we divided one day into 144 time cells. In each 10-minute cell, signals received in this time are combined with location data, and transformed as a vector of locations which consists of partial proportion of sequences sums up to 1. Using each student's mobility vector, we performed elementwise multiplication to generate co-occurrence vectors of all two student pairs, and utilized those vectors for input data of the supervised learning. Our model consists of four stacked convolutional neural network (CNN) with dropouts, and the output layer of those stacked CNNs are connected with fully connected network with make out final value by probability data between 0 and 1. We divided our dataset by 6:2:2, which are sets for training, validation, and test. compared our classification result with empirical supervised learning tasks, and 4 common metrics of link predictions. The summary of our experiments is depicted in [Table 1].

Table 1: Friendship Prediction Result

	Precision	Recall	F1	AUC
Proposed Scheme	0.707	0.697	0.702	0.705
Random Forest	0.691	0.606	0.646	0.663
KNN	0.654	0.476	0.551	0.601
SVM	0.657	0.567	0.609	0.621

Also, we checked the false-positive instances of our classification with the acquaintances relationship between students. In average, almost 70% of false positive instances are acquaintances. Therefore, it is a strong evidence that they have potentials to become friends, so our prediction can be useful for predicting potential friendship. In next step, we will continue improving our model and utilize this dataset for development of further recommendation system such as location and activities.

4 ACKNOWLEDGMENTS

The SNU-Samsung Smart Campus Research Center at Seoul National University provides research facilities for this study.

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