IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 5, May 2016

Road Quality & Valley Complexity Analysis Using Android Application

Prof. P. S. Toke[1], Shweta Maheshwari[2], Aishwarya Asawale[2], Aishwarya Dhamale[2], Nigel Paul[2]

Asst. Professor, Computer Engineering Dept, Padmabhooshan Vasantdada Patil Institute of Technology, Pune, India[1]

Bachelors in Engineering, Computer Engg, Padmabhooshan Vasantdada Patil Institute of Technology, Pune, India[2]

Abstract: With the growing speed of technological advancement, Smartphones have become the essential components of our daily performance. Smart phone offers advanced technologies with functionality similar as a personal computer. There are advanced features in smartphones such as internet, GPS and also built-in sensors such as magnetometer, accelerometers which are very typical. In this study, we have created a successful android application, to monitor road surface and complexity of valleys which is accepted by wide user community. The goal is to minimize and manage current accidents on roads with the help of a user-friendly interface. To this purpose, the model formulation for the application includes a three-tiered architecture encompassing: i) a mobile application at user level that processes raw data from the embedded accelerometers and transmits the result of the computation (i.e. a roughness index) together with geographic localization data from GPS to a server; ii) a back-end server running a geographic information system where geo-referenced data are properly aggregated, organized and stored; iii) a graphical front-end based on a cloud platform service for visualization.

Keywords: Road Maintenance; Accelerometer; Road Roughness Condition; GPS; Magnetometer.

I. INTRODUCTION

With shrinking maintenance budgets and the need to 'do more with less,' the needs for accurate, robust road maintenance tools are greatly needed for the transportation engineering community. A mobile phone-based approach to traffic monitoring is a good match for developing regions because it avoids the need for expensive and specialized traffic monitoring infrastructure. It also avoids dependence on advanced vehicle features such the Controller Area Network (CAN) bus that are absent in the many low-cost vehicles that are commonplace in developing regions (e.g., the 3-wheeled auto rickshaws in India).

Road maintenance is essential in order to (1) preserve the road in its originally constructed condition, (2) protect adjacent resources and user safety, and (3) provide efficient, convenient travel along the route. Unfortunately, maintenance is often neglected or improperly performed resulting in rapid deterioration of the road and eventual failure from both climatic and vehicle use impacts. It follows that it is impossible to build and use a road that requires no maintenance.

Road accidents are undoubtedly the most frequent and, overall, the cause of the most damage. The reasons for this are the extremely dense road traffic and the relatively great freedom of movement given to drivers. Accidents involving heavy goods vehicles (especially coaches and lorries with trailers) occur all too frequently despite calls for responsible behavior, for respect of the loading regulations and the highway code, as well as the obligation for drivers to adapt their speed, which affects stopping distances, to the traffic and weather conditions (rain, ice, fog, etc).

Poorly maintained roadways cause accidents in a variety of ways, mostly due to the fact that they create an enormous hazard to drivers. In many instances, a driver may attempt to avoid a certain situation, like a pothole or pooling water which could cause a serious accident.

Modern smartphones have built-in, 3-axis accelerometers and global positioning systems, which were investigated in this study as an efficient means for collecting and mapping vehicle vertical acceleration data and estimated pavement roughness (IRI).

The monitoring of road surface anomalies, such as potholes, speed bumps etc., has a great importance in order to ensure safety and comfort for all road users, from pedestrian to drivers. The constant mapping of real road conditions also allows adequate infrastructure's maintenance and management operations, together with a consistent allocation of resources. For this reason, informing road users on infrastructure quality and getting information from the same users have become the new frontier of mobile devices applications for driving assistance and navigation (such as a specific social network for safety road). In the light of the above and thanks to the results obtained from previous studies, this paper focuses on the development of a useful automated sensing system for the monitoring of road surface quality.

II. RELATED WORK

The most basic approach to road damage detection was to use human reports to central authorities. While it had the highest accuracy, assuming that people were fair, it also had the most human interaction and was not comprehensive. Then statistical analysis was used to

DOI 10.17148/IJARCCE.2016.55181

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 5, May 2016

estimate damage probabilities of road segments based on their usage intensity. Unfortunately, the technology used expensive equipment and therefore limits its accessibility.
With the increasing difficulties a simplest method to collect photos of road damage and hazards taken by the participants and to upload them to a central server. However, this requires strong participation and interaction from the users as well as manual image analysis.
The major systems developed previously are:
1) BusNet system developed at University of Colombo is using Crossbow MICAz motes and several sensor boards including accelerometer and GPS as hardware platform. This system does not have the functionality for real time data processing.
2) Pothole Patrol system developed at Massachusetts Institute of Technology is using a specific hardware/software platform – Linux. Their pothole detection algorithm is based on simple machine-learning approach using X and Z axis acceleration and the vehicle velocity data as input.
3) Nericell and TrafficSense systems developed at Microsoft Research India are using Windows Mobile OS powered smart-phones as hardware/software platform with an array of external sensors such as accelerometers and GPS.
A bump recorder named application developed in Japan, which gives the details of the bumps recorded during the traversal. At first, for the first generation Bump Recorder which uses three-dimensional accelerometer and GPS, road bump detection logic and the experiment result are explained. Next, for the second generation Bump Recorder which also uses gyro sensor, effect of gyro sensor is explained.

In the first generation Bump Recorder Fujino et al (2005) reported that between IRI -International Roughness Index- and RMS -Root Mean Square- of vertical acceleration at one second recording data has a correlation. In the beginning of Bump Recorder development, this principle was tried. Experiment condition is as follows. For GPS positioning, a smart phone should be placed straight so that sensors can be caliberated. Therefore a smart phone is put on a vehicle dashboard in front of a passenger’s seat. In this experiment, any mounting equipment is not used, just a thin rubber sheet for anti slipping is used.
The X-axis of accelerometer is width direction, Y-axis is running direction, Z-axis is vertical direction. Recording cycle is 100[Hz]. It means that, when the vehicle is driven at 60[km/h], travel distance is 0.17[m] at one recording cycle. GPS recording cycle is about every 1[sec]. For emulating a bump step, a round wooden rod which has 24[mm] diameter and 900[mm] long, is put on an asphalt road. And the vehicle goes over this rod, and the tyre of passenger side is climbing over this rod. Vehicle speed is 30[km/h]. Here driver felt the bump beneath but not as intense which could cause a danger. It means that this bump step is not so large. In this experiment, TOYOTA PRIUS is used. That has 2700[mm] wheelbase, 4460[mm] long, 1520[mm] tread width, 1490[mm] height, 1350[kg] weight. The vehicle is running clockwise 5 laps at square course which has 620[m] long for one lap.

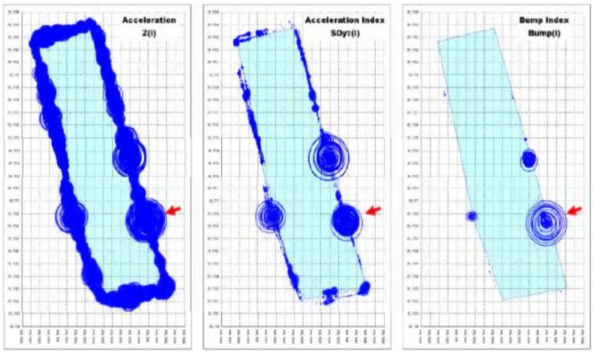

Fig 1: Standard deviation of vertical acceleration

Experimental result is drawn on the map. 1[sec] standard deviation of Z-axis acceleration which is vertical direction is drawn with circle diameter. A round wooden rod is located at arrowed position on right bottom side of Fig.1 part-1, but it is difficult to find a bump step form this figure. 50[ms] standard deviation of Z-axis acceleration or vertical direction SDz(i) is drawn in Fig.1 part-1. Simultaneity index SDyz(i) is drawn in Fig.1 part-2. Bump index Byz(i) is drawn in Fig.1 part-3

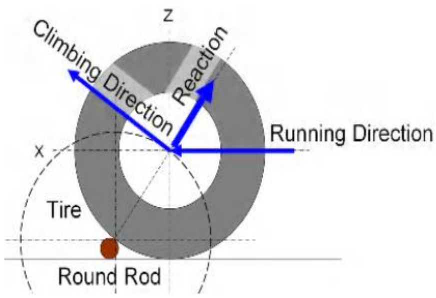

Fig 2: Schematic View when the Wheel climbs over the Round Rod

III.EXPERMENT

A. Smart Phone Capabilities
A smart phone may include any or all of the following capabilities of relevance:

• Computing:
- CPU, operating system, and storage that provides a programmable computing platform.

• Communication:
– Cellular: radio for basic cellular voice communication (e.g., GSM), available in all phones.
– Cellular data: e.g., GPRS, EDGE, UMTS, provided by the cellular radio.
– Local-area wireless: radios for local-area wireless communication (e.g., Bluetooth, Wi-Fi).

• Sensing:
– Audio: microphone.
– Localization: GPS receiver.
– Motion: accelerometer sometimes included for functions such as gesture recognition.
– Visual: camera

These capabilities are not only within the realm of engineering possibility, but in fact there exist smartphones on the market that include most or all of the above capabilities in a single package.

B. An Approach Using Acceleration Sensors

There are some studies of detecting road bumps using acceleration sensors. This Method uses three-axis acceleration sensors and a GPS sensor embedded in a vehicle. Methods involve placing a smart phone on the dashboard of a car, and can detect road bumps only during driving. The IRI (International Roughness Index), an index of flatness of road surfaces, has a relationship with the RMS (Root Mean Square) of the vertical component of acceleration values. Therefore, the study proposes a method for estimating the height and length of bumps using acceleration sensors. This method estimates the amount of vertical displacement using the double integral of the vertical component of acceleration values, and defines it as the height of a bump. In addition, this method estimates distance travelled forward using a GPS sensor, and defines it as the length of a bump.

C. An Overview of the Proposed System

There In this study, our method gathers driving log data by using the sensors of smartphones, and estimates road surface conditions using only the gathered log data. Moreover, the method manages the estimated results in a database, and detects changes in road surface conditions by comparing the latest estimation with past estimations. Smartphones are often used on a car dashboard because it has features such as audio and navigation applications. Therefore, smartphones can reduce the burden for drivers when we gather driving log data. In addition, sensors embedded in smartphones can robustly gather driving log data because they can be used in all weathers and at all times. This study aims to estimate road surface conditions and to detect changes in road surface conditions by using driving log data gathered by smartphones.

The proposed system consists of two stages: gathering log data and estimating road surface conditions. First, the system gathers the vertical components of acceleration values, location information, dates and time stamps by using the acceleration sensor and GPS sensor of a smartphone. Next, the system generates a log data file, and stores log data in the database.

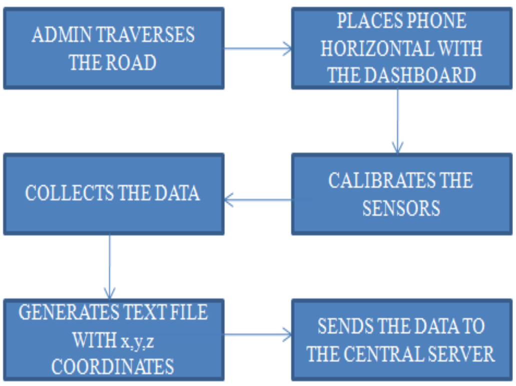

Fig 3: Admin Panel of the application

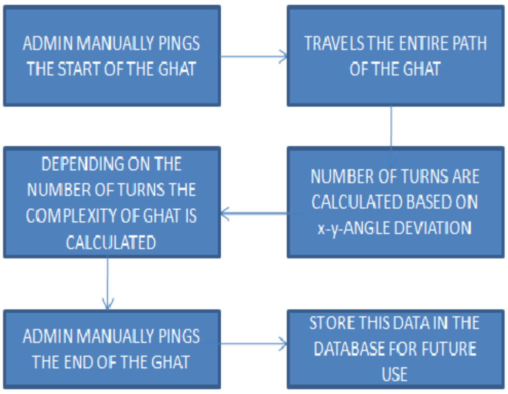

Fig 4:Admin Server Panel of the application

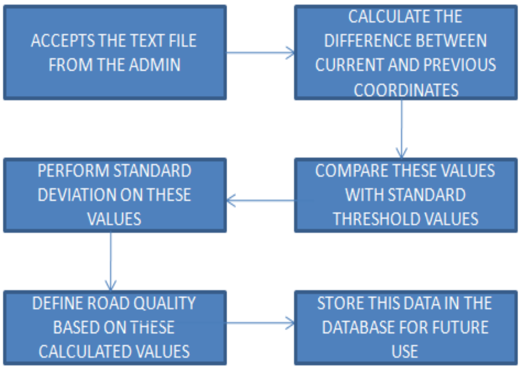

Fig 5:User Panel of the application

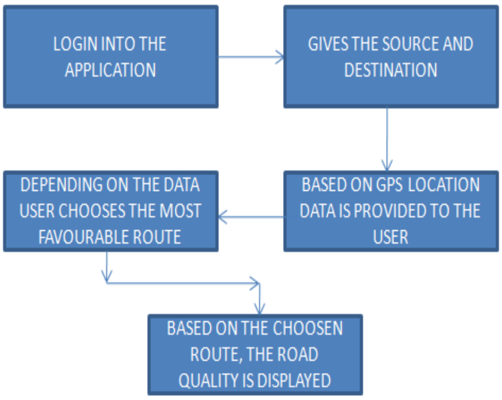

Fig 6: Admin Panel for Ghat

D. Estimating Road Surface Conditions

n this section, we explain how to gather driving log data, estimate road surface conditions and detect changes in road surface conditions.

Table 1: Structure of log table data

Attribute	Value
Id	Id of log data
Date	Value of date
Time	Timestamp
Accx	Three acceleration - axis Values
Accy	
Accz	

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 5, May 2016

Attribute	Detail
Orientation	Three-axis Value
Bump	
Acceleration	
Speed	Speed of Car
Lat	Latitude
Lon	Longitude
Direction	Direction

Table 2: Definition and classification of rough road levels

	Feature	Measure of Continuous Bounce
Rough Road level 0	A flat road on which no bounce is felt.	Small
Rough Road level 1	A road on which bounce is felt in certain spots due to asphalt damage.	Medium
Rough Road level 2	A road on which bounce is felt continuously, such as a dirt road.	Large

E. Determining Accelerometer Orientation

In general, the phone (or, rather, the accelerometer embedded in it) and its axes could be in an arbitrary orientation with respect to the vehicle and its axes. Furthermore, this orientation could change over time as the phone is moved around. A phone that is disoriented in this manner makes it non-trivial for its accelerometer measurements to be used to infer road and traffic conditions. For instance, if z were aligned with X, episodes of sharp acceleration and deceleration (i.e., horizontal acceleration) might be mistaken for bumps on the road (i.e., vertical acceleration). Thus, before the accelerometer measurements can be used, it is important for us to virtually reorient the accelerometer to compensate for its disorientation. The need to address this challenge is a key distinction of our approach based on phones.

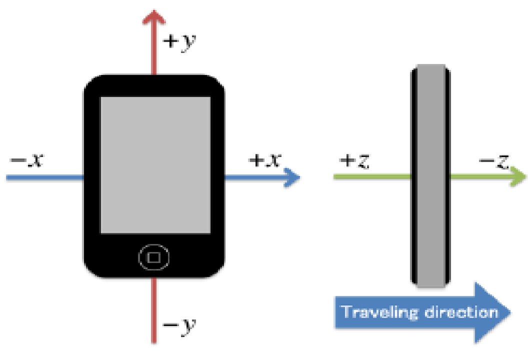

Fig 7: Acceleration Axis

F. Detecting Changes in Road Surface Condition

We detect changes in road surface conditions by using a table to compare estimation results with any past data that have the same segment ID and time. We divide time into three periods: 0:00-8:00, 8:00-16:00 and 16:00-24:00.

We compare estimation results using the following process. We define the number of estimation results with matching segment ID and time as n, the order of managed data as i and the result of estimation as (i). Then, the average value of past results $Past\_(seg\_id)$ is calculated as follows (after the decimal point is rounded):

$$Past\_(seg\_id) = \Sigma i{=}1\text{-}n\ Est(i)/\ n$$

The reliability of estimation results is high when there is a wide range of past data to refer to. However, this changes depending on season. In summer, road surface conditions do not change frequently. For this reason, it is appropriate to compare the average of the past month's results with the latest result to detect the latest changes. In contrast, in winter, in snowy regions, road surface conditions change frequently, meaning that comparing the average of the past month's results with the latest result is not effective. Therefore, this study detects changes in winter road surface conditions by comparing the result from the same time on the previous day, and the average of the past week's results, with the latest result. In this way, the range of reference data varies according to season and purpose.

Therefore, we define that range is set by the user, based on these variables. Next, we compare latest estimation $Latest\_(seg\_id)$ with past estimation $Past\_Est(seg\_id)$. We can assume that road conditions remain constant if $Past\_(seg\_id)$ is equal to $Latest\_Est(seg\_id)$. However, if $Past\_(seg\_id)$ is not equal to $Latest\_Est(seg\_id)$ we can assume that road surface conditions have changed within the past few hours.

IV. RELEVANT MATHEMATICS

In this section, we explain the mathematical calculations we conducted to confirm the effectiveness of the proposed method, and discuss the results.

Based on the experiment result, road bump detection logic is designed as follows.

Condition 1: Both of the Y-axis or running direction and Z-axis or vertical direction, 50[ms] standard deviation is large

Condition 2: These sections appear with wheelbase time.

Here, each variable is defined as follows. A recording order number is defined i. An acceleration data is defined as X(i), Y(i), Z(i) for each axis. For Y-axis or running direction and

Z-axis or vertical direction, 50[ms] standard deviation is defined as SDy(i), SDz(i). For the condition 1, simultaneity index is defined SDyz(i), and it is calculated by equation 1.

SDyz(i) = SDy(i) * SDz(i) --- (equation1)

Cycle number of wheelbase time is defined Nw. For the condition 2, Bump Index is defined Byz(i), and it is calculated by equation 2.

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 5, May 2016

Byz(i) = SDyz(i)*SDyz(i + Nw) --- (equation2)

Nw is related with vehicle speed. Vehicle speed is defined V[m/s]. Wheelbase is defined Lw[m]. Recording cycle is defined H[Hz]. Nw is calculated by equation 3

Nw = (Lw/V) * H --- (equation 3)

The graph below shows x-trend, y-trend and the z-trend of a particular .txt file generated during collection of data.

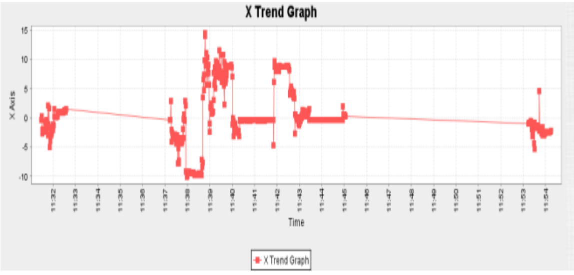

Figure 8: x-trend graph

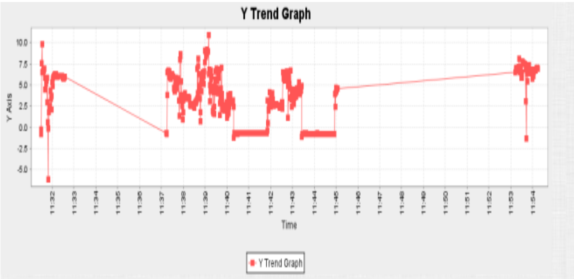

Figure 9: y-trend graph

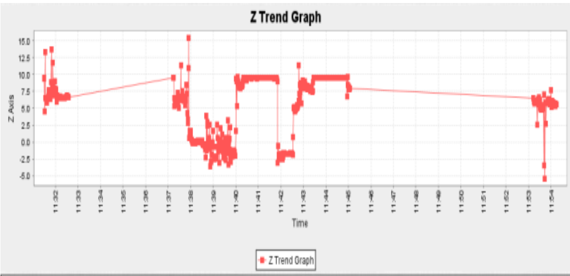

Figure 10: z -trend graph

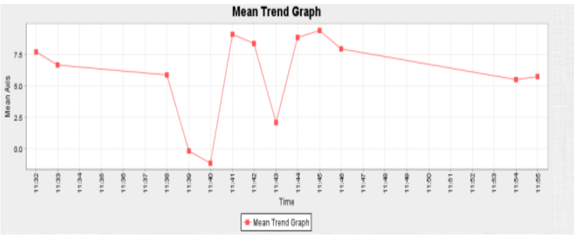

Figure 11:mean-trend graph

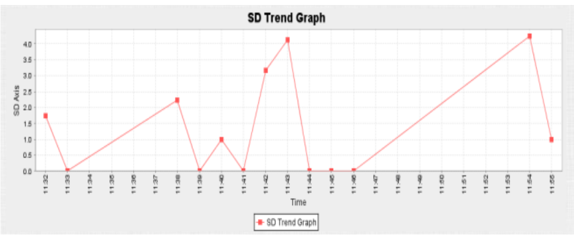

Figure 12: standard deviation-trend graph

The following graphs show the variations in the x, y and z-axes respectively with respect to time of a particular data.

As a large amount of data is collected in a span of 1 second, to aggregate the data we apply standard deviation on the entire set of data and single data represents one sec.

V. FUTURE SCOPE

Our future work would be to develop a system in a vehicle which will auto generate a particular message and send it to a list of registered numbers when met with an accident or any extreme conditions.

In the future, we will consider a method to improve estimation accuracy and implement a system for detecting and visualizing changes in road surface conditions. We will also consider the influence of vehicle speed.

VI. CONCLUSION

This paper describes the relationship between acceleration data collected from smartphones and road roughness condition. The use of smartphone for collecting the data is a promising alternative because of its low cost and easy to use features. To make driving more comfortable this information can be useful for user to check whether the road is safe to journey or not. This information can also be useful in road management and planning.

ACKNOWLEDGMENT

We are thankful to our guide **Prof. P.S.Toke** for her proper guidance and valuable suggestions. We are also greatly thankful to **Prof. N.D. Kale,** the Head of Computer Engineering Department and other faculty members for giving us an opportunity to learn and present. We are also thankful to IJARCCE for giving the opportunity to explore our ideas. We once again extend our sincere thanks to all of them.

REFERENCES

[1] Mednis, A., Strazdins, G., Zviedris, R., Kanonirs, G., Selavo,L. : Real time pothole detection using Android smartphones with accelerometers, Paper presented at the 2011 International Conference on Distributed Computing in Sensor Systems,Barcelona, Spain, June 27-29, 2011.

[2] V. Douangphachanh, H. Oneyama, "Estimation of Road Roughness Condition from Smartphones under Realistic Settings," Proc. Of the 13 th International Conference on ITS Telecommunication (ITST), pp.427-433, November 2013.

[3] V. Douangphachanh, H. Oneyama, "Formulation of a Simple Model to Estimate Road Surface Roughness Condition from Android Smartphone Sensors" IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP) Symposium on Human-Centric Sensing and Social Networks Singapore, 21–24 April 2014.

[4] Dimpal V. Mahajan, Prof. Trupti Dange, "Analysis of Road Smoothness Based On Smartphones" IJIRCCE June 2015.

[5] Viengnam DOUANGPHACHANH, Hiroyuki ONEYAMA, "A Study on the Use of Smartphones for Road Roughness Condition Estimation" Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9, 2013.

[6] Douangphachanh, V., Oneyama, H. : "A Study on the Use of Smartphones for Road Roughness Condition Estimation", J. Eastern Asia Society forTransport Studies in press.

[7] IJRRCCE, "Analysis of Road Smoothness Based On Smartphones" : Dimpal V. Mahajan, Prof. Trupti nde1,Amol Jadhav2, Shreyas Shinde3, Ashish Dhoka4, Sande