ISSN:0975-9646

B.Lanjewar et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (6) , 2015, 5133-5136

Survey of Road Bump and Intensity Detection algorithms using Smartphone Sensors

Prof.B.Lanjewar, Jyoti Khedkar, Rahul Sagar, Rasika Pawar, Kunal Gosavi.

Department of Computer Engineering, Savitribai Phule Pune University

Abstract-As we know that the navigation through road to unknown places is critical, in the same way, condition of the road is important to reach a certain place within certain time. If we know the route source to destination but don't know the condition of that road then although we try to reach that point at specific time we are unable to reach. This problem can be solved if we know the alternate route for that road as well as condition of that road.

This survey paper tries to solve all these problems, so that user will not face any inconvenience while driving. The study of this paper discovers various kind of data we received to sensors from Smartphone's under practical setting in which the Smartphone's are placed in more accurate places and under accurate means inside a moving vehicle to evaluate its relationship with the actual road smoothness. Road smoothness (Quality) and Complexity analysis using Smartphone's propose to utilize the GPS system and different sensors like accelerometer, magnetometer, etc. of phone, so we can analyze the road condition and upload this information on the central server so any application user can use this information during travelling.

Keywords:- **Road surface analysis; Smartphone; Accelerometer; Magnetometer; Pothole**

I. INTRODUCTION

Road surface in India is relatively bumpy, which can cause uneasiness and have safety risk to the drivers who traverse these roadways. There are many constrains affecting the road condition example road construction, Quality of material used. Weather is usually humid and warm in India, causing nature to also take its toll on roadways. As an effect, these low quality road surfaces lead to many potholes which are very dangerous for drivers and can also cause considerable vehicular damage. It may increase fuel consumption, road user cost for vehicle maintenance, reduced driving comfort and sometimes it may pose a significant traffic safety threat to road users. Road surface condition is very useful for the road user because with the availability of such information road users can be avoid or get cautious of the bad road ahead. For many decades, roughness is internationally accepted indicator which is usually used to measure the ride quality of road surface. Therefore road condition information is usually the interest of the general public, and particularly the government or road authorities. This task requires the collection of huge amount of road links data which is very important for maintenance, planning and monitoring in excess of time. In the developing countries concentration on the data collection is generally ignored or neglected mainly due to the need of technology and budget. Therefore in these countries, road smoothness condition data is often left out-of-date and this makes it difficult for correct planning and programming of the maintenance. This paper focuses mainly on road roughness condition.

Using Smartphone as a tool to collect data is promising alternative because of its least cost and easy to use features in addition to its potentially wide population coverage as probe devices. Accelerometers and GPS are among many sensors that can be found in today's Smartphone's. There are some researches and studies that have explored the use of standalone accelerometer and that comes with Smartphone to detect road bumps and anomalies. However majority of this study focuses mainly on identifying and locating anomalies. Standalone accelerometer is fitted in a simulation car and used to generate X, Y, Z Co-ordinates. The simulation conclude that roughness of the road can be estimated from acceleration data obtained from the sensor. This data is further used to access road and traffic condition.

To achieve our finale goal, this paper explores features and the relationship between Smartphone sensor or data, collected by accelerometer and GPS, and road roughness condition (IRI).Such information would enable us to develop a Smartphone application with simple algorithms or models that can be used to evaluate or estimate road roughness condition.

II. METHODS FOR DETECTING ROAD CONDITION

I. Z -THRESH

The first and the simplest event detection algorithm Z-THRESH (fig.1) were tested on the acquired data set and is thresholding the acceleration amplitude at Z-axis. The features that classify the measurement are the values exceeding specific thresholds that identify the type of the potholes, e.g. a large potholes or a cluster of potholes. The algorithm assumes that the information about Z-axis position of accelerometer is known. Additional virtual reorientation of the accelerometer is possible However, we used a simpler approach -a controlled placement of the accelerometer, eliminating the extra processing required for the virtual reorientation.

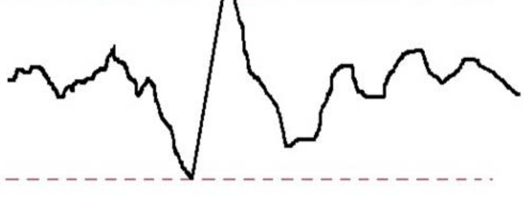


Fig.1. Pothole detection algorithm Z-THRESH.

II. Z-DIFF

Next, a slightly more advanced was Z-DIFF (Fig2) tested on the acquired data set. Contrary to Z-THRESH a search for two consecutive measurements with difference between the values above specific threshold level was performed. Thus the algorithm detected fast changes in vertical acceleration data. The algorithm requires the determination of the Z-axis position similarly to the previous approach.

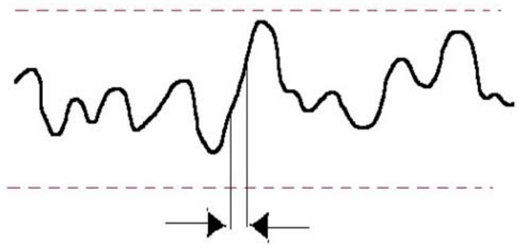


Fig.2. Pothole detection algorithm Z-DIFF.

III. G-ZERO

While using visual data analysis tools and searching for specific data patterns authors found that there exist certain events characterized by measurement tuple. All three axis data in this tuple was with values near to the e.g. Empirical analysis of these data sets led to two preliminary conclusions: 1) such data tuples could be acquired when the vehicle was in a temporary free fall, for example, entering or exiting a pothole; 2) such data tuples could be analyzed without information about exact Z-axis position of the accelerometer. We named this algorithm G-ZERO (Fig.4) after the main feature of the detected event.

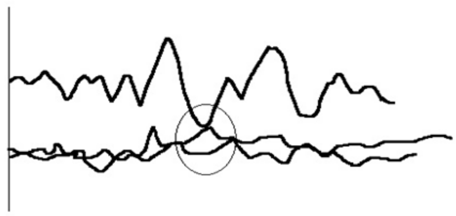


Fig.3. Pothole detection algorithm G-ZERO.

IV. VIMS

Inspection of the expansion joints from the inside is generally very difficult because of narrow space and visual inspection from the road surface is practically the only way. The road profiling system can't be applied to expansion of joints, because the condition of the expansion joints are not well captured and failure of expansion joints indeed occurs ,resulting in traffic accidents in some cases.

For solve these problems for road maintenance, "Vehicle Intelligent Monitoring System" is being developed. An accelerometer, a microscope, a GPS and laptop PC are installed in an ordinary road patrol car. The accelerometer measures the vertical dynamic response of car and the microphone measure the tire noise to determine the condition of road surface. The GPS identifies the positions where the measured responses occur. The laptop pc stores the measurement date.

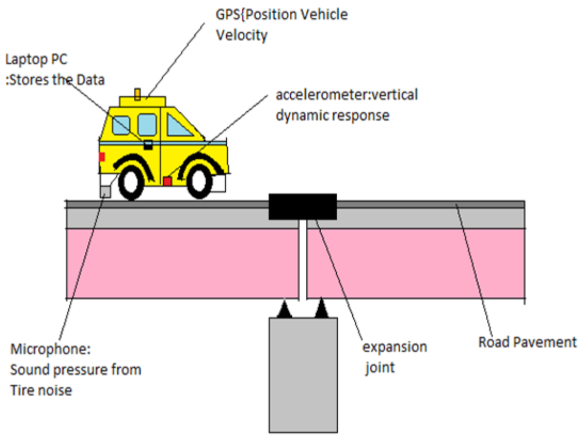


Fig.4. VIMS

A VIMS is installed in an ordinary car and measurements are made at the actual roads. At presents, we can measure the data without difficulty. In this presentation, the repeatability of the measurement data is confirmed, the locations of large response on Metropolitan expressways are demonstrated and the possibility of detection of abnormal sound is showed.

For the future, development of the diagnostic system, like setting of the criteria which evaluate the abnormal response will be needed.

V. STDEV (Z)

In this algorithm events are detected by thresholding deviation of Z-axis acceleration. The lowest false positive rate, promising but additional research has to be done to and appropriate window size.

VI. IRI (International Roughness Index)

The International Roughness Index is the roughness index most commonly obtained from measured longitudinal road profiles. It Is Calculated using quarter car vehicle math model, whose response is accumulated to yield a roughness index with units of slope (in/mi, m/km etc).

Once we have the classifying function with model of a smooth road, the quality of road section is ready to be examined. From the definition of IRI the measure of roughness is based on the measure of vertical deviations over a section of the road. To be precise, the roughness of IRI is defined as the cumulative deviations in vertical inches per internal mile. We modify the definition slightly, defining roughness as the number of road anomalies per kilometer. The details of roughness is in the definition

1.The input data segment.

X_s contains a time series of input data X, and this segment is defined as $X_s=\{X_1.X_2\ldots X_x\}$. Furthermore, the set of input data segments is defined as$\mu_R=\{X_{R.1}\ldots\ldots\ldots X_{R.n}\}$,

where n is size of $\mu_R.F_S^{\sigma}(X_{S.i}|\ M_s)$

Is the classifying function with the smooth surface model M_s under speedσ.

Definition 1: Roughness Index Function

$$I\ (\mu_R) = \frac{\sum_{i=1}^{n} F_S^{\sigma}(X_{s.i}|\ Ms)}{Length(\mu_R)}$$

Where $X_{s.i} \in \mu_R$ and n is size of μ_R.

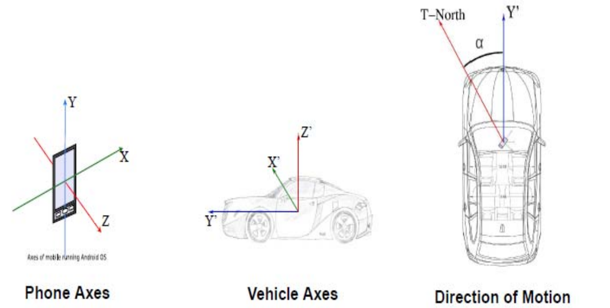
The roughness index function given above is an indicator for estimating the quality of the input road section. We further offer semantic labels to describe the given road section. These semantic labels have values “good”, ”fair”, ”inferior ”and “dangerous”. In addition, three thresholds are learned to assign semantic labels to road sections.

In H.ONAYAMA paper author introduces method in which it merges IRI data from VIMS with the acceleration data from Smartphone’s for the same road sections. Then the merged data files are cut into small 100 meter sections based on VIMS GPS Coordinates.

In the sectioning process, road section where experiment vehicle have stopped are excluded since data at these sections cannot be used to estimate road roughness condition. In addition, section that are less than 100 meters are also ignored. All selected data sections are converted to frequency domain and perform Fast Fourier Transform (FFT). Magnitude from FFT is amplitude or strength of the associated frequency component. This acceleration data generally has linear relationship with road condition.

VII. *Road Bump Detection Logic*

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 are appeared with wheelbase time.

Here, each variable is defined as follows. A recording order number is defined ‘i’. An acceleration data are defined as X (i), Y(i), Z(i) for each axis. For Y-axis or running direction and axis or vertical direction, 52[ms] standard deviation is defined $SD_y(i)$, SDz(i). For the condition 1, simultaneity index is defined $SD_{yz}(i)$, and it is calculated by equation 1.

SD_{yz} (i) =SD_y (i)*SD_Z(i) ....(Equation 1)

Cycle Number of Wheelbase time is defined Nw.

For the condition 2, Bump Index is defined B_{yz} (i), and it is calculated by equation 2.

B_{yz}(i) = SD_{yz}(i)*SD_{yx} (i+Nw) ....(Equation 2)

Nw is related with vehicle speed. Vehicle speed id 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)

Standard Deviation

$\sigma=\sqrt{\frac{\sum(x-x')^2}{N}}$

Where

σ=The standard deviation

X=each value in the population

X’=Mean of the value

N=the number of values (the population).

VII. *Location Based Distance Calculation.*

This uses “Haversine” formula to calculate the circle distance between two points. That is the shortest distance over the earth’s surface –giving “as-the-crow-files“ distance between the points.

Haversine formula:-

a=$\sin(\Delta\emptyset/2)^2+\cos(\emptyset_1).\cos(\emptyset_2).\sin(\Delta\vartheta/2)^2$

c=2a $\tan 2(\sqrt{a},\sqrt{(1-a)})$

d=R.c

Where

$\emptyset = latitude, \vartheta = longitide, R = Earth\ radius.(mean\ radius = 6{,}371km)$

(Angels in radian)

III. DISCUSSION AND COMPARISON

In this survey paper we have discussed mainly two concepts VIMS and IRI. Road profiler system is used in past few years for inspection of road surface but time and cost consumption is huge for same. Road profiler enables users to measure the condition of expansion joints. To solve this problem Vehicular Intelligent Monitoring System is being developed. By using VIMS we can inspect the road several times per day where as using road profiler it is possible only once every two year. Operating cost and time to analyze the data is also high in road profiler.

There is one more method used in which data has been checked, filtered, matched with reference data and sectioned. The selected sections are then analyzed in frequency domain to calculate magnitudes of signal in different frequency ranges. The relationship between the magnitudes and road roughness is investigated. In H.ONAYAMA paper road sectioning method is used in which 100 meter length of acceleration data is chosen as a unit for road surface estimation, which gives result for every 100 meters road condition and there is a concern on the accuracy of GPS position data.

By using Bump Detection algorithm we try to analyze captured sensor data to get information about speed of vehicle. We draw conclusion from analyzed data i.e. whether road is safe for journey or not and complexity of that road. This data will be stored on the web server. After analyzing this data, is displayed on users’ phone similar to Google map. Also it displays user’s current location and alternate routes on map by sending route information as per his location updates. This is very effective method for analyzing road condition among all above discussed algorithms. In location based algorithm users current location as well as the shortest route is searched out among all possible paths.

IV. CONCLUSION

Road needs to be monitored continuously for roughness and other anomalies to avoid inconvenience to the road users. Road monitoring also helps to predict estimate travel time from one place to another place. This paper presents detail survey methods for detecting road condition. We have presented comparative study of various algorithms like Z-THRESH,Z-DIFF,G-ZERO, STDEV (Z), and concepts likes VIMS, IRI. From the survey it is noted that the most commonly used sensors accelerometer and GPS. Smartphone sensor increase scalability. Analyzing from the research activity it is certain that this area will gain more importance in future.

REFERENCES

[1] A.Mednis, L.Selavo, R.Zviedris, G.Kanonirs, G.Strazdins, 2011 "Real Time Pathole Detection Using Android Smart phones With Accelerometers"

[2] Takashi Furukawa, Japan 2012 "VIMS Manual." VIMS Consortium, Nagasaki University.

[3] A.Mednis, L.Selavo, R.Zviedris, G.Kanonirs, G.Strazdins, "Towards Vehicular Sensor Networks With Android Smartphone For Road Surface Monitoring," Paper presented at the 2nd International Workshop on Networks of Cooperating Objects, Chicago, USA, April 11, 2011

[4] Y.Tai, C.Chan, J.Y.Hsu, "Automatic Road Anomaly detection Using Smart Mobile Device," Paper Presented at the 2010 Conference on Technologies and Applications of Artificial Intelligence. Hsinchu, Taiwan, November 18-20, 2010

[5] V.Douangphachnh, H.Oneyama, "A Study On The Use Of Smartphone For Road Roughness Conditions Estimation," Proc. of the Eastern Asia Society Transportation Studies,P297,Vol.9,2013 and J. Eastern Asia Society For Transport Studies, Vol.10,1551-1564,2013