Ubiquitous Crowdsourcing Model for Location Recommender System

Saroj Kaushik[1], Sunita Tiwari[2*], Chhavi Agarwal[3], Aakash Goel[4]

[1] Dept. of CSE, IIT Delhi, India.
[2] School of IT, IIT Delhi, & Dept. of CSE, ABES EC Ghaziabad, India.
[3] Dept. of CSE, NIT Kurukshetra, India.
[4] Dept of CSE, Seth Jai Prakash Mukand Lal Institute of Technology, Radaur, India.

* Corresponding author. Tel.: +91-9871093327; email: sutiwari@gmail.com
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Abstract: Crowdsourcing is methodology in which task is completed by distributing it amongst the crowd. The objective of proposed work is to generate recommendation of places close to tourist's current location using crowdsourcing approach. Technological advances in WWW and the mobile devices have opened the possibilities of gathering and sharing the required information from people moving around. Contextual information from user can be collected by several techniques like sensors, collaborative tagging, crowdsourcing etc. In this work, contextual information about the places is gathered from crowd visiting those places and their collective knowledge is further used to generate recommendations for the tourist. Since crisp quantification of context parameters such as weather, traffic, crowdedness is difficult for a general user (crowd), this information is collected from them in terms of fuzzy linguistic variables and fuzzy inference system is used to generate a popularity score of each place nearby tourist's current location. Finally, the system sorts the score of each place in order of their popularity score and sends these recommendations to the tourist. Additionally, the proposed system collects latest images, audio recorded feedback etc. from the crowd currently present at to be recommended place. These collected images, audio clips, feedbacks etc may be pushed along with recommendations to help the tourist to take decision about visiting these places. Additional current information about tourist spot definitely improves the quality of recommendation and experience. To implement this concept, a prototype system has been implemented using Android SDK, database is designed using MYSQL, fuzzy inference system is simulated using fuzzy logic toolbox of MATLAB and backend tasks are performed using PHP. The proposed prototype has also been tested over a set of real users.

Key words: Tourist guide application, contextual information, fuzzy inference system, implicit rating, audio reviews.

1. Introduction

The crowdsourcing concept was first introduced by Jeff Howe [1] in 2006. Crowdsourcing refers to a distributed problem-solving model in which a crowd of any size is occupied to solve a complex problem through an open call. The crowdsourcing platform consists of following components-

- **Crowd:** the crowd consists of the people who contribute to complete part of some task.
- **Crowdsourcer:** the crowdsourcer is an entity (a person, a for-profit organization, a non-profit organization, etc.) who seeks the power and wisdom of the crowd for a task at hand.

- **Crowdsourcing task:** the crowdsourcing task (simply called the task here in after) is the activity in which the crowd participates.
- **Crowdsourcing platform:** the crowdsourcing platform is the system (software or non-software) within which a crowdsourcing task is performed.

Check-in to various location based applications and social networking sites using smart mobile devices is becoming more and more popular. People share their experiences and variety of content with their friends and other members on these sites and apps. This tendency of sharing information by people about the location may be exploited to solve several problems. The proposed work aims to use the information collected from crowd to generate recommendations about places for the tourist in his/her vicinity. In ubiquitous crowdsourcing as opposed to web crowdsourcing, the set of participants (crowd) keeps changing all the time. For instance, in a situation where system requires traffic updates, crowd at different sites can contribute about current travel status throughout the day. The crowd will keep on changing. Applications of crowdsourcing includes but not limited to monitoring pollution impact, analyzing context-awareness, personal context sharing, real-time traffic, recommendations etc. Services based on the current location of the contributor or crowd is most important in ubiquitous crowdsourcing.

In the past, researchers in different fields have used crowdsourcing concept. However, the potential of the field is not fully exploited yet. So far, the crowdsourcing work included txteagle [2], a mobile crowdsourcing system, which publish simple tasks such as translation, transcription, and filling out surveys for mobile phones users. Fashism [3], is a fashion web site for styling cloths while shopping and getting the feedback in real time. Crowdsourcing model is used by Google to collect the road traffic data and provide the real time traffic conditions [4]. Askus [5] is a geographic location based service which allows user to support networked action. Erictson *et al*. [6] used geocentric crowdsourcing to enable cities and regions to more effectively address issues ranging from infrastructure to governance. In [7] Zhao *et al*. proposed location privacy recommender using user-user collaborative approach. Wu *et al*. [8] used Smartphone based crowdsourcing approach for indoor localization problem. Other location aware crowdsourcing services include mCrowd [9], and GigWalk [10]. Authors in [11] introduced concept of information enrichment for location recommender systems. Some more relevant work on crowdsourcing can be found in [12]-[17]. In this paper, the generation of recommendation using crowdsourcing especially for those domains for which explicit ratings are not easily available has been introduced. Rest of the paper is organized as follows: Section 2 discusses the overall design of the proposed location recommender system, in Section 3 details of implementations and results are presented and Section 4 discusses working of the prototype system. Finally, Section 5 concludes the paper and gives future directions.

2. Overall System Design

The proposed system design shown in Fig. 1 comprised of five components namely: 1) Authentication System 2) POI List Generator 3) Data Gathering System 4) Data Processing System(DPS) residing on Server along with database and 5) Data Verification System. Additional services are provided by Data Outlet component discussed later. The system components are briefly described as follows:

2.1. Authentication System

The authentication subsystem checks the validity and credentials of the registered user which are stored in database during the registration phase. Registered users can play two roles that is-

1) **Crowd**: who may fills the questionnaire or uploads the Images or audio description of a place.
2) **Tourist**: who wish to get recommendation of nearby places/locations.

2.2. POI List Generation

POI generation module generates list of tourist places from the chosen category of POIs for the tourist around its current location within an specified radius.

2.3. Data Gathering System

The data gathering system collects the contextual information about POIs proactively in order to give updates information to the users in real time. The system keeps collecting data from the registered crowd users currently visiting the POIs. Information collected by crowd is in the form of pictures, audio recordings or questionnaire is stored in database against the latitude and longitude of the place.

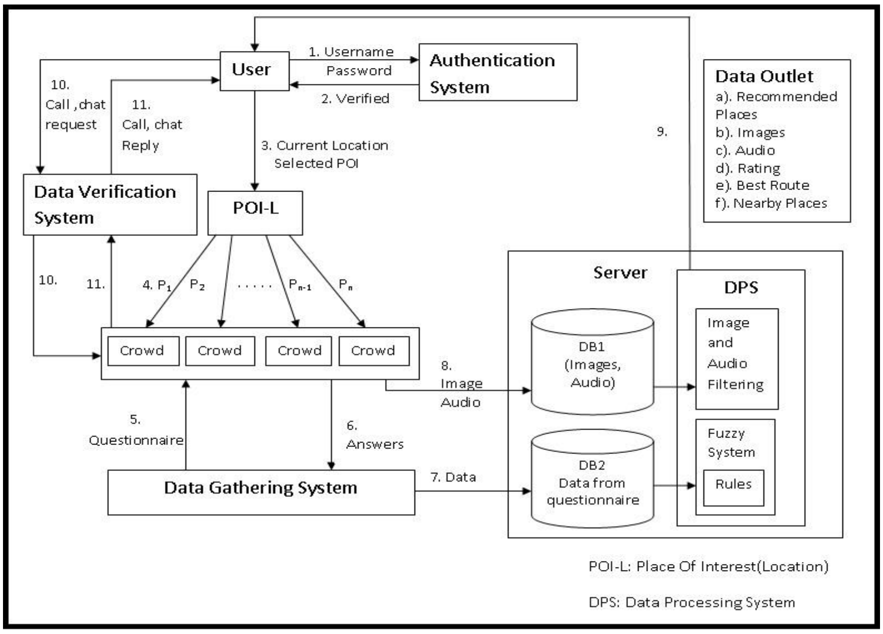


Fig. 1. Proposed system design.

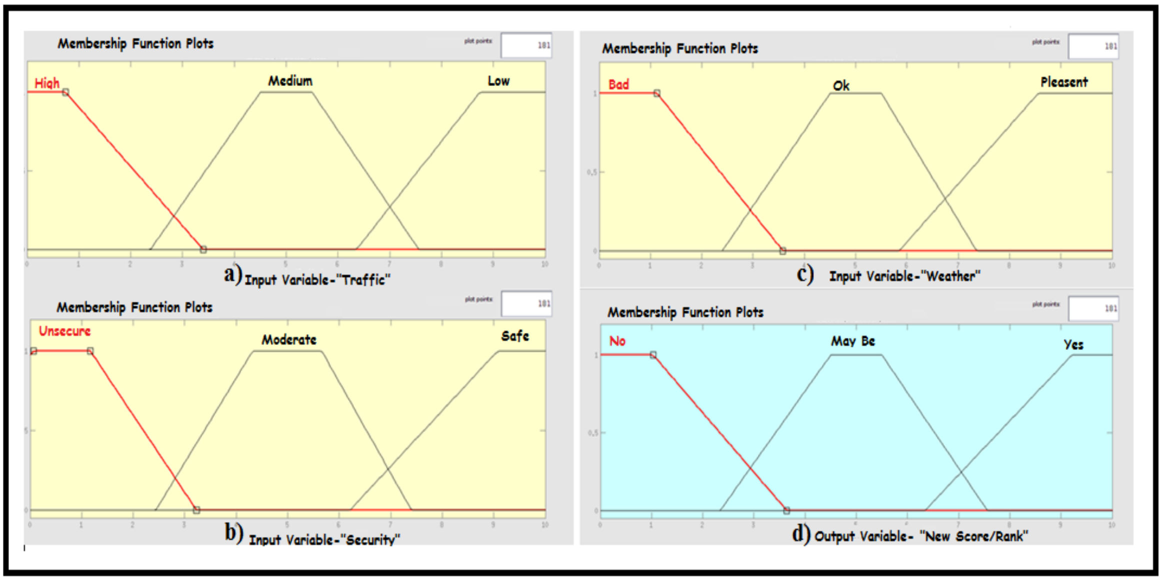


Fig. 2. Membership functions of Input and output variables of Fuzzy system.

2.4. Data Processing System (DPS)

The data processing system (DPS) consists of two components namely, image/pics and audio filtering component and fuzzy component. These components are discussed as follows.

2.4.1. Image and audio filtering

The image/pictures and audio uploaded by crowed are temporal in nature and resides on server temporarily for maximum 2 hours and after that it is archived. This is done to provide real time information to the tourist.

2.4.2. Fuzzy inference system

The fuzzy inference component of the system is used to compute the score/rating for every POI or place as crowd uploads questionnaire which has fuzzy responses. Fuzzy system uses three input variables - weather, traffic and security. The fuzzy membership functions for each of these variables are shown in Fig. 2a), Fig. 2b) and Fig. 2c) respectively. The output of the fuzzy system is a new score/rank and its fuzzy membership functions are shown in Fig. 2d). Some sample fuzzy rules are shown in Fig. 3. For evaluating antecedent, fuzzy min and max operators are used. When the antecedents are connected by “and” operator then min method is used. Whenever the antecedents are connected by “or” operator the max method is used. For implication product method is used. The max method is used for aggregation of results. The list of POIs is displayed to the user in order of score and score is also annotated with POI name.

2.5. Data Verification System

The system provides information about the nearby location to the tourist i.e. within the radius of 1Km in order of its popularity. In addition, a communication system is integrated by which tourist can have conversation with the crowd present at that location to verify the current context.

2.5.1. Data outlet

After processing the data i.e. after applying fuzzy rules, the results are obtained and these results are used to recommend places to the user. Data outlet contains score/rating, image and audio of each nearby location. Additionally, the best route to reach the destination is provided. When a user selects one of the recommended places for visiting, the system provides the best route to reach that place. The best route to the selected place is computed using bing API which provides the set of APIs to incorporate location services to the application [18].

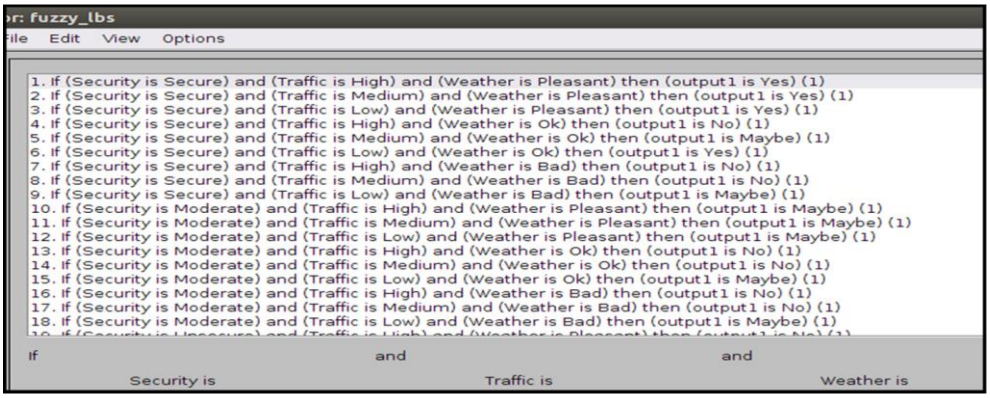


Fig. 3. Sample Fuzzy rules.

3. Implementation and Results

This section contains details of Implementation of prototype system in the form of a mobile application.

3.1. Technology Used

Details of system components along with languages/technology used to implement them are as follows-

- Google Map and Google Place APIs are used for finding places around a particular location and displaying them on map.

- Crowd Sourcing Services such as sharing images and audio clip or giving feedback/rating for a place are implemented using Java and PHP. For displaying slideshow of images and recorded audio HTML, JavaScript and jQuery is used.
- MySQL is used for database.
- Fuzzy inference system is implemented using MATLAB and for connecting fuzzy system with java application Bash Script and PHP are used.
- For implementing chatting and audio calling services Sinch API is used.
- To find best route between two places Bing API is used.

3.2. Experiment and Result

Proposed system is tested by a small set of real users. It was tested on places nearby Indian Institute of Technology Delhi, India. Three general attraction categories were chosen for testing: cafe, shopping and restaurant. The example of registered set of checked-in users at the system startup along with their current locations is shown in Fig. 4.

id	name	email	password	checkin	lat	lng
1	chhavi	chhavi.agarwal2208@gmail.com	*****	yes	28.5454704	77.1913108
2	aakash	aakashgoel12@gmail.com	****	yes	28.553267	77.193716
3	anam	anamj09@gmail.com	******	yes	28.54167	77.187271
4	satabdy	satabdy@gmail.com	*****	yes	28.542515	77.186986
5	yasha	yasha.agarwal13@gmail.com	******	yes	28.542042	77.185589
6	udit	udit.18garg@gmail.com	*****	yes	28.546579	77.196807
7	vidit	viditagg@gmail.com	*******	yes	28.553691	77.194115
8	Ashul	anshulji.garg@gmail.com	****	yes	28.538552	77.198768
9	Ankit	ankit2081@gmail.com	******	yes	28.544884	77.191443
10	Asif	asif.jawed@gmail.com	*****	yes	28.547593	77.184507
11	shubham	sahu.shubham@gmail.com	*****	yes	28.546341	77.196651
12	Megha	megha.gupta1995@gmail.com	*******	yes	28.538579	77.198782
13	Jasmeet	jassi.jmit8@gmail.com	******	yes	28.540682	77.18532

13 rows in set (0.01 sec)

Fig. 4. Database of users.

mysql> select * from feedback;

lat	lng	traffic	weather	safe	time	saferating	nop
28.553267	77.193716	4.572298049926758	6.445059776306152	8.8482084274292	1437036829	5.8019	1
28.54167	77.187271	3.2812561988830566	4.3246564865112305	6.307159900665283	1437371420	1.9029	1
28.542515	77.186986	5.784920692443848	5.893758773803711	7.438237190246582	1437554837	5.0479	1
28.542042	77.185589	8.28110122680664	6.542503833770752	7.484906196594238	1437554930	8.4882	1
28.546579	77.196807	3.0492005348205566	5.447568893432617	4.338104248046875	1437555191	1.5993	1
28.553691	77.194115	6.111255645751953	2.191226005554199	7.580970287322998	1437555306	1.5052	1
28.538552	77.198768	8.149402618408203	8.618343353271484	4.790614128112793	1437555431	4.9666	1
28.544884	77.191443	6.378354549407959	8.457748413085938	7.553451061248779	1437555667	8.507	1
28.547593	77.184507	8.052794456481934	6.253671169281006	8.143566131591797	1437555850	8.5791	1
28.546341	77.196651	4.6845903396606445	7.839136123657227	6.909611701965332	1437555948	6.2218	1
28.538579	77.198782	6.981039047241211	7.279840469360352	7.3044633865356445	1437556021	7.1131	1
28.540682	77.18532	3.3576548099517822	7.597241401672363	6.7768473625183105	1437556086	5.8958	1

12 rows in set (0.00 sec)

Fig. 5. Computed score of location in database.

mysql> select * from feedback;

lat	lng	traffic	weather	safe	time	saferating	nop
28.553267	77.193716	4.572298049926758	6.445059776306152	8.8482084274292	1437036829	7.22595	2
28.54167	77.187271	3.2812561988830566	4.3246564865112305	6.307159900665283	1437371420	1.9029	1
28.542515	77.186986	5.784920692443848	5.893758773803711	7.438237190246582	1437554837	5.0479	1
28.542042	77.185589	8.28110122680664	6.542503833770752	7.484906196594238	1437554930	8.4882	1
28.546579	77.196807	3.0492005348205566	5.447568893432617	4.338104248046875	1437555191	1.5993	1
28.553691	77.194115	6.111255645751953	2.191226005554199	7.580970287322998	1437555306	1.5052	1
28.538552	77.198768	8.149402618408203	8.618343353271484	4.790614128112793	1437555431	4.9666	1
28.544884	77.191443	6.378354549407959	8.457748413085938	7.553451061248779	1437555667	8.507	1
28.547593	77.184507	8.052794456481934	6.253671169281006	8.143566131591797	1437555850	8.5791	1
28.546341	77.196651	4.6845903396606445	7.839136123657227	6.909611701965332	1437555948	6.2218	1
28.538579	77.198782	6.981039047241211	7.279840469360352	7.3044633865356445	1437556021	7.1131	1
28.540682	77.18532	3.3576548099517822	7.597241401672363	6.7768473625183105	1437556086	5.8958	1

12 rows in set (0.00 sec)

Fig. 6. Updated score/rating of location in database.

Group of user are sent to different POIs chosen from general attraction's category and are requested to fill the questionnaire for their current location. The fuzzy system computed ratings/score as shown in Fig. 5

on the basis of fuzzy values submitted by the users through questionnaire. That score is then stored in the database against a particular latitude and longitude.

If any user fills the questionnaire at same latitude and longitude more than once, database is updated with the weighted average of previous score and new score generated as shown in Fig. 6. The final rating is calculated by finding the weighted average of the ratings which were taken in the range of 50 meters of that place. Some sample results for different category of places is shown in Table 1 with top 4 recommendations.

Table 1. Sample Results Generated by Recommender System for a User

S.No	Current Location of Mobile Requester	Category	Top 4 Recommended Places			
1.	Bharti School (IIT Delhi)	Shopping Mall	Akriti Mall (8.4882)	Home Mart (5.319)	Reitz Mall (3.4754)	Ahana Mall(3.4754)
2.	Bharti School (IIT Delhi)	Café	Amul Cafe (6.73435)	CCD (6.03985)	Kafferine (5.319)	Costa Coffee (3.91055)
3.	Bharti School (IIT Delhi)	Restaurant	The Golconda Bowl(8.5791)	Waves (6.03985)	Mandarin Court (5.8958)	Pizza Square (3.91055)

4. Working of the Prototype Recommender System Application

The navigation diagram of the prototype recommender system application is shown in Fig. 7. The main functionalities of the system (from user point of view) can be divided in two broad categories namely view places (for using recommendations services) and upload contents (for using crowdsourcing services) discussed as follows:

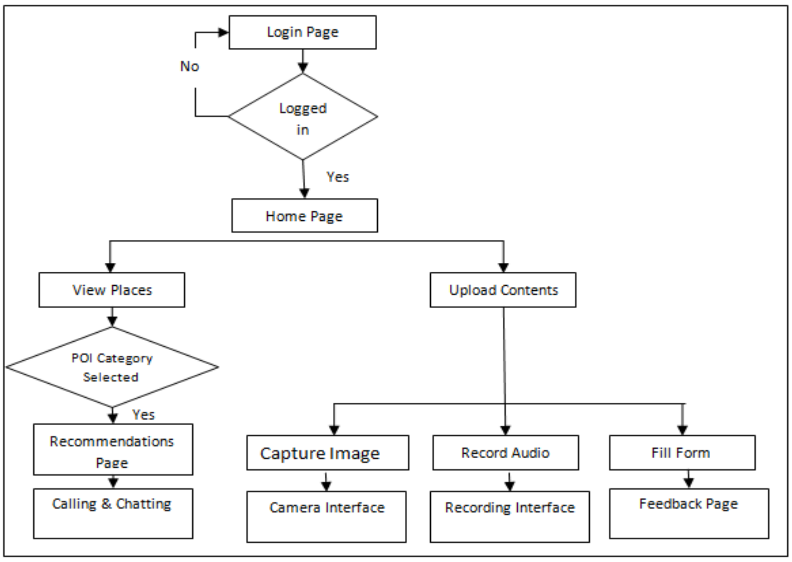
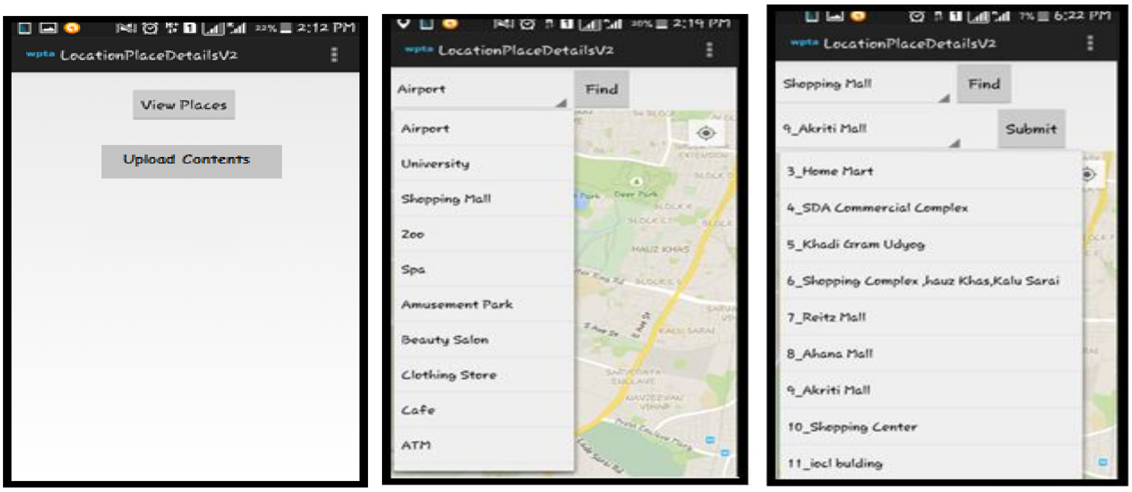


Fig. 7. Navigation diagram of the proposed application.

4.1. View Places (Recommendation Services)

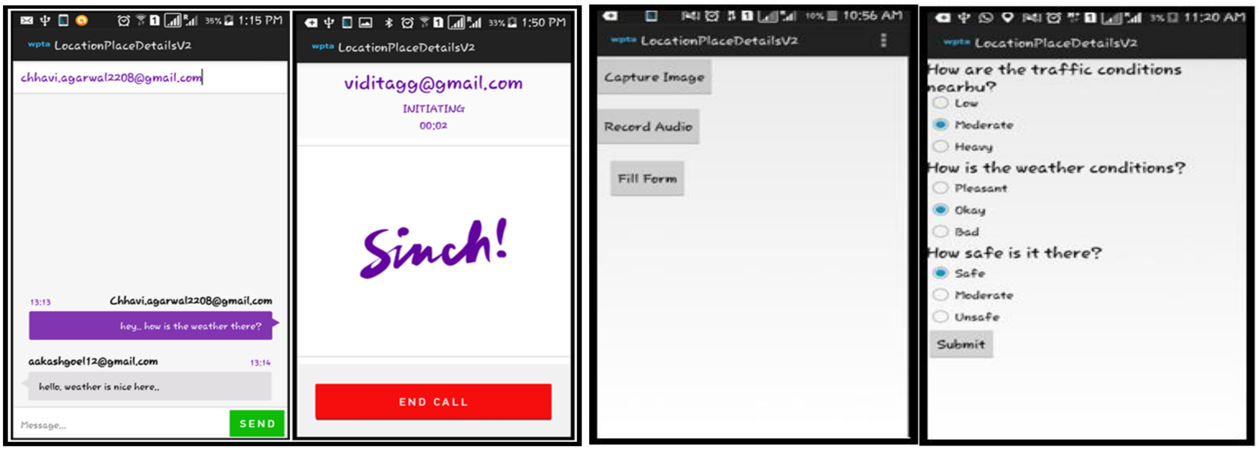
The main interface of the prototype system which is a mobile application is shown in Fig. 8 and Fig. 9. If user wishes to use recommendation services, he/she clicks 'View Places' button of interface shown in Fig. 8a) and then categories of POIs is displayed and tourist can choose one of these categories. On the basis of category selected, the nearby POIs of that category within the specified radius are displayed in order of popularity score (refer Fig. 8b) and Fig. 8c)). Popularity score is computed by the procedure discussed in Section 2.4.2. User can see live images, audio clips, score, and best route to reach etc for POI by selecting it on the map.

A communication system is integrated with the proposed system which can be used by the tourist to verify the accuracy of recommendation by having a conversation or chat with the crowd currently present at that location. The 'Chatting and Calling' services are provided using Sinch API [19]. Fig. 9a) and Fig. 9b) shows the screenshots of chatting and calling services.



a) b) c)

Fig. 8. a) Home Page, b) Select POI category, and c) POIs of selected category.



a) b) c) d)

Fig. 9. a) Chatting, b) Audio calling, c) Content uploading, d) Crowd feedback.

4.2. Upload Contents

If user selects 'Upload Contents' then user will play role of crowd. Crowd may choose to fill a feedback form or may upload a audio describing the situation or recent images/pictures of the current location. Fig. 9c) shows the interfaces to upload contents. Images are stored in JPG format and audio recordings are stored in MP3 format on the server. Using this audio clip user can describe the current situation at that place and it is also stored with latitude and longitude of the place. If user clicks 'Fill Form' button, interface shown in Fig. 9d) is displayed which contains three questions and these question has three linguistic values.

5. Conclusion and Future Directions

In this paper, a model to show how crowdsourcing can be used to generate list of recommended location is proposed. While recommending a place to the tourist, contextual information about that place is provided in form of Score/Rating and additionally real time image and/or audio description of the places may also be given by people present at that place. Additionally, if user wish to visit a recommended place, the system provides the best route to reach the destination and also allow live chatting and audio calling with the crowd present at that place. Using.

To gather the real time information of location, there are several techniques like sensors, collaborative tagging, crowdsourcing etc. At present, proposed system is using only location aware crowdsourcing. In future, sensors may be used to get more real time information like weather, crowdedness etc. Also, different questionnaire for different category of location may be developed so that more relevant information of that location can be provided to the user.

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Saroj Kaushik is a professor at the Computer Science and Engineering Department of Indian Institute of Technology (IIT) Delhi, India. Her primary research interests are artificial intelligence, natural language processing. In addition, she directs research in the areas of artificial intelligence, location based services, recommender systems and natural language processing. She received her PhD degree from IIT Delhi. Currently she is the head of Computer Science & Engineering Department at IIT Delhi.

Sunita Tiwai is a PhD student at Indian Institute of Technology, Delhi, India. She is working with ABES EC, Ghaziabad, India. Her research efforts focus on GPS log mining, location based services, recommender systems and soft computing techniques. She received B.E. (CSE) degree from RGPV Bhopal and her M.Tech.(CS) degree from Indian Institute of Technology(IIT) Delhi.