A smartphone-cloud application as an aid for street safety inventory

A Digest Paper

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***Abstract*— Potholes, debris, sunken manhole covers and others are common street safety hazards drivers experience daily as they "bump" into them unexpectedly while driving. The repair and maintenance process by municipals is an ongoing effort that requires periodic streets inventory to guarantees safety. Unless someone reports the location of a street problem, such process cannot take place. This paper presents a simple, yet an effective technique to aid in reporting such street hazards automatically using a smartphone application. The smartphone's accelerometer is used to detect bumps during driving and report the data and location to cloud service. The cloud application utilizes an artificial neural network that is trained to differentiate between a "shock" resulting from normal driving maneuvers from those possibly resulting from road problem. It also analyzes the location and based on the frequency of reporting a certain "shock" data from the same geographical location it reports a street hazard location. The city's municipal can then take the suitable actions for inspection and repairs. Promising results were obtained by using a preliminary test implementation indicating the effectiveness of the proposed technique.**

Keywords—road safety; street hazards; smartphone; cloud, neural network

I. Introduction

Road repairs represent one of the challenging problems to many city municipals. Potholes, debris and sunken manhole covers are some of the common road problems that represent safety risks and also source of complaints by drivers. Although most city municipals preform periodic inspection to locate such road problems and initiate repairs, this process would usually take a considerable amount of time unless these problems are reported quickly. Drivers experience such road problems daily as they "bump" into them unexpectedly during driving. Taking the initiative to report such road problems is an effort. Many municipals started to offer an online service to report these problems. The "Fix My Street" is a popular example of such service in many European countries[1]. However, the delay in reporting these issues, the provision of an estimated location and the kind of general description of the problem renders such reporting technique somewhat limited in terms of effectiveness in initiating repairs quickly.

Many location-aware smartphone applications have emerged recently utilizing the integrated GPS receiver [1, 2]. With the provision of fast mobile Internet access, real-time communication became possible [3]. This has even encouraged building more daring smartphone applications such as monitoring & emergency reporting for the elderly [4]. In this digest paper the authors propose a technique to aid in reporting such road problems automatically using a smartphone application. The application utilizes the phone's accelerometer to detect the "shocks" resultant from driving over such road problems. The application encodes the obtained data along with the location and sends to a data-collection cloud service. The cloud service utilizes an artificial neural network (ANN) that is trained to differentiate the "shocks" resulting from road problems and those resulting from driving maneuvers.

The rest of this paper is organized as follows: section 2 presents some background info, section 3 presents the proposed technique and finally section 4 presents the early testing and results.

II. Background

Smartphones have became very popular within the last couple of years owing to their decreasing prices. It is estimated that 95% of the world population are now mobile phone subscribers [2]. Based on an IDG technology report, the sales of such devices is estimate to be around 1.2 billion with 770 million of those having location/GPS hardware [5]. Coupled with accurate geospatial information, this location technology promotes developmental planning in many countries including services like public safety [1, 5]. In addition, such technology also enabled the studying of human mobility patterns [2].

Cloud computing on the other hand, has introduced new resource availability without the management burden [6]. This encouraged the utilization of this new computing paradigm in business and the industry [7]. With the technologies offered on the client side represented by smartphones, smartphone-cloud applications are destined to becoming a trend [6].

[1] Example URLs:
UK: http://www.fixmystreet.com
Sweden: http://www.fixamingata.se
Belgium: http://fixmystreet.irisnet.be/fr/

978-1-4799-4106-3/14/$31.00 © 2014 IEEE

III. Proposed Technique

Smartphones could be equipped with many types of sensors. Motion sensors measure acceleration forces and rotational forces along three axes. The “shock” resultant from driving over a road problem, unexpectedly, is detected by the device and the “shock” wave pattern is stored. With the availability of location hardware, the pattern along with positional information is sent to a cloud service to analyze and record. If the frequency of reporting a certain location increases then this indicates the probability of a street safety hazard. The location is then reported to the responsible municipal department. Figure (1) shows the workings of the proposed technique.

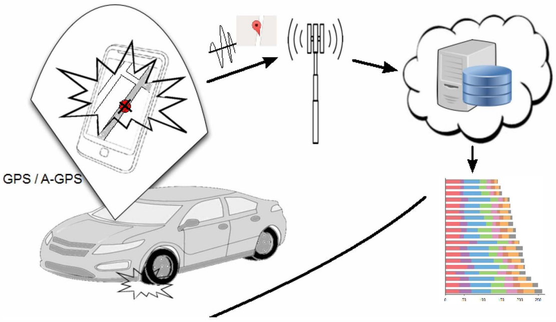

Fig. 1. Resultant shock data & current location trasferred by the smartphone to the cloud service.

A. *Client Smartphone Application*

The smartphone application is written as a light background service that must be installed on the driver’s smartphone. A mobile Internet connection is required to access location services, such as Google Maps, and send data. During driving, the application will detect relatively rough motion changes, i.e. shocks, and encode them into a digital pattern. Using the location hardware available (GPS along with A-GPS), the location of the incident is recorded and a data package is prepared for sending to the cloud data-collection software. The application does not require any user intervention other than enabling data and location services on the device.

B. *Clould Data-Collection Software*

The cloud application was written as software as a service (SAAS) anticipating that many municipalities would be interested in using it. The software receives the data packages sent by different participating drivers and analyzes the digital patterns received. With the help of a dedicated trained artificial neural network, the software can differentiate between shock waves resultant from driving maneuvers and those resulting from road problems. The service processes and accumulates shock patterns coming from different participating clients monitoring the frequency of reporting a certain geographic location. After a certain threshold value, this is interpreted as a possible road problem and that location is reported.

IV. Eaerly Testing & Results

In building the SAAS, the received “shock” pattern data must be analyzed by using pattern recognition techniques. To obtain the initial ANN training data, the phone was placed on the car’s dashboard using non-slipping mat and data were recorded by driving over actual road potholes and other problems with different speed considerations. 70% of the patterns were used for training and the rest for testing. Generally, the detection performance of the ANN was acceptable with a success rate of over 61%. However, it is believed that this could be improved.

An Android client application was written and installed directly on the smartphones using development mode. Testing involved several types of road problems and was performed by volunteering drivers. During testing the phones were connected to the car’s charger since such application might exhaust the battery. Different smartphone brands were used in testing and it was discovered that the quality of the encoded “shock” pattern data is affected to a certain extent by the quality of the smartphone’s accelerometer installed on the device. The degree of sensitivity of these sensors is not the same and this might impose certain coding variations to suit different smartphones. The implementation also suffered from an issue related to GPS / A-GPS availability in certain areas. Such problem was reported in other works and the authors are currently implementing a remedy similar to that used in [3].

Early results are promising indicating the potential of this application as an aid for street safety inventory. The authors aim to publish more detailed results once the work is complete.

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