FixCyprus: Crowdsourcing Smartphone Imagery Data For Managing Road Safety Hazards

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Abstract—**In this demonstration paper, we present FixCyprus, which is a cost-effective crowdsourcing service for road transportation authorities in Cyprus to gather information and manage defects and incidents on the road network and surrounding infrastructure (e.g., pavements, lighting, drinking water pipes, etc.). The production service, which includes a lightweight and user-friendly mobile application for sharing image-annotated incident reports, is already operating nationwide for six months providing significant budget savings by reducing field inspections and the use of expensive equipment. We will demonstrate FixCyprus using two modes: i) Interactive mode, where attendees will be able to create and submit their own dummy incident reports and see the end-to-end processing flow in a test environment and ii) Trace-driven mode, where attendees will be able to visualize a large number of synthetic reports, see the workload for manually managing them, and explore enhancements that are underway for automating some of the underlying tasks using machine learning.**

Index Terms—**Crowdsourcing, road safety, mobile application**

I. Introduction

Road authorities face increasing challenges in managing traffic and infrastructure to provide advanced services to the citizens and meet the goal to make transportation greener, smarter and more sustainable [1]. This goal is tightly coupled with the reduction of carbon emissions and the improvement of road safety; however, the deteriorating condition of roads and pavements including structural defects can have a detrimental impact on both the safety and comfort of road users, as well as on the functioning of vehicles [2]. It is therefore essential that cities monitor and manage transport infrastructure for road defects and other issues. Typically, this is done by regular field inspections, while some road authorities have introduced road and pavement condition data collection using vehicles equipped with sensors to identify defects [3].

Nevertheless, these methods tend to be expensive, have low speed in collecting data, and are generally employed solely on the primary road network [3]. Thus, several authorities and social initiatives have introduced crowdsourcing methods to collect data for road defects such as *FixMyStreet*, *Street Bump*, and *Streets Wiki* [4]. However, none of these efforts has been launched by the government, nor has country level coverage [4]. In addition, they do not consider defects and damages to infrastructures that are closely related to the road network, e.g., lighting, drinking water pipes, sewage and drainage, etc.

The Ministry of Transport, Communications and Works (MTCW) in Cyprus, in its efforts to provide a smarter and safer road network to citizens, is closely collaborating with the KIOS Research and Innovation Center of Excellence (KIOS CoE) at the University of Cyprus on several Intelligent Transportation Systems (ITS) initiatives [5]. These initiatives rely on multi-source input data to accurately represent the road network. Recently, a new source was added, i.e., user-generated reports amended with imagery data crowdsourced through a mobile application as part of the FixCyprus service that was introduced in our previous work [6].

By the end of March 2023 (i.e., 6 months after public release) the service had more than 6K registered users and nearly 1K users (i.e., around 16% of all registered users) had reported at least one (unique) defect/issue. In addition, based on the FixCyprus statistics[1] (in Greek), more than 3K reports have been submitted (the vast majority concerning defects on roads and pavements) with ∼12% of them completed and ∼70% of them scheduled.

In this demonstration paper, we discuss a number of ongoing research activities to enhance the original FixCyprus service for automating some of the intrinsic tasks that are traditionally time consuming and cumbersome for human operators (e.g., identifying duplicate reports, confirming the type of defect/issue and associated infrastructure from the images, etc.). In addition, we describe the plan for demonstrating the end-to-end FixCyprus service and providing an engaging experience to the conference attendees.

II. The FixCyprus Service

A. Overview & System Architecture

The FixCyprus service aims at gathering information from citizens that live in the Republic of Cyprus about any defects or issues present in the roadway and surrounding infrastructure that may jeopardize road safety. The service was launched on September 27th, 2022, with the slogan "Fix today, prevent tomorrow". In a nutshell, citizens may use

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[1]FixCyprus statistics, https://www.fixcyprus.cy/mcw/el/open/stats/

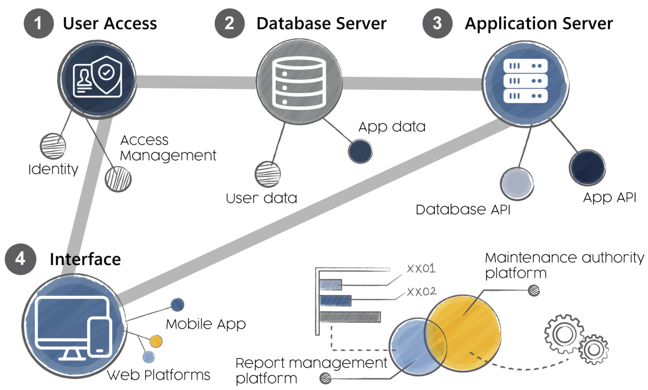


Fig. 1. System architecture of the FixCyprus service and ecosystem.

a mobile application that is available on both Android and iOS devices to easily report infrastructure-related issues such as damages, vandalism, and other road safety hazards. Each report includes by default a photo and the location of the issues. Reports are then automatically forwarded based on their geographic location to the relevant district office of the Public Works Department (PWD) at the MTCW. The reports are then evaluated and assigned to the relevant maintenance authorities to take action, provided they adhere to the application's terms and conditions[2], while the user remains in the loop through the status of his/her report that is updated within the mobile application to reflect the progress. The end-to-end operation of the FixCyprus service is demonstrated in a video[3] (in Greek).

The FixCyprus architecture has four main components, as shown in Figure 1.

1) **User Access (UA):** The authentication service that provides identity and access management ensuring that the right users have access to the appropriate functionalities.
2) **Database Server (DS):** The server that runs the FixCyprus Database and consists of the user data and application data.
3) **Application Server (AS):** The server that hosts the software to deliver all FixCyprus functionalities and communication with the DS and the relevant interfaces
4) **Graphical User Interface (GUI):** The user interface of the FixCyprus service that consists of three different views, namely i) the mobile application, b) the PWD Portal, and c) the Authority Portals.

The FixCyprus ecosystem includes two additional elements, i.e., the platform for managing the reports (accessed through the PWD Portal) and the platforms of individual maintenance authorities to view and accept the assigned reports (accessed through the respective Authority Portals).

B. FixCyprus Mobile Application

The GUI of the FixCyprus mobile application is user-friendly and straightforward, as shown in Fig. 2. The application may be used after registration through Google/Apple account or using a personal email address. Once the users are logged-in, they can either start creating a report for a new incident/issue (Fig. 2a, left) or browse previously submitted reports in the history view (Fig. 2a, right). Choosing to create a new report, the user starts by taking a picture of the identified issue within the application (Fig. 2b) that is automatically geo-tagged together with the location accuracy, he/she can select the category of the incident (Fig. 2c), e.g., damage, obstacle, vandalism, etc., and then mark the associated infrastructure from the categories shown in Fig. 2d, e.g., road, pavement, cycle path, etc. Subsequently, the user is asked to confirm the location and there is the option to manually correct the location of the incident (within a fixed range to avoid abuse), as shown in Fig. 2e. Finally, the user can add some details/comments before submitting the report (Fig. 2f), which will be reviewed and handled by PWD officers; see Section II-C.

Navigating back to the home screen (Fig. 2a), the user can switch to the report history screen to scroll through his/her past reports and quickly check the *status* of each report, as shown in Fig. 2g. The status of a report can be i) pending, ii) authority notified, iii) scheduled, iv) completed, or v) rejected (due to various reasons described in Section II-C) . Clicking on a specific report displays the corresponding details (Fig. 2h).

C. Report Management Platform

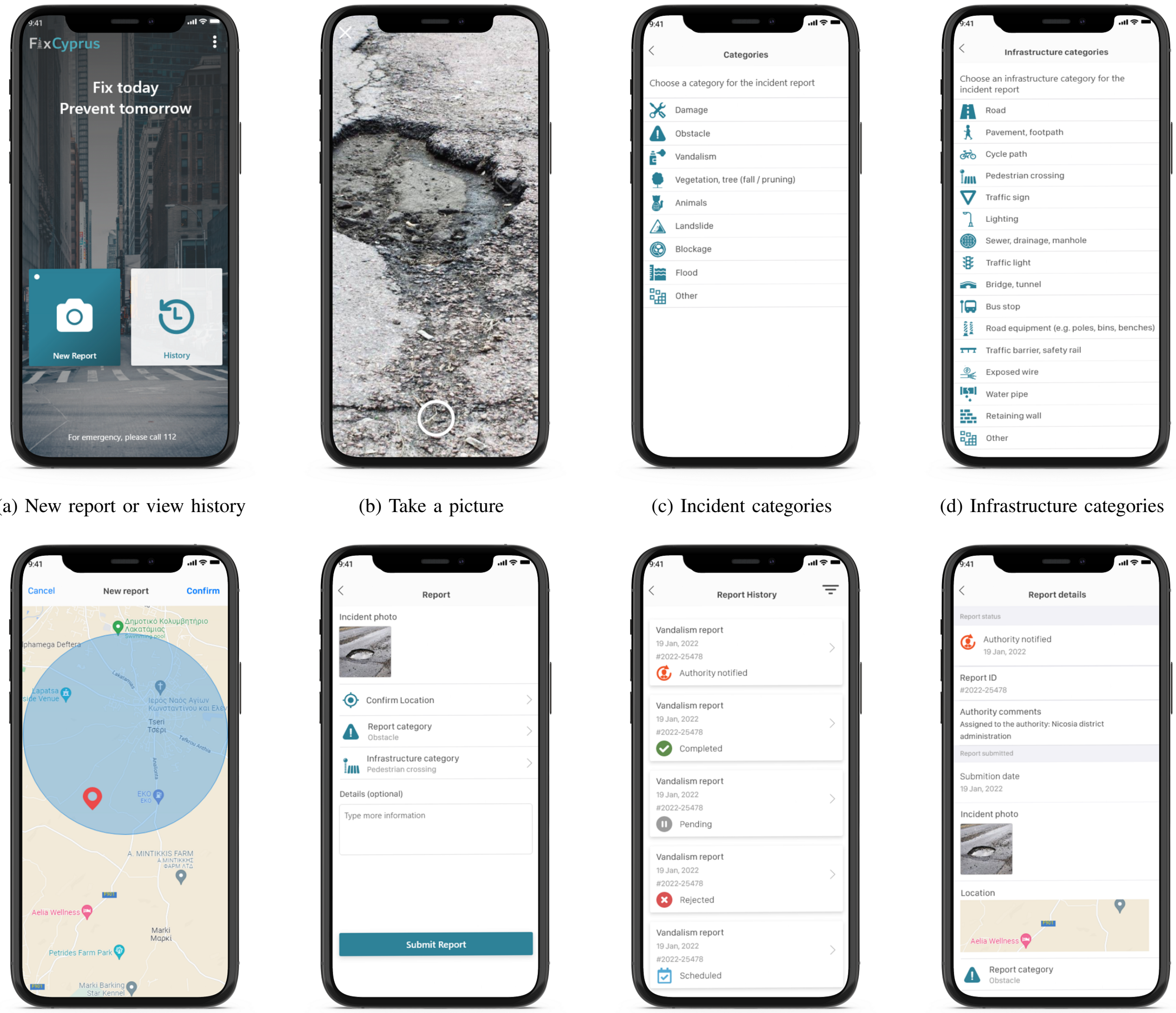
The *Report Management Platform (RMP)* enables PWD officers to access the submitted reports. The database view provides the basic information including the report ID, submission date, incident and infrastructure categories, current status, and relevant maintenance authority. The PWD reviewers can easily search through the reports using various filters, which are transparently translated to relevant database queries, and can then select a report to either reject it or assign it to one of the 400 maintenance authorities linked to FixCyprus. Updating the report status is automatically reflected within a user's application, as described in Section II-B. The reviewers can conveniently visualize all reports and associated details (e.g., incident picture, user comments, location and accuracy level) on a dynamic map in the PWD Portal including clustering of reports upon zoom in/out, as shown in Fig. 3.

A report may be rejected because it is outside the terms and conditions of the service (e.g., a vehicle blocking the entrance of a building), the picture is of low quality, the location error is more than 50 meters, or a report for the same incident was submitted by another user. Once the reviewers assign a report to an authority, then the respective authority receives an email notification and can process it within their dedicated platform (see Section II-D). The review process is an extremely time-consuming task, thus enhancements to FixCyprus are underway in collaboration with PWD officers to automate some of the steps, as discussed in Section II-E.

D. Maintenance Authority Platform

The *Maintenance Authority Platform (MAP)* works similarly with the RMP enabling the users of an individual maintenance

[2]FixCyprus Terms of Use, https://fixcyprus.cy/mcw/en/terms/
[3]FixCyprus video, https://bit.ly/40pC37W



(a) New report or view history (b) Take a picture (c) Incident categories (d) Infrastructure categories

(e) Confirm location (f) Submit report (g) Reports history (h) Details of a submitted report

Fig. 2. The user interface of the FixCyprus mobile application.

authority to access and view through the respective Authority Portal only those reports that have been assigned to them. In the following, they can review them to either reject the report or schedule an on-site inspection and maintenance work. For instance, a report can be rejected if it has been incorrectly assigned to a specific authority (i.e., the infrastructure referenced in the report is maintained by another authority) and in this case it will appear back to the RMP for re-evaluation. If the report has been correctly assigned, the authority may either fix the issue directly or plan a maintenance in the near future. In both scenarios, the maintenance authority must update the report's status to trigger the status change within the mobile application of the user who submitted the report.

E. Task Automation With Machine Learning

During processing the crowdsourced data in the submitted reports, a large volume of *labelled* images is produced. That is, human experts at the PWD and the maintenance authorities are correcting the incident and infrastructure categories, if needed, as part of the report management process. Such high-quality imagery data can be used to train Machine Learning (ML) algorithms to (semi-)automate some of the underlying tasks, thus reducing turn-around time and consequently increasing citizen satisfaction. For instance, a user might upload a blurry image with his/her report, which should be rejected by default; yet, it adds up to the overall processing time and introduces unnecessary delays in servicing valid reports. Also, duplicate reports decrease efficiency, e.g., reports by different users having nearby locations and/or images taken from different angles or light conditions. These could be automatically rejected to save valuable time. Moreover, in some reports the users might select the wrong incident and/or infrastructure category leading to extra time for reviewing, correcting, and assigning to the

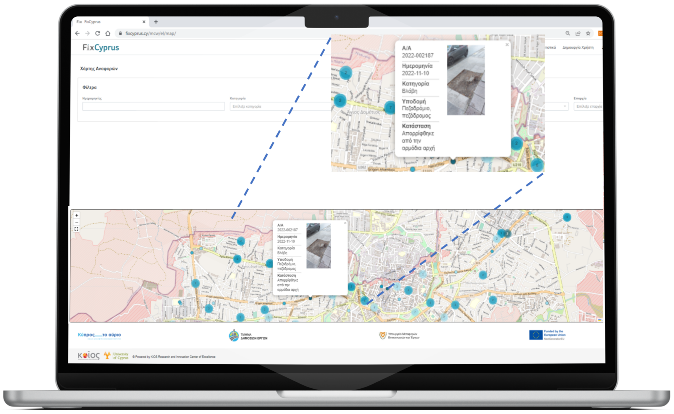


Fig. 3. FixCyprus Report Management Platform.

proper maintenance authority.

In all aforementioned scenarios, officers at the PWD and maintenance authorities would greatly benefit from the use of ML in the processing pipeline. In particular, as part of the continuous development of the FixCyprus service, the use of out-of-the box ML tools, that are properly trained and parameterized is underway to automate the following tasks:

- identification of duplicate reports based on similar location data and resemblance in the uploaded pictures
- rejection of invalid reports based on the shared data
- validation of the incident and/or infrastructure category and automatic correction, if needed, with immediate forwarding to the proper maintenance authority.

We also plan to explore ML tools to analyze data and identify hidden patterns and correlations in the reported data (e.g., road segments that are prone to various defects and issues) to make forecasts and recommendations towards predictive maintenance of the road network and associated infrastructures.

III. Demonstration Scenario

During the demonstration, the attendees will be able to have a hands-on experience with the FixCyprus mobile application and see the data flow in the end-to-end service.

Demo Artifact: The FixCyprus backend services are built upon open-source technologies, i.e., the Django Rest Framework for developing the web portal and mobile API. Data storage is based on PostgreSQL using PostGIS for geospatial data and pgcrypto for sensitive data encryption. Asynchronous functionality is handled through a combination of Celery and Redis. The platform frontend is developed using the Angular web application framework, while the Ionic framework was used for the development of the FixCyprus mobile application that is available on Google Play Store[4] and Apple App Store[5].

Demo Plan: For the demo, we will bring and deploy a few smartphones running the FixCyprus mobile application, one laptop, two screens for displaying separately the PWD Portal and the Authority Portal, and use the local Wi-Fi network in the venue to connect to the RMP and MAP, respectively. To attract interest and engage several attendees in parallel, we will carry out our demonstration in 2 modes, namely *Interactive* and *Trace-driven*. The Interactive mode will run on a *test environment* that does not interfere with the production system and participants will have the opportunity to take one of the 3 key roles in the FixCyprus service, namely *Citizen*, *Report Manager*, and *Authority Personnel*. Citizens will carry our FixCyprus-ready smartphones and move freely outside to create and submit a few dummy reports with real data. Starting with an empty Database, the Report Managers will be able to view and handle the reports and assign them to a specific maintenance authority or reject, while the Authority Personnel can accept the assignments and update their status or reject a couple of them. Throughout the demo, the participants will observe in real time the effect of different actions, e.g., Citizens will see the updated status of their reports after the actions of the Report Managers and the Authority Personnel.

In the Trace-driven mode, another instance of the Database will be populated with several synthetic reports based on incidents reported in Cyprus. In this case, the attendees will have the opportunity to experience the workload for manually handling the reports and appreciate the benefits of ML to (semi-)automate the management and assignment process through representative examples shared by the demo team.

[4]FixCyprus application on Google Play Store, http://bit.ly/3z6vv2d
[5]FixCyprus application on Apple App Store, http://bit.ly/40f1Obl

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