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Place Recommendation Using Location-Based Services and Real-time Social Network Data

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***Abstract*—**Currently, there is excessively growing information about places on Facebook, which is the largest social network but such information is not explicitly organized and ranked. Therefore users cannot exploit such data to recommend places conveniently and quickly. This paper proposes a Facebook application and an Android application that recommend places based on the number of check-ins of those places, the distance of those places from the current location, the number of people who like Facebook page of those places, and the number of talking about of those places. Related Facebook data is gathered via Facebook API requests. The experimental results of the developed applications show that the applications can recommend places and rank interesting places from the most to the least. We have found that the average satisfied score of the proposed Facebook application is 4.8 out of 5. The users' satisfaction can increase by adding the app features that support personalization in terms of interests and preferences.

***Keywords*—**Mobile computing, location-based services, recommendation system, social network analysis.

I. Introduction

IN the past several years, social networks have been integrated into our life's quotidian which incurs information growth enormously. Therefore, information stored on the network contains all types of unorganized data that cannot be effectively used. An example of such data is where people eat and what people like. This kind of information may help other people make a decision about where to eat.

Nowadays mobile devices popularity is rising. There were 968 million mobile devices sold in 2013, which was 42.3% increasing from 2012 [1]. Mobile devices are not used for only voice communication but also for locating positions on Earth which we call GPS (Global Positioning System) that enables Location-based Service (LBS) to use locate the position by using through mobile device that can connect to the internet and use its benefit to apply with healthcare, works, or productivity through daily life.

There are two types of services: pull service and push service. Pull service requires users' request such as pizza service. For push service, the service owner offers users some information such as promotion message, and advertisements. Previously programmers cannot take advantages from pull service for GPS. However in recent days, programmers can make a request for the location from GPS.

Android is an operating system for mobile electronic devices and are open for programmers for developing applications. Android also offers software development kit for freely use. Other than that, there are several factors that make mobile application development still growing. Selling mobile application by individuals in the present day is much easier and simpler than selling software that is largely by companies in the past. Programmers do not need to work in a big company or search for customers by themselves.

We wish to have an Android application that is capable to find places by typing "Restaurant" or "Cafe". Then the application will bring the information about nearby restaurants found via the proposed algorithm and system. There is no Android application available in Google play [2] that exploits the statistics of social network data to recommend popular places.

In this paper, we propose and develop Facebook application and Android application that exploits both location-based services and online social network data. We also conducted the survey of users' satisfaction and found that the average satisfaction score is 4.8 out of 5.

The remainder of this paper is organized as follows. In Section II, we review some related work and contrast it with our work. Section III describes some background. In Section IV, we present our design and methodology. Experimental evaluation and analysis is explained in Section V. Finally, we conclude in Section VI with some directions of future work.

II. Related Work

Wolframalpha (https://www.wolframalpha.com) is a semantic web that generates many answers based on question. For example, if you ask 3+4, then this web will return the result in number, graph, spelling, etc. However, the website cannot recommend places that users wish to go. Wongnai (http://www.wongnai.com) is an application that recommends favorite Thai places but does not exploit social media data such as Facebook check in and Facebook pages.

Lee et al. [3] proposed CLR, which was a collaborative location recommendation framework based on co-clustering which is to find user POI (point of interest). To reduce a large memory requirement, CLR collected users' GPS information to only find nearby locations. The proposed framework used the CLM (Community Location Model) that contained other activities include user, activity, and location with Co-clustering (CADC) algorithm to manage CLM for more

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accuracy results. This related work is similar with our proposed paper in the aspect that both works exploit the location-based service to pull the list of locations. However, in our work, the system exploits Facebook data to represent real user data.

Balduini et al. [4] proposed BOTTARI, which was an augmented reality mobile application to deliver personalized and location-based recommendations by continuous analysis of social media streams. BOTTARI was different from other mobile apps that recommend restaurants because it used inductive and deductive stream reasoning to continuously analyze social media streams (focusing on Twitter) in a given area. Although both BOTTARI and this proposed work focus on only local area, BOTTARI estimates the popularity of places based on the number of tweets related to those places while our work takes into account the number of check ins which are the real number that represents the number of people who have been there. Another main difference is that there is no user satisfaction evaluation for BOTTARI but there is for our proposed application.

Zhiming et al. [5] collected check-in spots from online social network services to get semantic location formation for calculating similarity of users' interests and then recommended unvisited places. There are two main differences between this related work and our proposed work as follows: (1) their proposed method recommended only unvisited places but our applications may recommend places that users have visited before (2) their method evaluation is based on the prediction accuracy but our system evaluation is based on users' satisfaction.

III. Background

In order to understand the overview of the background knowledge needed to develop the system, we present the flow diagram of the proposed system as shown in Fig. 1.

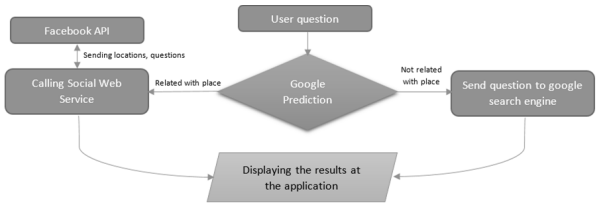


Fig. 1 The flow diagram of the proposed system

When a user enters a question, the question is then feed to Google prediction service to check whether the question is related with a place or not. If it is, then the social web service is invoked to find more information about the inquired place. The web service then interacts with Facebook API to retrieve information about that place, such as the number of check-ins and the number of likes on the page of that place. On the other hand, if the user question is not related with place, the question is sent to Google search engine to retrieve information about that question. The information whether as the result of the social web service or as that of Google search engine will then be displayed to the users via the developed applications which are available as a Facebook application and an Android application.

In this paper, we will briefly describe about some background knowledge which includes web services, Google prediction, Android, location-based service, HTML5 geolocation, and social media.

A. Web Services

Web services are software that can communicate with other programs via internet protocols, such as HTTP (HyperText Transfer Protocol), FTP (File Transfer Protocol), and SMTP (Simple Mail Transfer Protocol). XML (eXtensible Markup Language) or JSON (JavaScript Object Notation) are used as commonly used as exchanged data formats. There are categories of web services: SOAP (Simple Object Access Protocol) and REST (Representational State Transfer). SOAP web services can be implemented by using any internet protocol but the exchanged messages need to follow SOAP protocol. On the other hand, REST web services are called through only HTTP methods while the exported data can be any XML or JSON.

In this paper, the proposed system employs REST [6] web service with instead of SOAP with the exchanged data format as JSON because it is easy to develop. Another advantage is that the size of exchanged data in JSON is usually smaller than that of in XML.

B. Google Prediction

Google Prediction is an artificial intelligence tool for data analysis. Process of Google prediction is executed on Google cloud. Google prediction supports many types of data such as finding spam mail, organizing data, or recommendation systems. Languages that can be used to call Google prediction service are such .NET, Java, JavaScript, Objective-C, PHP, and Python.

Our proposed system uses Google prediction since it is easy and scalable for a large amount of data. The service is stable and ready to be used all the times. We use it for making a decision whether the user question is related with a place or not.

C. Android

Android [7] is a software stack used in mobile devices which contains operating system, middleware, and mobile applications.

In this paper, we have developed an Android application to recommend places. We choose Android because it is free and popular among mobile users. It also supports location-based services that we need to use in order to implement our system.

D. Location-based Service

Location-based Service [8] is a platform to manage data of the position of users. Such data is received from a mobile communication network or a global navigation satellite system. A location-based service employs GIS (Geographic Information System) and internet technology for locating and

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displaying the current position. GIS location is described using latitude and longitude.

In this paper, the system requires that the mobile devices of users need to have location-based service enabled so that the developed Android applications can detect the users' locations automatically.

E. HTML5 Geolocation

HTML5 geolocation is needed to locate a user's current location via a web application that uses HTML5 technology and JavaScript. In this paper, our developed Facebook application is implemented as a web application which can be invoked via internet browser that support HTML5 such as internet explorer 9+, Firefox, Chrome, Safari, and Opera.

F. Social Media

Media means tools that used for communication. Social means society in social media [9]. Social means sharing content in society such as file, likes, comment, or relationship. Thus, social media means electronic media that people use to introduce themselves to interact or share with others.

In this paper, we choose to focus on Facebook because it is the social media with the most number of users on earth and in Thailand [10]. Facebook was first available on February 4, 2004 by Facebook Inc. By the first quarter of 2014, Facebook has 1,280 million users [11] In Thailand, there are currently 26 million users [12]. With Facebook, users can create their own profile, add contact of other users as friend and exchange information, get notification when they update their profile, create a group with the same interest, workplace, school, college, etc. Facebook 9,450 users have found that, photo is this most type of post in 57%, next is check in at 33%, post with link at 5%, video post with 3%, and status post with 2% [13] and from statistics has found that Facebook will automatically check in with 33% from total uses.

FQL (Facebook Query Language) is a query language that makes an opportunity for developers to query data with the same format with JSON. Another channel to get Facebook data is through Facebook graph API.

Graph API | FQL Query

```
SELECT name,description,geometry,latitude,longitude,
checkin_count,display_subtext,type,page_id  FROM place
WHERE distance(latitude, longitude, "16.4804", "102.8136") < 10000 AND
checkin_count > 50 AND
( CONTAINS ("อาหารเช้า")  ) order by checkin_count DESC LIMIT 100
```

Learn more about the Graph API syntax.


```
{
  "data": [
    {
      "name": "ร้านอาหารเช้าเอมโอช อ.เมือง จ.ขอนแก่น",
      "description": "",
      "geometry": {
        "type": "Point",
        "coordinates": [
          102.83612778529,
          16.435407768496
        ]
      },
      "latitude": 16.435507713738,
      "longitude": 102.83608453976,
      "checkin_count": 10075,
      "display_subtext": "3.4 mi · 10,075 were here",
      "type": "PLACE",
      "page_id": "148825868514175"
    },
```


Fig. 2 Example of using FQL

This paper chooses to use FQL language instead of graph API because using graph API cannot retrieve check in information. However, we can retrieve such information by using FQL as shown in Fig. 2. In this figure, we can observe a FQL query which is similar with a SQL query in the aspect that both languages have SELECT, FROM, and WHERE clause. However, FQL is different from SQL in many other perspectives such as the query can be imposed on only one table not many tables as can be done in SQL. Another main difference is that while a SQL statement returns the result as a table that consists of rows with multiple columns, a FQL statement returns the result in the JSON data format.

IV. Design and Methodology

The core part of the propose system is illustrated in Fig. 3.

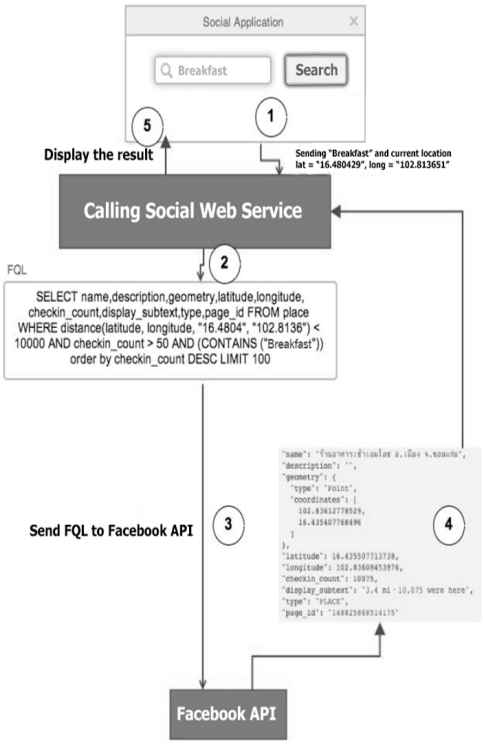


Fig. 3 Social web service and Facebook API

In Fig. 3, when the user types a keyword ("Breakfast") to search and that keyword is related to places, the system will send that keyword along with the current location information (the latitude as 16.4804 and the longitude as 102.813) to the social web service. The social web service then forms a FQL statement and then sends the FQL statement to Facebook API service. The Facebook API service then sends the reply message back to social web service as shown in Fig. 4. The system then ranks the scores of the places returned back from the FQL statement and displays the matched locations with their scores from the most to the least.

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```
"name": "ร้านอาหารเช้าเอมโอช อ.เมือง จ.ขอนแก่น",
"description": "",
"geometry": {
  "type": "Point",
  "coordinates": [
    102.83612778529,
    16.435407768496
  ]
},
"latitude": 16.435507713738,
"longitude": 102.83608453976,
"checkin_count": 10075,
"display_subtext": "3.4 mi · 10,075 were here",
"type": "PLACE",
"page_id": "148825868514175"
```


Fig. 4 Result from the Facebook API

TABLE I
FQL COMMANDS USED TO GATHER DATA

Line	Code
1	SELECT name,description,geometry,latitude,longitude,
2	checkin_count,page_id FROM place
3	WHERE distance(latitude, longitude, "$lat", "$lon") < 10000 AND
4	checkin_count > 50 AND
5	(CONTAINS ("$keyword"))
6	order by checkin_count DESC LIMIT 100

The result of the Facebook API has the details as follows:

1. name: name of the place
2. description: place description
3. geometry: location of the place which is described by using latitude and longitude
4. checkin_count: number of total check in of this place
5. page_id: place id on Facebook

To calculate each place ranking, the application will need to call Facebook API named FQL and will execute commands as shown in Table I.

In Table I:

- Line 1 shows the SELECT statement to choose the attributes that the program needs to calculate for ranking which are already described above.
- Line 2 shows the FROM statement to specify the data to be selected from which is Facebook's place table.
- Line 3 is a condition to filter only places that are within the distance 10 kilometers from the current location.
- Line 4 is a condition to filter only places that there are at least 50 people check in
- Line 5 is a condition to choose only places that contain the query entered by a user.
- Line 6 will sort the places according to the number of check in count from the most to the least and limit to only the first 100 places.

After the system receives the information about places that match with the input query, the system needs to calculate score for each place from using T_{score} algorithm. This algorithm will calculate the score by using the number of check-in counts, the distance from current location to destination, the number of likes of that page, and the number of people are talking about that place.

T_{score} can be calculated by (1). In this equation, x refers to the pure score, $\bar{x}$ refers to the average score in the group, and SD refers to the standard deviation

$$T_{score} = \left[\frac{x-\bar{x}}{SD} x10\right] + 50 \quad (1)$$

To weigh the distance parameter, the score value depends on how far the place is from the current location. The closer the place is, the higher the score should be. Thus, we use the formula as shown in (2):

$$\overline{distance} = \frac{1}{distance} \quad (2)$$

Then, we calculate the total score by using (3):

$$Score = ((0.4\ x\ T_{sck}) + (0.2\ x\ T_{scl}) + (0.2\ x\ T_{scd}) + (0.2\ x\ T_{scta}) \quad (3)$$

T_{sck} means T_{score} of people check in; T_{scl} means T_{score} of total likes; T_{scd} means T_{score} of distance between current locations to destination; T_{scta} means T_{score} of number of people talking about that place.

T_{score} is computed based on the hypothesis that the factor that affects the decision the most should be the most weighted. We assume that the number of check in is the most important indicator about the quality of that place. Thus the weight is set to 40% which can be calculate from while other three remaining factors are equally weighted at 20% and can be calculated from (0.2 x T_{score}). The system returns the result of places information according to their ranking scores that are sorted from the most to the least as shown in Fig. 5.


```
[
  - {
      name: "ข้าวมันไก่ ส.มหาชัย",
      lat: 16.4259419467,
      lng: 102.832321931,
      chk: 200,
      dist: "6.42",
      score: 58.661372349941,
      likes: 5,
      talking_about: 3,
      page_id: "359406504101367"
    },
  - {
      name: "รับทรัพย์ข้าวมันไก่ตอน เจ๊ปู เสี่ยวุฒิ",
      lat: 16.4333,
      lng: 102.833,
      chk: 64,
      dist: "5.69",
      score: 54.912643918285,
      likes: 81,
      talking_about: 0,
      page_id: "487065024734517"
    },
```


Fig. 5 Results from using web service

V. EXPERIMENTAL EVALUATION AND ANALYSIS

A. Facebook Application

We develop Facebook application to recommend places that can be accessed from http://www.socialplace.in.th/facebook/. Any Facebook user can use the application via http://www.socialplace.in.th/facebook/ that requires user permission of their public information and their friend list. In order to support the detection of the current location on many

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computers that may not have GPS, HTML5 geolocation was introduced to solve this problem.

To evaluation the system, we create a survey form as a part of the Facebook application with the questions that are shown in Fig. 6. These questions can be divided into four parts as:

1) *Users who use this application*
2) *Factors that are most related to a user.*
3) *Top five interesting places for users*
4) *The weight of factors that users can adjust*

When the user enters some keyword and clicks on the search button, the system will return the table view of recommend places as shown the in Fig. 6 and Google map view with those places as in Fig. 7.

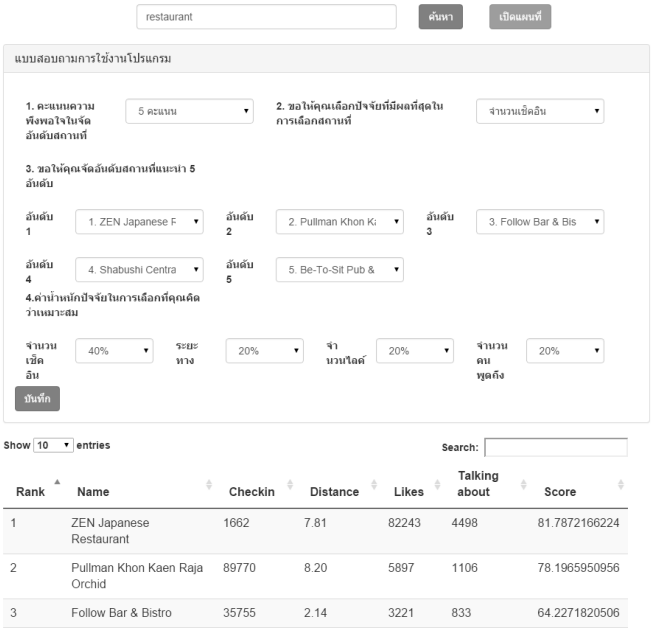


Fig. 6 Facebook app with the search box and the survey form

In Fig. 6, the user can sort the results in table view according to the category that they are interested in by clicking on its title in the table header.

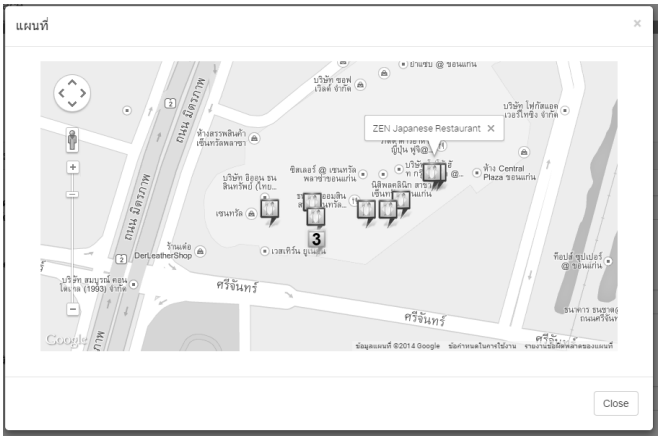


Fig. 7 Facebook app with the recommend places on Google map

Regarding to the survey result, there were 54 users who answered the survey. It was found that the average satisfaction score of place recommendations is 4.759 of 5. From the survey result, the average weight is 30% for the check-in factor, 22% for the distance between current location and destination, 23.6% for the number of likes and, 24.4% for the number of people talking about this place. The score of user satisfaction may increase if the user can choose their own score weight formula and can set their personalized preferences.

B. Android Application

To develop an Android application to recommend places, we use Android Developer Kit and Facebook SDK. The usage of the Android application is similar to the Facebook application except that there is no the survey form to ask users' satisfaction. The application returns the list of the recommend places along with its location information and its coordinate on the Google map as shown in Fig. 8.

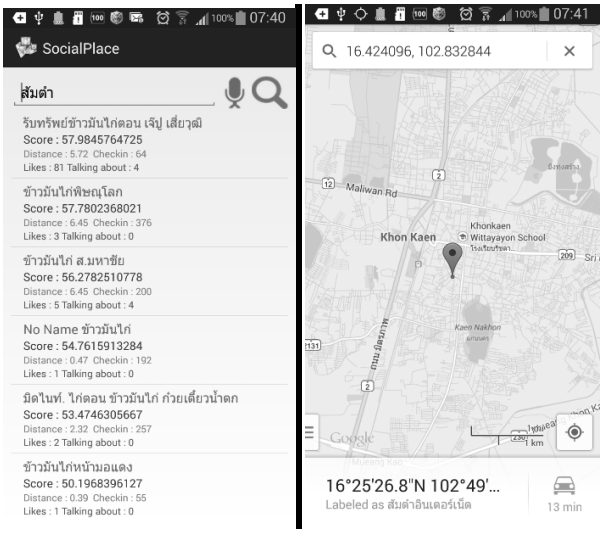


Fig. 8 Andriod app to recommend places

However, when the user uses the Android application, the user can click the phone number of that place and conveniently make a call to that place as shown in Fig. 9. The application can be downloaded from https://play.google.com/store/apps/details?id= pjiranuwatt.thesis.socialplace or input "socialplace" in Google Play Store search box.

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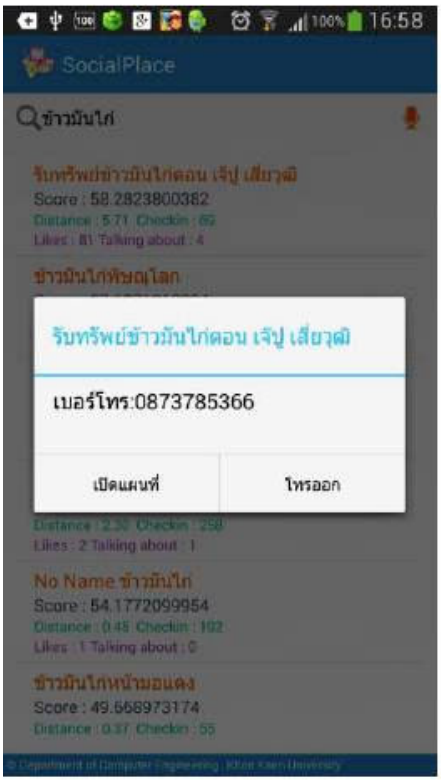


Fig. 9 Calling to recommended places on Android app

VI. Conclusions and Future Work

This paper has proposed the design and methodology to recommend places by using the users' current location and the social information of the nearby places. The users' location can be detected via GPS technology on a smart phone and via HTML5 geolocation on a web application. The algorithm to recommend places consider information which include the number of check in of places, the distance between the current location and the destination, the number of likes of Facebook pages, and the number of people who are talking about those places on Facebook.

We have implemented the system and develop the applications to recommend places as a Facebook application and an Android application. These applications are available freely for anyone. We also have performed the evaluation on the application and found that the average satisfaction score is 4.759 of 5. One of the features that we can improve on our applications is to increase the speed of the score calculation of recommended places.

In the future, we plan to improve our applications by adding description of each place, allowing users to suggest places, and using other formulas in enhancing the speed and the precision of the recommendation of places.

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