2022 8th International Conference on Control, Decision and Information Technologies (CoDIT) | 978-1-6654-9607-0/22/$31.00 ©2022 IEEE | DOI: 10.1109/CODIT55151.2022.9804123

R-Safety: a mobile crowdsourcing platform for road safety in smart cities

Ibtissem Khedher[1], Sami Faiz[2] and Souhayel Gazah[3]

***Abstract*— Road insecurity is a real scourge; road accidents cause more and more human and material losses worldwide, however, inequalities in the distribution of damages. On the one hand, a report published by the WHO estimated that some 1.3 million people are killed and 50 million injured in road accidents worldwide each year. On the other hand, a report published by the National Observatory of Road Safety in Tunisia showed that 1007 people were killed and 6757 injured in Tunisia in 202. Certainly, the statistics allow estimating the level of road insecurity at the global and national levels. To improve the current situation of road safety in Tunisia we propose a new mobile crowdsourcing platform called R-safety which allows road users to report in real-time their road safety feeling indexes. It also allows users to report violations they witness and interact with the NORS. R-safety also aims to inform citizens about risk areas through a vulnerability map that divides the areas into five types from the least dangerous to the most dangerous. In our approach, we are interested in improving the current situation of road safety by integrating the opinions of road users in the decision support tool of the national observatory of road safety. Thus, integrating citizens opinions into the information system would serve to have new sources of incoming data to improve decisions. This research work responds to real needs discussed with the members responsible for the studies and research of the NORS. We are evaluating our proposal through a questionnaire with 524 participants. This questionnaire helps us to choose among the proposed safety indicators those that affect road safety according to the citizen's opinion. This result confirms the importance of our crowdsourcing service.**

keywords: safety index, crowdsourcing, decision support, road risks, smart city

I. INTRODUCTION

Motor vehicle crashes are one of the most important public health and injury prevention problems in the world, since according to the World Health Organization 1.3 million people were killed and 50 million injured in road accidents in the world in 2021 [1]. The problem is even more serious when the victims are in very good health before their collisions. The statistics also show that young people are the first victims of traffic accidents. This result is due to a combination of various factors.

Official statistics show that in 2021 Tunisia recorded 4975 road accidents that caused 1007 fatalities and 6757 injuries [2]. As shown in Figure 1, the number of people killed changes in a variable and non-constant manner.

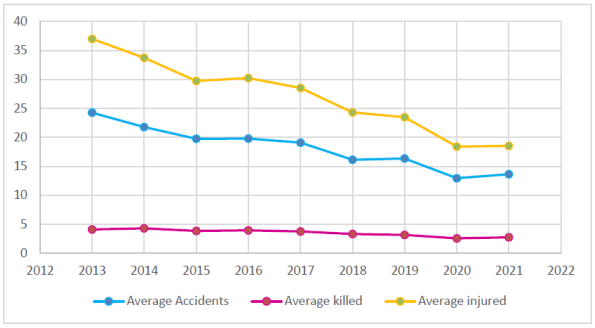

Fig. 1. Graphical representation of the daily average of accidents and victims in Tunisia from 2013-2021

TABLE I
THE DAILY AVERAGE OF ACCIDENTS AND VICTIMS IN TUNISIA FROM 2013-2021

Year	*Average Accidents*	*Average killed*	*Average injured*
2013	24,26	4,11	36,99
2014	21,78	4,28	33,75
2015	19,74	3,84	29,73
2016	19,8	3,95	30,23
2017	19,1	3,75	28,53
2018	16,12	3,3	24,31
2019	16,36	3,15	23,49
2020	12,95	2,56	18,4
2021	13,63	2,75	18,51

These statistics confirm this stressful situation. The non-compliance with traffic regulations, the speed of traffic inappropriate, non-compliance between citizens, the overall unconsciousness of drivers, the condition of the road, and the weather make every day several families come to a tragedy in Tunisia.

Statistics remain insufficient because, systematically, no reality can be observed except through two complementary aspects: the objective aspect of this reality (revealed mainly by statistics) and its subjective aspect. This principle applies to the reality of road safety because statistics remain insufficient in covering the reality for several reasons. On the one hand, road safety statistics reflect the activity of police units and not all other things, so these statistics do not reflect the time and place and the exact causes that correspond to reality. On the other hand, the work of the NORS concerns only the statistics of accidents that cause body injuries. These statistics concern the indicators of the severity of the accidents or the indicators of black spots... so these data are insufficient to give a clear and complementary idea on the

[1]Ibtissem Khedher is with the national school of computer science in Tuniia,Manouba University,Geomatics team LTSIRS ibtissem.khedher@ensi-uma.tn
[2]Sami Faiz is with the Higher Institute of Multimedia, Manouba University, Geomatics team LTSIRS sami.faiz@isaam.uma.tn
[3]Souhayel Gazah is with the national observatory of road securiy in Tunisia S.gazzah@onsr.nat.tn

Authorized licensed use limited to: Auckland University of Technology. Downloaded on April 29,2025 at 06:43:20 UTC from IEEE Xplore. Restrictions apply.

reality of the traffic, which influences the decisions of the NORS.

Digital technologies and digital services has been invested our daily life and our organizations to improve the quality of life of citizens in their cities and make them more attractive. In addition the crisis of covid encourage and accelerates the digital development of society. for this reason we propose a new platform of mobile crowdsourcing that allows to enrich the database of the NORS through the integration of citizens evaluaion.

Crowdsourcing services are knowledge-sharing services based on the use of mobile devices continuously connected to the Internet to perform collaborative tasks. An example of this task is Wikipedia, in which thousands of people consult and contribute every day [3].

A smart city model is based on digital technologies [4]. Mobile crowdsourcing applications allow them to integrate citizens into public services, as they are the ones that collect information for the city in a faster way. An example of a crowdsourcing application would be that of the real-time monitoring of public transportation schedules by users [5], or the dissemination of information to citizens in case of evacuation following natural disasters [6].

To improve the quality of life of citizens and to decrease the number of accidents and to increase road safety we propose a new crowdsourcing platform that allows citizens to give their safety ratings as well as to report traffic violations.

In this article we present the following sections, we first present related work and a comparative study in section II. Then we detail our mobile crowdsourcing service that allows NORS to collect data on several factors being involved in road safety through citizens in Section III. The latter can evaluate the different road components and indicate their safety sentiment index. We discuss possible improvements for mobile crowdsourcing services in an urban environment in Section VI. Finally, we conclude this article and present our research perspectives in Section V.

II. STATE OF THE ART: ROAD SAFETY ANALYSIS

R-Safety is a new mobile crowdsourcing platform. This type of service has shaped our daily life and our organizations to improve the quality of life of citizens in smart cities.

Several services have been proposed, such as uSafe [7], a mobile service allowing participants to indicate their subjective perception of safety in their urban environment. This participatory application allows users to report information about their cities, such as a violent incident or an unlit alley at night. These data are then aggregated into summary maps accessible by other users and city planners.

Based on the information collected from citizens, administrators can adapt and improve their urban plans by adding lighting, for example. In addition, the application provides mechanisms to protect the privacy of citizens. we can also mention AppsInTheCity [8], an application that is part of the development of the Digital project that allows users to know which applications are most used in their neighborhood so that they can use them and interact with other users.

Or CityObserver [9], which collects information from citizens for urbanization campaigns through crowdsourcing applications.

We also mention CrowdOut [10], a mobile crowdsourcing service that allows the identification of traffic violations and other traffic-related events in a city. This service aims at informing users of dangerous areas and allowing administrators to modify signage or certain risky roads, to improve the quality of life of citizens within their city.

There is also the mobile crowdsourcing application CommuniSense [11]. The application has two main functionalities: collecting and visualizing data on the state of the road in Nairobi. This application is built on the Android platform. Using the Android platform, the application allows collecting abundant and pertinent data, including multimedia (images), location (GPS), and other sensors. And still, use Twitter hashtags as a tool to involve citizens in raising awareness of these road conditions.

Or UrbainEmotions [12], a system that allows users to indicate their subjective perception according to the context (traffic, hospital, tourism...). This system is designed to build an emotional database to improve urban planning and implement innovative planning.

Another system [13] that detect potholes through a crowdsourcing application and image processing algorithms allowing citizens to share problems in the form of images and to give their opinions. These data are analyzed and processed by official authorities to improve the road infrastructure and inform citizens through a vulnerability map.

Another example is the mobile platform Transafe [14], which captures and analyzes public perceptions of safety to provide collective intelligence on locations in the city of Melbourne, Australia, so these perceptions may constitute insecurity factors for visitors and residents moving in and through the city.

There is also an application [15] that allows drivers to detect and report speed bumps on a map and share them with other drivers. it can also detect bad road conditions with an application based on smartphone sensors (GPS and accelerometer) [16].

The previously cited approaches allow users to report in real time road violations ([10], [15]), or to give their subjective perceptions ([7], [14]), or to evaluate the road infrastructure ([11], [16]). However, these approaches are not able to assess all the hazards that may exercise an influence on the road safety index.

As shown in table II, R-Safety can be considered as the first platform that allows users to indicate their road safety sentiment indexes and report road violations and allows to integrate the collected information into the decision support process of the NORS. R-Safety allows citizens to evaluate their subjective and objective perceptions of all factors involved in road safety. Moreover, R-Safety respects the privacy of its users.

Authorized licensed use limited to: Auckland University of Technology. Downloaded on April 29,2025 at 06:43:20 UTC from IEEE Xplore. Restrictions apply.

TABLE II
COMPARISON OF APPROACHES

References	*subjective rating(1)*	*objective rating(2)*	*(1)+(2)*
[7]	X		
[8]		X	
[9]		X	
[10]		X	
[11]		X	
[12]	X		
[13]		X	
[14]	X		
[15]		X	
[16]		X	
R-safety			X

III. ROAD SAFETY

Today, smartphones and mobile applications have become an important part of our daily lives. Citizens use mobile applications for most of their tasks: checking email, checking their bank accounts, shopping online, and communicating with their families and friends via instant messaging applications. Crowdsourcing-based transport projects prove that crowdsourcing has the potential to bring together a large group of people on a single platform when it comes to an issue that affects them all. The systematic use of user information and feedback for transport planning or improving service standards[17]

A. PROTOTYPE DEMONSTRATION

A report published by Digital Tunisia shows that the use of cell phones connected to the internet exceeds 17 million with 7.9 million internet users and approximately 93.8 percent of citizens have an Android phone [18].

On the one hand, to make the city more and more smart, and to facilitate the collection of information for official authorities, citizens must participate in the welfare of the community. On the other hand, modern security strategies have proven that the extrapolation of citizens' expectations and concerns, its adoption in the formulation of action plans and security priorities is one of the most effective methods of security work.

To this end, we propose a mobile crowdsourcing service called Road Safety or R-Safety to include the subjective perceptions and objective evaluations of citizens regarding road safety in the decision support process of the National Observatory of Road Safety in Tunisia in order to increase safety and to improve the current road safety situation.

Although driver behavior analysis [7] is an effective way to reduce accidents and to improve road safety, many other factors can influence road safety.

Our R-Safety platform is designed to collect various types of data concerning essentially three main components that have a direct influence on road safety.

These three components are :

- The first one concerns the human components
- the second one concerns the road services
- the third one concerns the road components

These different components are classified under nine indicators as shown in Table III.

TABLE III
ROAD SAFETY SENTIMENT INDICATORS

The components of the road	*Sentiment Index*
the Human components	Evaluation of public transport drivers behavoir
	Evaluation of driver behavior
	Assessment of passenger behavior
the Road services	Evaluation of road policing services
	Evaluation of civil protection services
	Evaluation of information published by the NORS
	Confidence level of coverage for road accidents victims
The road components	Evaluation of the condition of road infrastructure
	Evaluation of the safety of public transports means

The contributions of these indicators:

- Prioritize the work of road traffic by location, that is, explain in which are the first boroughs to support and monitor their road traffic.
- The ability to provide data that allow the creation of methodological mechanisms, concrete, credible that allow us to evaluate The performance of the different parties involved in traffic (at national and regional levels), The mechanisms can be an effective support (security or political), at the national or regional level (in the work sessions that bring together the rest of the parties)
- Inclusion of this index in the periodic evaluations and analyses published by the national road safety observatory, which reinforces the credibility of the reports published by the observatory.
- Increased capacity to analyze traffic problems in more depth at various levels...

To evaluate our proposal, we carried out a study in the form of an online questionnaire, which was published on the official page of the NORS and the official page of our university and other partner universities. As a result, 524 participants responded to our questionnaire. The result of the survey is shown in the table IV.

The table IV shows that the participants chose the first five indicators much more than the last three indicators. These results show the importance and he influence of the first 5 indicators on road safety.

Our choice makes us more interested in indicators with high responses. The study of responses related to the indicators allowed us to propose a new mobile crowdsourcing platform for road safety in cities.

B. ARCHITECTURE OF R-SAFETY

Our mobile crowdsourcing platform is developed on the Android platform. This service offers a low-cost solution

Authorized licensed use limited to: Auckland University of Technology. Downloaded on April 29,2025 at 06:43:20 UTC from IEEE Xplore. Restrictions apply.

TABLE IV
SURVEY RESULTS

Indicator	*Number of responses*
Evaluation of public transport drivers behavoir	509
Evaluation of driver behavior	496
Evaluation of public transport driver behavior	494
Evaluation of passenger behavior	479
Confidence level of coverage for road accidents victims	388
Evaluation of the safety of public transports means	251
Evaluation of civil protection services	40
Evaluation of road policing services	37
Evaluation of information published by the NORS	28

that exploits mobile technology. We chose to work on the Android platform because it offers the possibility to collect rich data such as images and GPS location. The latter is based mainly on two functionalities, the first one allows the user to indicate their safety feeling index as well as the traffic violations committed. These data will be stored in a database that will be subsequently analyzed by the NORS. The second functionality consists of informing users about risk areas based on the information collected and statistics through the official web pages of the NORS and through notifications sent via the mobile application.

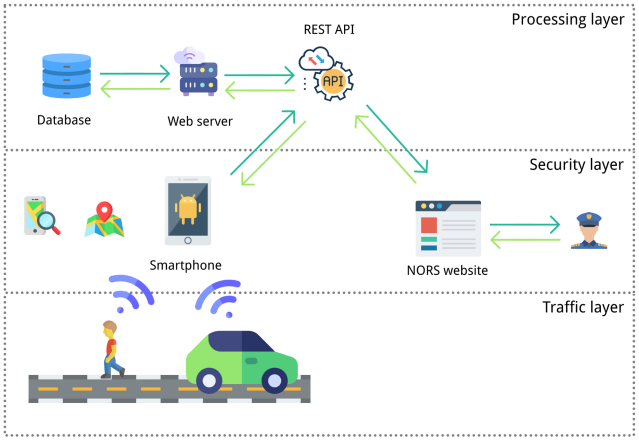

Fig. 2. R-safety platform architecture

As shown in the figure 2 our architecture contains three layers. The first layer represents the road traffic layer, this layer is responsible for providing data on traffic conditions through a mobile crowdsourcing platform. Pedestrians and drivers can evaluate the road space and inform about road violations and indicate their safety feeling indexes.

The second layer represents the safety layer which contains the NORS accident database as well as data collected from citizens through our crowdsourcing service which was designed on the Android platform. This layer contains all the information about accidents as well as traffic violations committed by road users and the influence of these violations on the safety feeling index of other users.

The processing layer: This layer is responsible for merging and exploiting the data provided by the lower layers. In this layer, R-Safety classifies the traffic conditions and the levels of insecurity on each road in order to identify the dangerous areas.

Our platform is connected to a PHP server which manages the authentication of users and receives reports and manages all communications. All the information sent by the users will be stored in a MySQL database. To protect the privacy of the users, only the NORS administrators have access to the collected data to enrich their database. Users have three possible functionalities, either to indicate a danger through pictograms and other information, or to consult the map or to contact the NORS, the civil protection or the national guard. In order to indicate the pictograms on the Google map, we use a development API of GoogleMap.

C. PROTOTYPE FUNCTIONNING

To explain the functioning of our R-Safety platform we consider the following scenario, when the user sees a danger or a traffic violation, using his smartphone connected to the internet he can indicate this danger. Our platform offers a low-cost solution that leverages mobile technology and provides the ability to collect rich data including multimedia (image), location (GPS), and other sensors.

The first interface of our platform after the authentication process is successfully completed allows users to choose the road indicator they want to evaluate.

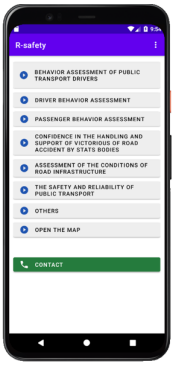

Fig. 3. Interfaces of submitting reports

The user side interface is presented in figure 3, this interface includes a set of road safety indicators. Through this interface the user can indicate a traffic violation or a problem in the street such as potholes and also indicate their subjective perception or contact the observatory or the national guard or the civil protection or the police.

As shown in figure 4 our platform hleps the user to evaluate and to submit a completely documented report which includes many informaions about road infraction like the method of transportaion, description, governorate, sense of security index, the offenses, the date and the time, he can also take or insert picture and the corresponding location .

Authorized licensed use limited to: Auckland University of Technology. Downloaded on April 29,2025 at 06:43:20 UTC from IEEE Xplore. Restrictions apply.

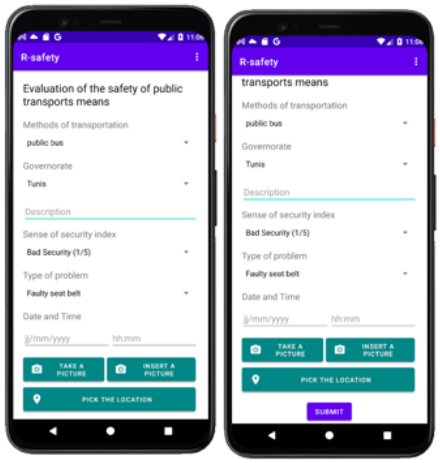

Fig. 4. Interfaces of submitting reports

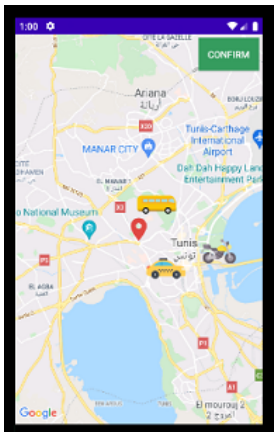

Fig. 5. Hazard identification interfaces on the city map

Users can also directly contact the NORS, the road police and the civil protection by phone in case of emergency through our platform. In order to evaluate an indicator, the user has to fill in the data concerning an offence such as non-compliance with traffic regulations, insecurity of a public transport tool, etc. The information transmitted to the server is presented in Table V.

The informations collected are presented in Table VI will be analyzed to identify risk areas. These data will be used by the National Observatory of Road Safety in periodic analyses in order to make the best decisions and improve road safety.

TABLE V
INFORMATION SENT TO THE SERVER BY A USER REGARDING A TRAFFIC VIOLATION OR HAZARD

Name	***Information***
Governorate	The name of the governorate
Type of offence	Type of offence committed
Sense of security index	A number between 1 and 5
Date	date of infraction
Time	time of infraction
id identifier	user's ID
GPS coordinates	latitude and longitude
Photo	Image of the offence
Text	Text Comment

R-Safety permits users to report traffic violations they witness in real time and indicate their subjective perceptions and share it with the user community on the city map in real time, the user can also take a photo of the violation and add a comment. All users can consult the city map to know the safest areas in their environment.

As indicated in Figure 5, there are several types of icons used to localize the different types of risks on the city map . For example, the taxicab logo indicates that there is a violation that has been committed by a taxidriver. Even users who do not give ratings can consult the violation map by pressing the "update" button. This button allows the map to be updated in real time.

Each indicator contains several icons and each icon is related to a traffic violation. The collected data will be analyzed to identify the risk areas on the city map. Then the vulnerability map will be published on the official website of the NORS.

To protect the privacy of the users the collected images will not be published to the public. The user can choose to indicate his subjective perception and objective evaluation concerning an indicator in real-time or indicate it later to protect their location.

D. IDENTIFICATION OF RISK AREAS

The risk areas will be identified using the data collected through our crowdsourcing platform in order to specify the dangerous areas and inform the citizens either through the official website of the observatory or through notifications. Users can also view the city map to see the areas at risk.

TABLE VI
IDENTIFICATION OF RISK AREAS

index of feeling of security	***Safety Levels***
1/5	Dangerous
2/5	Unsafe
3/5	Hazardous
4/5	Medium
5/5	Safe

The table VI shows the way and the score of zone classification used on the map.

Each security feeling index has a specific color on the vulnerability map. The user is asked to give his security feeling index which is between 1 and 5. Each index refers to a level of security from least secure to most secure.

In order to identify the areas at risk we have developed an algorithm in python that is used to classify the areas based on the reports sent by the citizens.

The platform users send reports containing the governorate, the security index and other information. These data will be stored in a database and then the data will be processed to determine the security index for each governorate.

Authorized licensed use limited to: Auckland University of Technology. Downloaded on April 29,2025 at 06:43:20 UTC from IEEE Xplore. Restrictions apply.

Fig. 6. Tunis vulnerability map

Based on the security index of each governorate, a python script generates the mapping that presents each governorate is its security index by the matching color.

If many users give different evaluations on the same area, the security index of this area will be the average of all the collected indices.

As shown in Figure 6, the vulnerability map presents the areas according to the number of reports collected using the color blue from lightest (safe) to darkest (dangerous).

On the one hand, the objective of the vulnerability map is to identify risk areas and inform citizens about dangerous zones through our crowdsourcing platform and the official pages of the National Observatory of Road Safety.

On the other hand, the data collected will enrich the database of the NORS and help it to make the best decisions in order to reduce the number of accidents and improve the quality of life of citizens.

IV. DISCUSSION

In this section, we describe the advantages of our crowdsourcing platform. On the one hand R-Safety combines objective and subjective rating in road safety analysis, our platform offers new input data and involves road users in the decision support process of the national observatory of road safety in Tunisia. On the other hand R- safety is used to improve road safety and urban planning policy and informs citizens about risk areas.

Our architecture is based on the client/server model. The purpose of the R-safety service is to collect a massive quantity of data and make it available to a large number of users in real time.number of users in real time.

V. CONCLUSIONS

The digital transformation or digitalization entails a holistic review of society in all dimensions of life, and it leads to a global transformation. Our proposal in this article aims to improving the quality of citizen's life, increase security, enrich the knowledge of administrators for decision support in consequently improve the city's urban planning. In this paper, we present a new mobile crowdsourcing platform for road safety in the smart city. This service allows users to evaluate the different road components and actively participate in the decision support process of the NORS. This decision support will allow them to have a direct impact on their fellow citizens and the city's management policies.

In our future work, we will integrate mechanisms that ensure the credibility of collected data. In order to increase the accuracy of identification of risk areas we will also merge and analyze the NORS database with the data collected through our platform.

On the other hand, we will develop a machine-learning model to predict the road safety index based on the data collected through our platform and several other data sources.

REFERENCES

[1] World Health Organization: Road Traffic Injuries. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries. last accessed January 2022.
[2] National observatory of road safety in Tunisia. https://www.onsr.nat.tn/onsr/index.php?page=4ar. last accessed January 2022.
[3] Wikimedia Foundation. Wikipedia the free encyclopedia, 2021. https://fr.wikipedia.org/.
[4] Moss Kanter, R.,& Litow, S. S. (2009). Informed and interconnected: A manifesto for smarter cities. Harvard Business School General Management Unit Working Paper, (09-141).
[5] Tranzmate. Moovit real-time public transit app, 2021. https://moovitapp.com/nycnj-121/poi/fr.
[6] Goodchild, M. F.,& Glennon, J. A. (2010). Crowdsourcing geographic information for disaster response: a research frontier. International Journal of Digital Earth, 3(3), 231-241.
[7] Christin, D., Roßkopf, C.,& Hollick, M. (2013). usafe: A privacy-aware and participative mobile application for citizen safety in urban environments. Pervasive and Mobile Computing, 9(5), 695-707.
[8] Madynes team, inria nancy grand-est, digital cities project: Appsinthecity, 2021. http://www.inria.fr/equipes/madynes.
[9] Sap, florian probst, digital cities project: Cityobserver. http://www.sap.com/corporate-en/innovation/next-business-and-technology/index.epx, 2013.
[10] Aubry, E., Silverston, T., Lahmadi, A.,& Festor, O. (2014, March). CrowdOut: A mobile crowdsourcing service for road safety in digital cities. In 2014 IEEE International Conference on Pervasive Computing and Communication Workshops (PERCOM WORKSHOPS) (pp. 86-91). IEEE.
[11] Santani, D., Njuguna, J., Bills, T., Bryant, A. W., Bryant, R., Ledgard, J., & Gatica-Perez, D. (2015, August). Communisense: Crowdsourcing road hazards in nairobi. In Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services (pp. 445-456).
[12] Resch, B., Summa, A., Sagl, G., Zeile, P.,& Exner, J. P. (2015). Urban emotions Geo-semantic emotion extraction from technical sensors, human sensors and crowdsourced data. In Progress in location-based services 2014 (pp. 199-212). Springer, Cham.
[13] Enigo, V. F., Kumar, T. V., Vijay, S., & Prabu, K. G. (2016). CrowdSourcing based online Petitioning system for pothole detection using android platform. Procedia Computer Science, 87, 316-321.
[14] M. Hamilton, F. Salim, E. Cheng, and S. L. Choy, Transafe: A crowdsourced mobile platform for crime and safety perception management, Int. Symp. Technol. Soc. Proc., vol. 2015-July, 2015, doi: 10.1109/ISTAS.2011.7160600.
[15] Mukherjee, A., & Majhi, S. (2016). Characterisation of road bumps using smartphones. European Transport Research Review, 8(2), 13.
[16] Shorter, D., Alshammari, S., & Song, S. (2020). Characterizing Road Conditions Via Smart Mobile Crowd Sourcing. In 2020 IEEE International Smart Cities Conference (ISC2) (pp. 1-8). IEEE.
[17] A. Misra, A. Gooze, K. Watkins, M. Asad, and C. Le Dantec, "Crowdsourcing and its application to transportation data collection and management," Transp. Res. Rec., no. 2414, pp. 1–8, 2014, doi: 10.3141/2414-01.
[18] Digital discovery. https://www.digital-discovery.tn// last accessed January 2022.

Authorized licensed use limited to: Auckland University of Technology. Downloaded on April 29,2025 at 06:43:20 UTC from IEEE Xplore. Restrictions apply.