15th ITS European Congress, Lisbon, Portugal, 22-24 May-2023

Paper ID #

FixCyprus: Assessing the potential of crowdsourced data for identifying and managing road safety hazards

Georgios Christou [1]*, Andreas Georgiou[1], Aristotelis Savva[2], Christos G. Panayiotou[1]

1. christou.george@ucy.ac.cy*, KIOS Research and Innovation Center of Excellence, University of Cyprus, Cyprus

2. Public Works Department Ministry of Transport, Communications and Works, Cyprus

Abstract

This paper explores the potential of crowdsourced data for identifying and managing road safety hazards. The study uses the mobile application FixCyprus as an example, which allows citizens to report road defects and infrastructure-related issues. The authors found that the crowdsourced data collected through the app was effective in identifying and addressing road defects. Additionally, the data collected could serve as a cost-effective alternative to traditional methods of monitoring road quality, such as in-field inspections, as well as provide a more comprehensive and up-to-date view of transportation networks.

Keywords: Crowdsourcing, road defects, road safety, mobile app

Introduction

One of European Union's (EU) priorities is to make transportation greener, smarter and more sustainable [1]. This is strongly associated with the reduction of carbon emissions [2], and the improvement of road safety performance of the road network [3,4]. Therefore, multiple technologies such as the Intelligent Transport Systems (ITS) and Advanced Driver-Assistance Systems (ADAS) are expected to contribute to the EU goals. However, road authorities in the EU face increasing challenges in managing traffic and infrastructure to provide advanced services to the citizens and meet these goals [5]. It is therefore vital that cities have an integrated solution that allows them to monitor and manage infrastructure and transport operations in real time. It is observed that we are moving from traditional ITS with typical control centres to the era of Digital Twins for traffic management [6]. However, for such a large and complex system like a transportation network, it is important to use multiple data sources to create digital representations of physical systems for simulating, validating, predicting and controlling their life cycle [7]. ITS, which have been around since the 1970s, incorporate advance technologies that consume and produce a lot of data [8]. Apart from the obvious sources, such as traffic sensors, videos, and Global Navigation Satellite System (GNSS), crowdsourced data can be very valuable source as well (i.e., Waze and Google traffic data) [9]. This data are readily available mainly due to the wide use of smartphones, which offers new opportunities for crowdsourcing using mobile apps [10].

Regarding monitoring and managing road infrastructure, in addition to regular on filed inspections, some road authorities have introduced automated or semi-automated pavement condition data collection methods using vehicles equipped with sensors to identify road defects [11]. However, these technologies are costly, have low data collection speed, and are typically only used on the main road network. [11]. In addition, several authorities and social initiatives use crowdsourced data to collect data for road defects such as FixMyStreet, Street Bump and Streets Wiki [10]. Nevertheless none of them has been initiated by the government and has a country level coverage at the same time [10].

The Ministry of Transport, Communications and Works (MTCW) in Cyprus, in its efforts to comply with the ITS Directive 2010/40/EU [12], to deliver a safer road network, and deliver advanced ITS to its citizens, is closely collaborating with the KIOS Research and Innovation Center of Excellence (KIOS CoE) of the University of Cyprus to develop a Digital Twin of the main road network of Cyprus [13,14]. To implement this Digital Twin, multiple data sources are fused to have a real representation of the transportation network. One recently added data source, is crowdsourced data collected through a mobile app called FixCyprus, which is described in this article.

Objectives

The objectives of this article are to: 1) showcase the FixCyprus mobile app and the user roles, 2) present data from the deployment of this app, 3) assess the importance of crowdsourced data for identifying and managing road safety hazards, 4) to show how citizen engagement government initiatives in a country level could create a valuable source of data for several applications.

Method

The FixCyprus mobile app was developed to collect crowdsourced data from the residents in the Republic of Cyprus for defects in the road network and its surrounding infrastructure affecting the road safety. The mobile app was published by on September 27, 2022 with the motto "Fix today, prevent tomorrow". The mobile app is available for both Android[1] and iOS[2] devices. To use the app the users must first register and then they can submit reports highlighting infrastructure-related issues like damages, vandalism, and other risks to road safety. Each report should be accompanied by a photo, location, and optional comments. Once the report is submitted, it is automatically forwarded to the corresponding district office of the Public Works Department (PWD) based on the geographic location of the report. The PWD reviews all reports and assigns them to the appropriate authorities responsible for managing the problems recorded in each report, if they meet the terms and conditions of the application [15]. Authorities can then view and manage the report through a web portal and are

[1] https://play.google.com/store/apps/details?id=com.gnosis.crowdsource

[2] https://apps.apple.com/cy/app/fixcyprus/id1628319922

notified by email when a report is assigned to them. The mobile app user who reported an issue, is informed through the app for all the actions taken by the authorities.

System Architecture.

The FixCyprus system architecture consists of 4 functional elements (Figure 1):

1) The Identity and Access Management (IAM) component, which allows users to sign in with a single set of credentials to access either the mobile app or the web portal.
2) The Database Server, which consists of the user data and the application data. The application data are supportive data for the application and the web portal.
3) The Application Server, which communicates the data to the end-user via the interface of FixCyprus.
4) The graphical user Interfaces, that include the FixCyprus mobile app, the FixCyprus PWD Portal, and the FixCyprus Authority Portal.

Each Interface is described in the following sections.

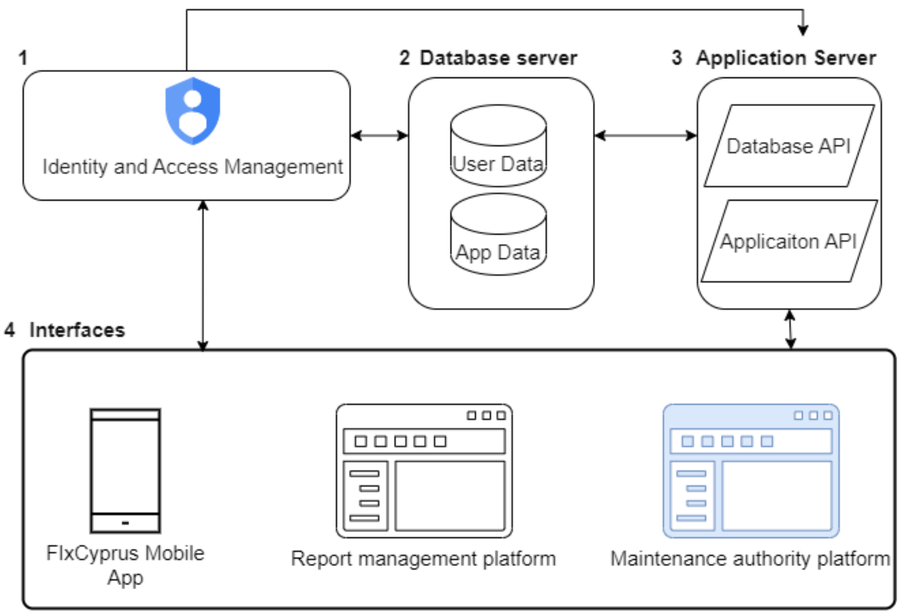


Figure 1 – FixCyprus System Architecture

Users

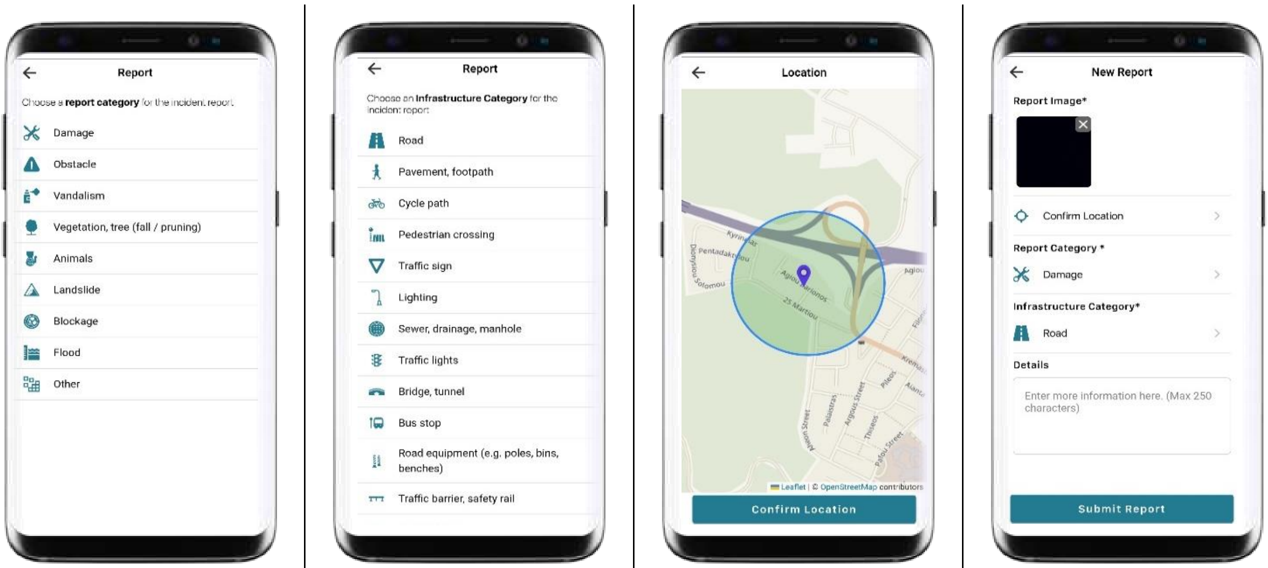
- Mobile app user: User who downloaded and registered to the FixCyprus Mobile app
- PWD reviewers: The reviewers are assigned engineers form PWD District offices and they can view reports that fall geographically within their district through the "Report management platform".
- The maintenance authority users: Assigned personnel form the respective maintenance authorities, who are responsible for monitoring the FixCyprus "Maintenance authority platform".

FixCyprus Mobile App

Through the mobile app, the users once they register can log in and use the app to take a picture of the reporting issue (Figure 2). At the time that the picture is taken, the location of the device is recorded along with its accuracy. In the next step, the users can select the category of the issue (Figure 3a) and then the infrastructure category (Figure 3b). The final step is to confirm the location taken, which is optional (Figure 3c), add some additional comments (optional) if they wish, and submit it (Figure 3d).

Log-in or register | New Report or view reports | Take a picture

Figure 2 – FixCyprus Mobile app – log-in and taking pictures



a) | b) | c) | d)

Figure 3 – FixCyprus Mobile app – submitting a report

The mobile app users may also view all the reports they have submitted and for each report they may be informed about its status. There are five status types, and each status can have different pre-defined messages to the user (Table 1). These messages could be selected by either the PWD reviewers or the authorities.

Table 1 – Status types and messages

Status Type	Definition	Messages
Received/ Under review	The report has been successfully submitted and it will be reviewed soon.	
Authority Notified	The report has been approved by the PWD and it was assigned to the maintenance authority responsible for the recorded issue.	Your report has been assigned to: (name of the maintenance authority)
Scheduled	The report has been reviewed by the maintenance authority and a maintenance work has been scheduled.	1) Your report has been recorded and will be handled soon. (For high priority reports) 2) Your report has been recorded and will be handled as part of the routine maintenance (For low priority reports)
Completed	An action has been taken. This action may be maintenance works or temporary works to ensure the infrastructure is safe. It could also mean that the authority has visited the location of the reported issue and it was identified that the infrastructure is safe, and no action are needed.	1) Your report has been completed 2) Actions have been taken to improve the infrastructure's safety. Further improvements will be made as part of routine maintenance 3) After an on-site inspection, no immediate action is required
Rejected	The report has been rejected for one of the reasons listed on the right.	1) The report is not relevant with the terms and conditions of the mobile app 2) The picture is not clear enough 3) The location has low accuracy (more than 50 meters) 4) The report has already been recorded and is handled by a maintenance authority

Report management platform

The report management platform, is a webpage from which the PWD reviewers, can access all the reports to review them. The reviewers, through the report management platform, can view a list of all the reports (Figure 4) and their details, consisting of: Report ID, date of the report, report category, infrastructure category, user's comments, photo, map with the location, and its accuracy.

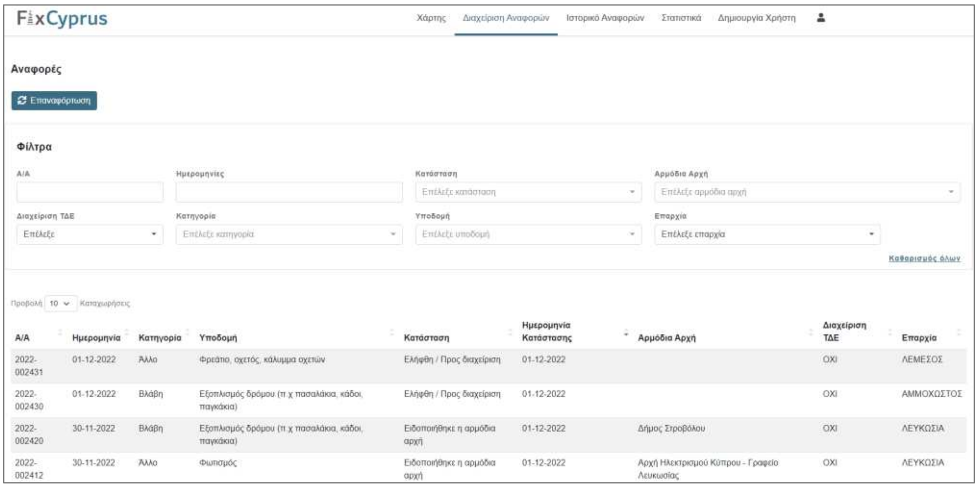


Figure 4 – FixCyprus Report management platform

Once the reviewers open a report, they can either reject or assign the report to a maintenance authority by changing the status of the report. In both cases the mobile app users will be able to view the status of their reports and be informed if their report was rejected or assigned to an authority. The reviewers may reject a report if the report is not relevant with the terms and conditions of the mobile app, if the picture is not clear enough, if the location has low accuracy (higher than 50m) and if the report has already been recorded.

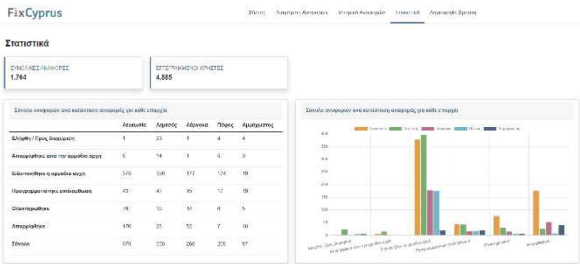
If the report is not subject to rejection, then the reviewer may assign the report to one of the 400 identified maintenance authorities. Maintenance authorities are categorized in the following categories:

- Utility companies (Electricity authorities, Telecom companies etc.)
- Governmental organizations (Water Development Departments, Police, Fire Brigade etc.)
- Road operators (Public Works Department, District Authorities, Local Authorities)

Once the reviewers, assign a report to one maintenance authority, they can add an internal comment to the maintenance authority as well as to add a priority for each report. There are three levels of priority, low, medium, and high. If a report is highlighted with a high priority, then the respective indication will be shown to the "maintenance authority platform" which is described in the next chapter. Once the reviewers, assign a report to an authority, then the respective authority receives an email notification.

Furthermore, the "Report management platform", has two additional functions. The first one is to visualise all the reports in one map, in which it is easy to identify areas with high concentration of reports (Figure 5a). The second one, is to view some statistics which can be used to assess the usage of the platform (Figure 5b).

a) FixCyprus map with spatial distribution of repots



b) FixCyprus statistics

Figure 5 – FixCyprus map and statistics

Maintenance authority platform

The “Maintenance authority platform” is similar to the “Report management platform”. The Maintenance authority users of this platform can see only reports assigned to their authority and review them, having two options: Either reject the report or arrange on the side inspection and maintenance works. The report can be rejected only in the case that a has been incorrectly assigned to them (e.g., the infrastructure recorded on the report is maintained by another maintenance authority). In the case that the report was correctly assigned to their authority, they can either fix directly what was reported, or plan a fix soon. In both cases, the maintenance authority is obligated to change the status of the report so the mobile app users who submitted the reports can be informed about the status of their report.

Results and Evaluation

For this chapter, the data collected during the period from 27th September until the 30th of November were analysed (Table 2).

Table 2 – Basic statistics reports statistics

Usage statistics	User usage statistics	Reports statistics
• Number of Registered users: **4.880** • Number of Reports:**1.734** • Number of users with at least one report: **641**	• Users with 1 report: **364** • Users with 2 to 5 reports: **223** • Users with 6 to 10 reports: **28** • Users with 11 to 19 reports: **20** • Users with more than 20 reports: **6**	• Reports related to the main road network: **430** • Reports related to the secondary road network: **986** • Other reports, duplicate and rejected reports: **318**

The acceptance of the FixCyprus mobile application by citizens is a crucial factor in the successful implementation of such a platform. The results and evaluation of the data collected during the 64-day period, considering that the population of Cyprus is 918.000 [16], show that there was a high level of engagement among citizens, with almost 5,000 registered users and 1,734 reports submitted. It is notable that around 37% of all registered users submitted a report and 57% of those users submitted just one report. 1% of users reported 14% of the total reports (total of 242 reports). It is also interesting that 986 reports were about the secondary road network and 430 about the main road network.

Regarding the spatial distribution of the reports, it was observed that the spatial distribution of the reports was directly linked to the residential population of each area in Cyprus.

The acceptance of the platform by employees is also important, as it enables them to efficiently and effectively manage and respond to the reports submitted by citizens. The results show that the majority of the reports were assigned to an authority, with only 1% remaining under review, indicating that the employees were able to effectively use the platform to process and respond to the reports. However, only 8% was marked as completed which needs to be monitored and coordinate with the authorities to understand if this number remains low. Furthermore, 13% were rejected, 4% marked as duplicate, 65% were assigned to an authority, 8% were scheduled. An example of completed report can be seen on Figure 7. The main reasons for the rejected reports are not clear photos (35%) and accuracy less than 50m (17%), while the rest were categorised as not relevant reports according to the terms and conditions of the app [15]. Regarding the 8% of the reports which were recorded as completed, 27% were related to road infrastructure, and 25% related to pavement walkways (sidewalks). An example of a report and after the maintenance operation can be seen on Figure 7.

Reported: 26/10/2022

Fixed: 11/11/2022

Figure 7 – Example of completed report

Conclusions

The purpose of this paper was to assess the potential of crowdsourced data for identifying and managing road safety hazards using the mobile app FixCyprus as an example. The authors conclude that citizen engagement government initiatives, such as FixCyprus, can create a valuable source of data. In this case, the crowdsourced data collected through the mobile app was effective in identifying and addressing road defects and had the potential to be used as a complementary source of data for identifying and managing road safety hazards. This complementary source of data can be more cost-effective compared to other sources for monitoring the quality of roads, such as Automatic Road Pavement Assessment vehicles [11], which have considerably higher cost. In addition, crowdsourced data can provide a more comprehensive and up-to-date view of transportation networks by filling in gaps in traditional data sources, such as regular inspections which might have a variety of frequencies, especially on roads with lower traffic. Overall, the use of crowdsourced data can provide a complementary, comprehensive, timely, and cost-effective representation of transportation networks, which can be used to improve the efficiency, sustainability, and safety of transportation systems.

Future Work

Future work on the FixCyprus application could include the implementation of automatic rejection of non-valid reports based on data collected, the automatic identification of duplicates based on location and reported data, the connection with the National Access Point to provide open data related to road infrastructure defects using the DATEX II format, and the inclusion of trust criteria on reports. These improvements could enhance the accuracy and reliability of the crowdsourced data collected through the FixCyprus app and make it easier for road authorities to use this data for infrastructure management and road safety. The connection with the National Access Point using DATEX II format (i.e., Damaged Road Surface [17]) could allow for the integration of FixCyprus data with other data sources, providing a more comprehensive view of transportation networks by facilitating the exchange of data with other transportation systems and agencies. Overall, these improvements could help to further the potential of crowdsourced data as an alternative source of data for Intelligent Transport Systems (ITS) and Digital Twins and the effective monitoring and management of transportation networks.

Acknowledgements

This research was funded by the Public Works Department (PWD) of Cyprus through a research collaboration with the University of Cyprus and the KIOS Research and Innovation Centre of Excellence (KIOS CoE). The work was partially supported by the European Union’s Horizon 2020 research and innovation program under grant agreement No 739551 (KIOS CoE) and by the Republic of Cyprus through the Deputy Ministry of Research, Innovation, and Digital Policy. The authors would like to express their gratitude to all PWD employees for their assistance, comments, and suggestions during the design, implementation, and testing of the FixCyprus platform. The authors also acknowledge the contribution of S. Kassinopoulou, S. Charalambous, A. Abed, M. Constantinou, P. Isaia, S. Nicolaou, M. Papageorgiou, C. Laoudias and K. Meli to the development of FixCyprus.

References

1. European Commission (2022). Delivering the European Green Deal.
2. Zhao C, Wang K, Dong X, Dong K (2022). Is smart transportation associated with reduced carbon emissions? The case of China. Energy Econ vol.August 2021 pp. 105715
3. Ayoub J, Wang Z, Li M, Guo H, Sherony R, et al. (2022). Cause-and-Effect Analysis of ADAS: A Comparison Study between Literature Review and Complaint Data. Main Proc - 14th Int ACM Conf Automot User Interfaces Interact Veh Appl AutomotiveUI 2022 pp. 139-149

4. Saleem M, Abbas S, Ghazal TM, Adnan Khan M, Sahawneh N, et al. (2022). Smart cities: Fusion-based intelligent traffic congestion control system for vehicular networks using machine learning techniques. Egypt Informatics J vol.3 pp. 417-426

5. Yannis G, Chaziris A (2022). Transport System and Infrastructure. Transp Res Procedia vol.2021 pp. 6-11

6. Rudskoy A, Ilin I, Prokhorov A (2021). Digital Twins in the Intelligent Transport Systems. Transp Res Procedia vol.2020 pp. 927-935

7. Bao L, Wang Q, Jiang Y (2021). Review of Digital twin for intelligent transportation system. Proc - 2021 Int Conf Inf Control Electr Eng Rail Transit, ICEERT 2021 pp. 309-315

8. Vidya VM, Deepa N (2019). Big data analytics in intelligent transportation systems using hadoop. Int J Recent Technol Eng vol.6 pp. 75-80

9. Zhang Z (2020). TRACE : Tennessee Research and Creative Exchange Exploring the Potentials of Using Crowdsourced Waze Data in Traffic Management : Characteristics and Reliability.

10. Attard M, Haklay M, Capineri C (2016). The potential of volunteered geographic information (VGI) in future transport systems. Urban Plan vol.4 pp. 6-19

11. Luo X, Gong H, Tao J, Wang F, Minifie J, et al. (2022). Improving Data Quality of Automated Pavement Condition Data Collection: Summary of State of the Practices of Transportation Agencies and Views of Professionals. J Transp Eng Part B Pavements vol.3 pp. 04022042

12. European Commission (2010). DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport. Off J Eur Union pp. 1-13

13. Christou G, Georgiou A, Christodoulou E, Shahzad M, Savva A (2022). An Integrated Geographic Information System for Intelligent Transport System for the Road Network of Cyprus. In: *ITS Europe 2022*.; 2022:1-9.

14. Christou G, Georgiou A, Christodoulou E, Tziakouri M, Christodoulou C, et al. (2021). Design and development of a GIS-based platform using open-source components for monitoring, maintenance and management of road network: The case study of Cyprus. Int Arch Photogramm Remote Sens Spat Inf Sci - ISPRS Arch vol.4/W2-2021 pp. 37-42

15. FixCyprus FixCyprus Terms of use. https://fixcyprus.cy/mcw/en/terms/

16. Cyprus Statistical Service Statistics about the population living in Cyprus. https://www.cystat.gov.cy/en/SubthemeStatistics?id=46

17. DATEX II (2022). Enumerations values DATEX II. https://www.datex2.eu/datex-model/DataDictionary_20-RC2/valeurs.htm