Safe Street Rangers: Crowdsourcing Approach for Monitoring and Reporting Street Safety

Panurat Sutigoolabud
Dept. of Computer Engineering
Faculty of Engineering
Chiang Mai University
Chiang Mai, Thailand
tour12033@gmail.com

Peerawit Naprae
Dept. of Computer Engineering
Faculty of Engineering
Chiang Mai University
Chiang Mai, Thailand
peerawit.naprae@gmail.com

Santi Phithakkitnukoon†
Dept. of Computer Engineering
Faculty of Engineering
Chiang Mai University
Chiang Mai, Thailand
santi@eng.cmu.ac.th

ABSTRACT

Looking out for each other's safety is always a nice thing to do. Crowdsourcing enables us to do just that as we've developed a system called *Safe Street Rangers* that allows the user or ranger to monitor and report via a mobile app the level of safety concern of any street segment regarding seven aspects including traffic signs, road obstacles, brightness, road condition, animals, solitariness, and traffic accidents, in relation to a transport mode (i.e., driving or walking). The system consists of three main components; mobile app, web app, and data server. Each submitted report will be verified and approved by an admin user via our web app. The data server handles all data storage and processing. It checks for overlapping of reported street segments with the existing ones and updates the safety rating values of street waypoints accordingly. The system has been tested with the real users from which its usefulness is highly perceived.

CCS CONCEPTS

Information systems → Crowdsourcing

KEYWORDS

Crowdsourcing, street safety, mobile app, urban application

ACM Reference format:

Peerawit Naprae, Panurat Sutigoolabud and Santi Phithakkitnukoon. 2019. iCoff: Towards Building an Intelligent Coffee Plate System to Enhance Coffee Shop's Customer Experience. In *Proceedings of the 2019 ACM International Joint Conference and 2019 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3341162.3349317

†Corresponding Author

UbiComp/ISWC '19 Adjunct, September 9–13, 2019, London, United Kingdom

ACM ISBN 978-1-4503-6869-8/19/09...$15.00
https://doi.org/10.1145/3341162.3349317

1 Introduction

Street safety is an issue that concerns us all. The number of accidents and deaths on the world's streets are unacceptably high. It has been estimated that 1.35 million people will be dying every year [1]. Particularly, in a low-income country, there has not been any reduction in the number of street traffic deaths and accidents. The rates of road traffic death are highest in Africa (26.6/100,000 people) and South-East Asia (20.7/100,00 people) [2]. More than half of all road traffic accidents are among vulnerable street users i.e., pedestrians, cyclists, and motorcyclists.

As reported in 2018 [2], 22 countries accounting for 1 billion people have amended their laws on one or more risk factors to them into alignment with best practice. In addition to these supportive law amendments that can potentially lower the street accidents and deaths, we as computer scientists believed that the information and communication technologies (ICTs) can also be utilized to further mitigate the issue.

There are a number of useful ICT applications that attempt to address the street safety. For instance, an online community called Hollaback [3] uses the digital storytelling method for social movement to draw awareness to street harassment, which is a one of the street safety concerns. Street harassment includes verbal harassment to groping, stalking, leering, flashing, and sexual assault. A mobile application called bSafe [4] allows the user to receive SOS alarm when their loved ones are in trouble, and ask friend to follow them on the map (real-time) when the user feels insecure. Another mobile application called WalkSafe [5] aids people that walk and talk, improving the safety of pedestrian mobile phone users. It uses the camera and accelerometer sensors and data classification

techniques to alert mobile phone users of unsafe cars approaching them.
In this work, we took a different approach to provide a different service that extend beyond the state of the art in addressing the street safety issue. We developed a prototype system called *Safe Street Rangers* that allows the user to report and monitor the level of street safety. It enables the local residents to report of the street safety issues in their area such as street damages, road obstacles, broken traffic signs, risky turns, unattended dogs, dark street, and so on, which will become a helpful source of information for other street users e.g., visitors, unfamiliar pedestrians, or anyone who wants to be aware of the street safety condition. The system is based on crowdsourced data that comes from the users and is for the users.

2 System Overview

Crowdsourcing has attracted considerable attentions with various approaches developed to utilize these enormous crowdsourced data from different perspectives. The crowd-contributed data have become a powerful information source that covers almost every aspect of our lives, including traffic conditions, environmental conditions, health, public events, and many others. Researchers have turned to crowdsourcing to seek the wisdom of the crowd to solve machine-hard operations, e.g., POI labeling [6], image search [7], and software development [8]. Along the same line, here we wish to utilize the crowd-contributed data that reflects on the level of street safety.

Our *Safe Street Rangers* (SSR) system consists of three main components; server, mobile application, and web application, as shown in Fig. 1. The SSR system accommodates two main types of users; admin and ranger. Ranger is a mobile app user who can observe and report the level of street safety. There are seven aspects of street safety that the ranger can report and observe through the mobile app, including safety concerning traffic signs, road obstacles, brightness, road condition, animals, solitariness, and traffic accidents. Admin user manages the reports submitted by the rangers by checking and verifying them. As data is flowing between the mobile and web apps, so there is an online server handling the data i.e., storing and processing the data streams.

2.1 Mobile Application

The mobile app allows the user or a safe street ranger to monitor and report the level or rating concerning street safety in relation to each of the seven different aspects. The mobile app was developed using *Ionic* framework[1], which is an open-source SDK (software development kit) for hybrid mobile app development created by Max Lynch, Ben Sperry, and Adam Bradley of Drifty Co. in 2013. It was chosen because of its cross-platform capability. The SSR app icon is shown in Fig. 2.

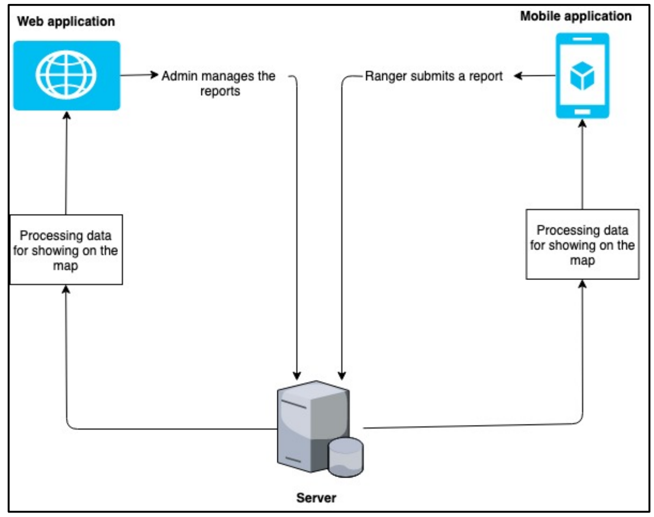


Figure 1: System overview of *Safe Street Rangers* that consists of three main components; server, mobile application, and web application

Figure 2: Mobile app icon

The level or rating of street safety ranges from 0 to 10. Depending on the reported rating, a color is used to represent the safety level; yellow if the rating is from 0 - 3, green if the rating is from 4 - 7, and red if the rating is from 8 – 10, where 0 implies the safest level and 10 means the least safe level.

The app is using the Google Maps API[2] for displaying a map and all other related geo-polylines and markers. Google Maps polyline is used to highlight a street segment in color corresponding to the reported rating and Google Maps marker is used to identify the beginning and ending locations of street segment on which the rating is given.

When the user makes a report, which is a data including the street segment and rating value, it is sent to the online server

[1] https://ionicframework.com

[2] https://developers.google.com/maps/documentation

to process and store the data. The admin user will then check and verify the report. Once the report is approved by the admin, the newly reported rating is then be added into the database and ready to be viewed via the mobile app.

2.1.1 Monitoring. The user can monitor the street safety level according to each of the seven safety aspects. As shown in Fig. 3, the user can choose the aspect that the user wants to monitor with respect to the street safety concerning driving or walking. We believed that each of these aspects is different from the perspectives of car driver and pedestrian walking on a street. So, we created two different perspectives for the user to monitor street safety in the perspective that is most relevant to them.

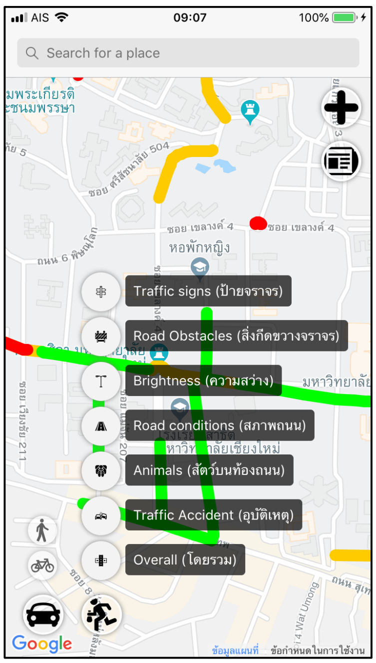


Figure 3: The user first chooses a transport mode (driving or walking) and then selects to monitor the safety level concerning one of the seven aspects i.e., traffic signs, road obstacles, brightness, road condition, animals, solitariness, and traffic accidents

The app will display the result on a map centered around the area where the user is located. Once the user has selected the transport mode and a safety aspect, then the app displays result on the map, as illustrated in Fig. 4. Of course, the user may want to see the result concerning a different transport mode as well as from a different aspect of street safety, the user can just simply click on the icon (car or person) in the bottom left of the screen then the list of aspects will prompt the user to select similarly to the snapshot shown in Fig. 3.

By monitoring or observing the street safety level, the user may use this insight to plan out their trip accordingly. They can even use this insight to give a warning to others. The user can also be a local official who manages and is in charge of monitoring the area to which the reported ratings can benefit their work and local residents as a whole as well.

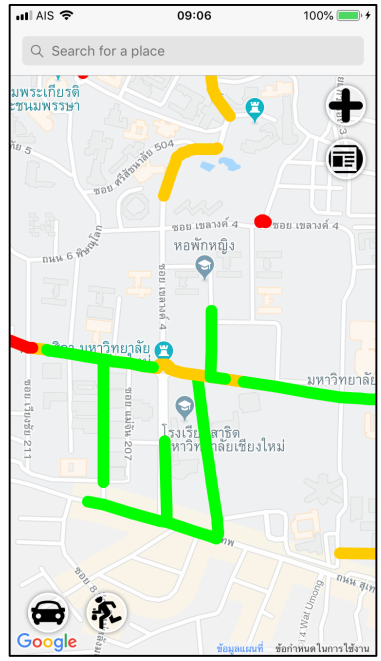


Figure 4: A snapshot of displayed street safety levels across different street segments

2.1.2 Reporting. When the user or a safe street ranger in this case wants to give a ratting to a street segment, the user can just use the same SSR app and come back to the monitoring module as shown in Fig. 4, and click on the plus icon on the upper right corner of the screen. The app will prompt the user with a map to select the street segment for which the ranger wishes to provide the rating. The user tabs on the map to identify the starting and ending points on the street to determine the street segment, as shown in Fig. 5.

In the case where the user mistakenly identifying either the starting or ending points on the street, the user can adjust their selection by simply click on the point left-arrow on the left-hand side of the screen to go back and re-do their street segment selection. The user can repeat this step as many times as needed until a satisfied street segment is selected.

Once a reporting street segment has been selected, the user will be prompted with a slide bar for giving a rating (from 0 - 10) to each of the seven aspects, as shown in Fig. 6. When the rating values are supplied and submitted, the user will see a confirmation message that the report has been submitted and pending on the admin's approval, as shown in Fig. 7.

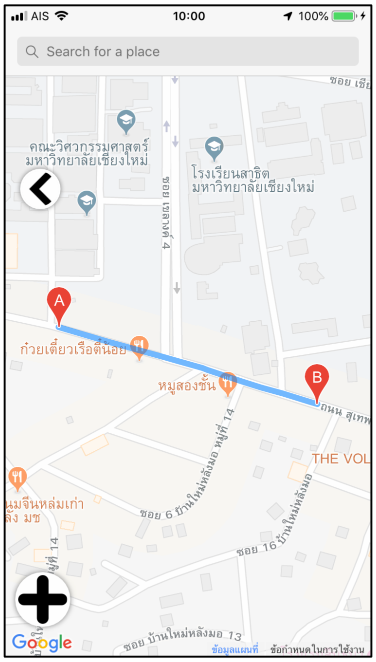


Figure 5: User selects the starting and ending points on the street to determine the street segment for which the safety rating is reported

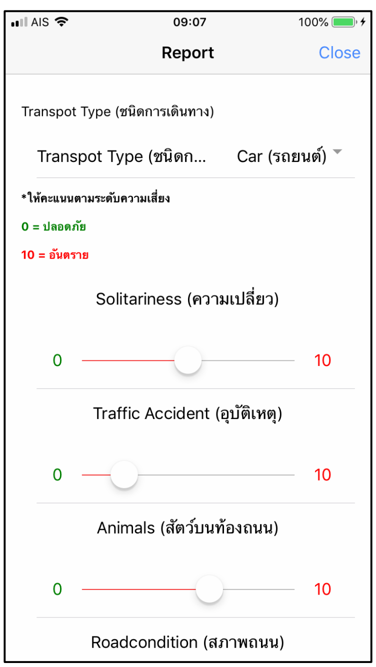


Figure 6: User chooses the rating for the reported street segment concerning each of the seven safety aspects

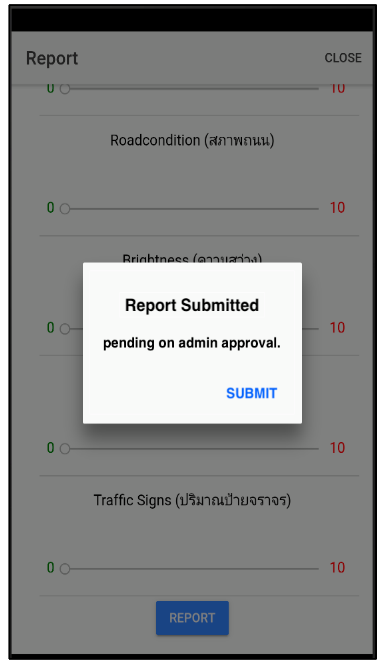


Figure 7: A confirmation message informing the user that the report has been submitted and pending on the admin's approval

2.2 Web Application

After a report has been submitted via the mobile app, it will arrive at the server ready to be read by the admin. So, a web app was thus needed to be developed to serve for this purpose. Therefore, the web app is mainly used by the admin to monitor and manage the reports. The web app was developed with the Laravel PHP framework[3].

When the admin logs into the web app, the admin will see a list of submitted reports both approved and pending. For example, Fig. 8 shows a snapshot of the admin's view of two pending reports with timestamp. Admin can click on option buttons on the right-hand side to accept, decline, or view the detail of each pending report.

When the admin clicks to view the detail of the report, the web app will show a map on which there is a reported street segment highlighted with a color corresponding to the safety level, as shown in Fig. 9. At this point, the admin needs to consider the report whether to approve it. There might be cases of spamming, exaggerated, or incorrect reports. The admin must be carefully digesting the report possibly by comparing it with other relevant reports or use his/her own local insights. Part of our future work will explore a system design for a more sophisticated report filtering mechanism.

[3] https://laravel.com

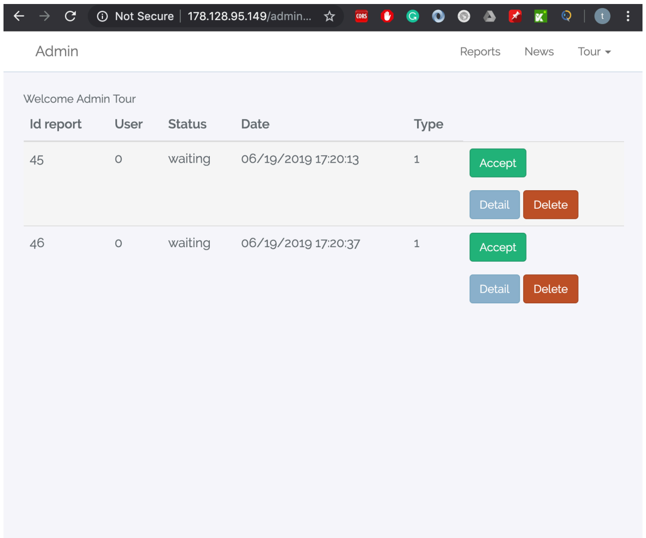


Figure 8: Admin's view of pending reports on the web app

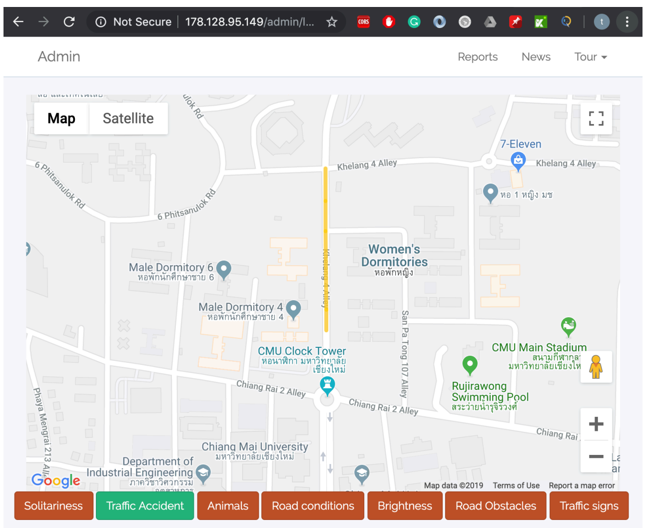


Figure 9: Admin's view of a reported street segment highlighted with color corresponding to the safety level on the web app

2.3 Data Server

Our data server is responsible for storing and processing the data including report ID, user ID, geolocation of the reported street segment (i.e., starting and ending locations), and rating value for each of the seven aspects. The server was built with the Laravel framework, which is capable of communicating with our mobile and web apps via our own developed API. A MySQL database was used for storage and data queries.

Some calculations are performed in the server. When a pair of geolocations determining the starting and ending points of street segment is submitted from the mobile app along with its corresponding ratting values, waypoints are queried and obtained through the Google Maps API and reported rating value is assigned to each waypoint. One street segment must have at least two waypoints (i.e., one for each end). A more curving street has more waypoints, each waypoint for each turning point on the street. An example of waypoints is shown in Fig. 10.

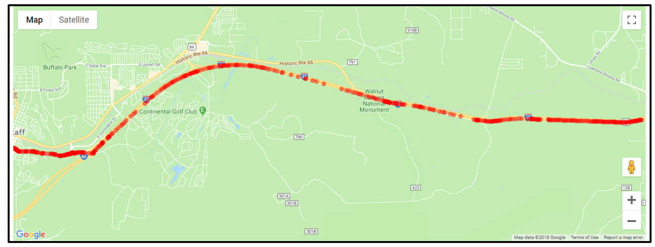


Figure 10: An example of waypoints obtained from using the Google Maps API

When reported street segment or some part of the street segment overlaps with the previously reported ones in the database, the ratings assigned to the overlapped waypoints are then re-calculated to the average rating of all current overlapped waypoints and stored back to the database.

There was one issue that we encountered while updating the rating values of the stored waypoints. There is possibility that a newly reported street segment overlaps with the existing one(s) but the starting or ending points does not match with any existing waypoints. As the user can pinpoint any geolocation on the map to be the starting or ending street segment, so this leads to the issue. To solve this, we basically assign the newly reported mismatched point to the nearest waypoint by using the Google Distance Matrix API for distance measurement. We chose to assign the rating value to the nearest waypoint instead of creating a new waypoint because the possibility of having the exact same location to this mismatched point in the future is relatively low, so assigning the value to the nearest waypoint helps average up the existing reported rating at the location.

Another issue is concerning checking for the overlapped waypoints. When a new reported waypoints arrive, the server then checks if the there are any overlaps with the waypoints stored in the database. Waypoint data is stored in the database as a linked list for this purpose of checking for overlapping. Each new waypoint is checked against the existing ones for a match. If no match found, then a geo-distance is measured between the new waypoint and each of the existing ones to find two nearest waypoints in the database and their corresponding distances, denoted as $d1$ and $d2$. A distance between these two nearest waypoints is also measured, denoted as $d3$. The system checks if $d3 > d1 +$

d2, then the new waypoint is said to be overlapping with the existing waypoints. As the waypoint data is stored in the database as a linked list, we can now insert the new overlapped waypoint between the two nearest waypoints accordingly. Then, the rating value is updated to an average between the newly reported rating and the adjacent waypoint located one position above in the linked list.

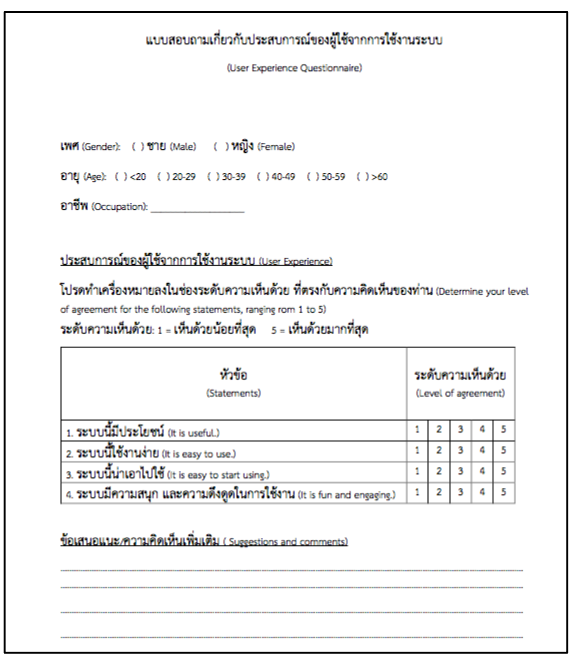
3 Demo

For the demonstration purposes, a video clip showing how the developed *Safe Street Rangers* system works is available at: https://youtu.be/NcEqagHz-lM. The mobile app is available on the Google Play at
https://play.google.com/store/apps/details?id=cmu.isne.ssr

4 User Experience Study

To evaluate the developed SSR system, we put it into the test by the real users by conducting a user experience study. Each user was asked to try out our SSR app and then asked to answer a questionnaire (shown in Fig. 11). Each user downloaded and installed the app on their smartphone. The survey questionnaire was designed base the Theory of Four Elements of User Experience [14], which askes to the user to rate their level of agreement with four different statements concerning the user experience with the system that include:

1. It is useful.
2. It is easy to use.
3. It is easy to start using.
4. It is fun and engaging.



แบบสอบถามเกี่ยวกับประสบการณ์ของผู้ใช้จากการใช้งานระบบ

(User Experience Questionnaire)

เพศ (Gender): ( ) ชาย (Male) ( ) หญิง (Female)

อายุ (Age): ( ) <20 ( ) 20-29 ( ) 30-39 ( ) 40-49 ( ) 50-59 ( ) >60

อาชีพ (Occupation): ________________

ประสบการณ์ของผู้ใช้จากการใช้งานระบบ (User Experience)

โปรดทำเครื่องหมายลงในช่องระดับความเห็นด้วย ที่ตรงกับความคิดเห็นของท่าน (Determine your level of agreement for the following statements, ranging rom 1 to 5)

ระดับความเห็นด้วย: 1 = เห็นด้วยน้อยที่สุด 5 = เห็นด้วยมากที่สุด

หัวข้อ (Statements)	ระดับความเห็นด้วย (Level of agreement)				
1. ระบบนี้มีประโยชน์ (It is useful.)	1	2	3	4	5
2. ระบบนี้ใช้งานง่าย (It is easy to use.)	1	2	3	4	5
3. ระบบนี้น่าเอาไปใช้ (It is easy to start using.)	1	2	3	4	5
4. ระบบมีความสนุก และความดึงดูดในการใช้งาน (It is fun and engaging.)	1	2	3	4	5

ข้อเสนอแนะ/ความคิดเห็นเพิ่มเติม (Suggestions and comments)

Figure 11: User experience study questionnaire

There ar17 participants in total that include 10 males and 7 females. Each participant was asked to give a rating of agreement level to the four statement where the rating score is a 5-likert scale where 1 means the lowest level of agreement and 5 means the highest level of agreement.

Overall, the users gave the highest rating for the system being useful at (4.53), followed by being easy to start using (4.12), then being easy to use (3.53), and lastly being fun and engaging (3.41). The overall result is shown in Fig. 12. This suggests that the users appreciate the usefulness aspects of the system, however there is still a need for improvement particularly in the aspects of being easy to use and being fun and engaging. One of the comments from the users was "*It's slightly difficult to know how to proceed with the app without any instructions. Although it's not super hard to use but at least some kick-off instruction would help.*". As suggested, a brief user instruction could clearly be an additional part of the app in our future app design and development.

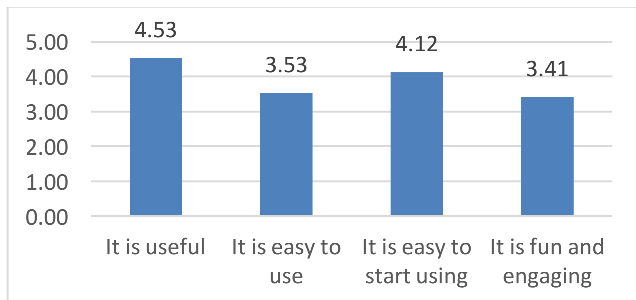


Figure 12: Overall result of the user experience study

When separate the users by gender, Fig. 13 shows the male users gave ratting similar to the overall trend, however female users highly rated the usefulness followed the easiness to start using aspects, then gave a higher rating to the aspect of being fun and engaging (3.71) than lastly being easy to use (3.14). It suggests that female users may struggle with using the app. It is also reflected in one of the comments from a female users saying that "*It looks interesting but it's difficult to use. If you (our researchers) don't explain to me, I wouldn't know how to use it*". Another comment from a female user was "*This is a good idea app. Since I'm not originally from here, I often have problem judging if this road or that road is better to ride my bike. I will definitely use it. I think the graphics and the way it displays can be better. Can I share the result (street safety result) on my social media?*". This suggests that we should consider improving the app appearance artistically as well as interesting features like social interaction or social media connectivity.

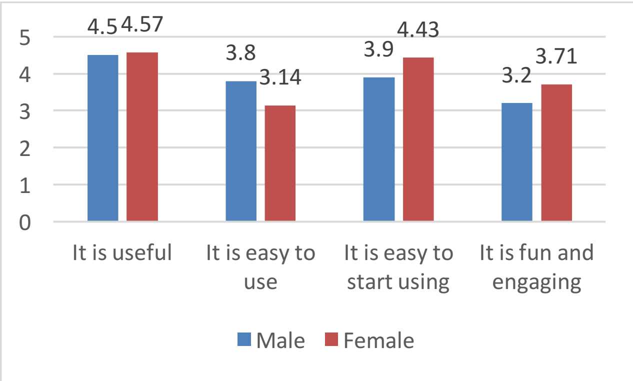


Figure 13: Result of user experience study when grouped by gender

When separate the users by age, there were two users who were younger than 20, 11 users who were 20-29 years old, one user who was 30-39 years old, and three users who were 40-49 years old. The result in Fig. 14 shows that the youngsters (<20 years old) highly rated the system in all aspects except for the aspect of being easy to use. This aspect of being easy to use has really been shown as an issue, particularly in the age group of 30-39 years old the users gave the rating as long as 2.0. Users in the 20-29 age group didn't seem to have issue with it but the aspect of being fun and engaging. One of the comments from this 20-29 age group was that "*I like the app. I can see myself using it in the future. But it needs to improve on its excitement that would make people stick with it and use it over and over again. One of the things that I can think of is social media stuff could probably boost up the its usability*". Similar to what has been suggested earlier that an addition of some exciting features like social interaction features could be helpful for the app's usability. Surprisingly, the aspects of being easy to use and being fun and engaging seemingly are the issues for the 30-39 age group than the older age group, 40-49 years old.

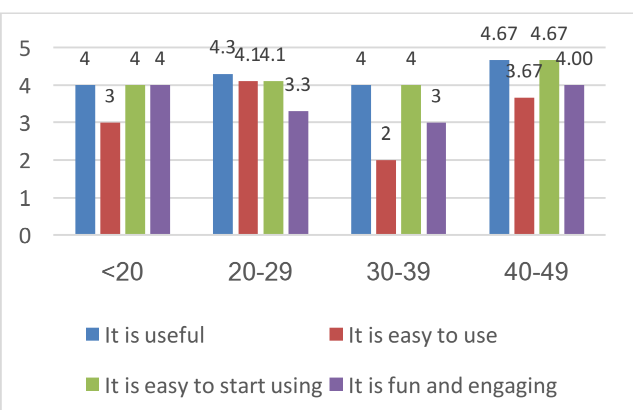


Figure 14: Result of user experience study when grouped by age

5 Conclusion

Various approaches have been developed to utilize the crowdsourced data from different perspectives. In this work, we developed a system that makes use of the crowd-contributed data to address the pressing issue of street safety. The developed system is called *Safe Street Rangers*. The rangers are the system's mobile app users who act as the street keepers. A ranger can monitor and report the level of safety on any street segment based on their experiences and perceptions regarding seven different safety concerns including traffic signs, road obstacles, brightness, road condition, animals, solitariness, and traffic accidents, in relation to a transport mode i.e., driving or walking. Once the report has been submitted, there is a web app via which an admin user logs in and verifies it. Report verification and approval are needed to ensure valid reports which will be displayed on the app for all other users to view. The system updates the rating values given to street segments shown on a map all the time whenever a new report has been submitted. The system checks for overlapped street segments and updates the rating values accordingly. To preliminary evaluate the system, a user experience study was conducted with the real-world users. The results suggest that the system's usefulness is highly recognized. However, there are still other aspects to be improved. Comments and suggestions from the users are constructive and advising us to consider an addition of user manuals and interesting social interaction features for our future development.

There are however some limitations and lessons learned from our prototype development. Due to the nature crowdsourced data that needs 'crowd' to gather massive data, there must be a mechanism for attracting users to use the app over and over again. A suggested social interaction feature could potentially achieve it. Another limitation is the shortcomings of the linked list approach for storing data is that although it enables a simple method for checking and organizing waypoint data overlapping, it can potentially give a different result if the direction of the street segment is opposite (i.e., positions of the starting and ending points are reversed). An alternative approach will be explored in our future development.

Nonetheless, we believe the *Safe Street Rangers* system overall is useful as another way to tackle the local street safety issue that concerns us all. We believe that it is our own responsibility to watch out for each other.

REFERENCES

[1] A. Karr, "1.35 Million People Die Every Year In Car Accidents, Study Finds," *motor1.com*, 2018. [Online]. Available: https://www.motor1.com/news/295823/global-road-safety-report-2018/. [Accessed: 08-May-2019].
[2] World Health Organization (WHO/NMH/NVI/18.20, "Global Status Report on Road Safety," Switzerland, 2018.
[3] J. P. Dimond, M. Dye, D. LaRose, and A. S. Bruckman, "Hollaback!: The

Role of Collective Storytelling Online in a Social Movement Organization," in *Proceedings of the 2013 conference on Computer supported cooperative work (CSCW'13)*, 2013, pp. 477–489.

[4] Google Play, "bSafe - Personal Safety App." [Online]. Available: https://play.google.com/store/apps/details?id=com.bipper.app.bsafe&hl=en_US. [Accessed: 08-May-2019].

[5] T. Wang, G. Cardone, A. Corradi, L. Torresani, and A. T. Campbell, "WalkSafe: a pedestrian safety app for mobile phone users who walk and talk while crossing roads," in *Proceedings of the Twelfth Workshop on Mobile Computing Systems & Applications (HotMobile '12)*, 2012.

[6] H. Hu, Y. Zheng, Z. Bao, G. Li, J. Feng, and R. Cheng, "Crowdsourced POI labelling: Location-aware result inference and Task Assignment," in *2016 IEEE 32nd International Conference on Data Engineering, ICDE 2016*, 2016.

[7] T. Yan, V. Kumar, and D. Ganesan, "CrowdSearch : Exploiting Crowds for Accurate Real-time Image Search on Mobile Phones," in *Proceedings of the 8th international conference on Mobile systems, applications, and services (MobiSys '10)*, 2010, pp. 77–90.

[8] K. O. and G. Sukthankar, "AmalgaCloud: Social network adaptation for humana and computational agent team formation," in *Proceedings of the 27th IEEE/ACM International Conference on Automated Software Engineering (ASE'12)*, 2012, pp. 61–73.

[9] N. Prapaitrakul and S. Phithakkitnukoon, "EQviz: A visualization tool for monitoring world earthquakes," in *UbiComp and ISWC 2015 - Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the Proceedings of the 2015 ACM International Symposium on Wearable Computers*, 2015.

[10] K. Piriyawarangkul, K. Rodphotong, and S. Phithakkitnukoon, "Tweet of the town: A case study of Thailand," in *UbiComp and ISWC 2015 - Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the Proceedings of the 2015 ACM International Symposium on Wearable Computers*, 2015.

[11] A. Binthaisong, J. Srichan, and S. Phithakkitnukoon, "Wi-Crowd: Sensing and visualizing crowd on campus using Wi-Fi access point data," in *UbiComp/ISWC 2017 - Adjunct Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*, 2017.

[12] T. Klomklao, P. Ratanarungrong, and S. Phithakkitnukoon, "Tweets of the nation: Tool for visualizing and analyzing global tweets," in *UbiComp 2016 Adjunct - Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 2016.

[13] C. Somdulyawat, P. Pongjitpak, S. Phithakkitnukoon, M. Veloso, and C. Bento, "A tool for exploratory visualization of bus mobility and ridership: A case study of Lisbon, Portugal," in *UbiComp and ISWC 2015 - Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the Proceedings of the 2015 ACM International Symposium on Wearable Computers*, 2015.

[14] F. Guo, "More than asability: The four elements of user experience, part IV," 2012. [Online]. Available: http://www.uxmatters.com/mt/archives/2012/04/more-than-usability-the-four-elements-of-user-experience-part-i.php. [Accessed: 21-Dec-2017].