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Analysis of Road Smoothness Based On Smartphones

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ABSTRACT: Almost every today's smartphone is integrated with many useful sensors. The sensors are originally designed to make the smartphones user interface and applications more convenient and appealing. These sensors are potentially useful for many other applications in different fields. Using smartphone sensors to estimate road smoothness condition may be also possible, since many similar sensors are already in use in many sophisticated road smoothness profilers. This study explores the use of data, collected by sensors from smartphones under practical settings in which the smartphones are placed at more realistic locations and under realistic manner inside a moving vehicle, to evaluate its relationship with the actual road pavement smoothness. In this paper, road smoothness(Quality) and Ghats complexity analysis using smartphone proposes to utilize the GPS system of phone and different sensors like accelerometer, magnetometer, etc. of phone, so we can analyse the road and can upload this information of that road on central server so every application user can use this information during travelling.

KEYWORDS: Smartphone; Accelerometer; magnetometer; Road smoothness; practical settings.

I. INTRODUCTION

Roads are key part of the people in their lives. Hence monitoring the road conditions has expected a significant amount of attention. Road smoothness is one of the most important road condition measure and primary indicator of the utility of roads. Road users can avoid or be cautious of the bad road ahead by using road surface condition information. Due to this demand initiates the development of the road surface inspection system. Road smoothness condition can be defined by the irregularity, which may be in the form of surface bumpiness, potholes, cracks, corrosion or damages and so forth, in the pavement surface that adversely affects the ride quality of vehicles.

One of the most important road condition measures throughout the world is Road Smoothness and it is constantly recognized. The time to time recording of smoothness data allows pavement managers to review the smoothness progression rate of pavements and to take appropriate action as a result[1]. The Road smoothness condition is measured by the International Smoothness Index (IRI) and that has been used widely for road infrastructure maintenance and monitoring for many years [2]. To measure IRI, many approaches are available but majority of them on one hand requires sophisticated profilers and tools and which are expensive to buy and for operating on it requires skilful operators. On the other hand, a popular practice in many developing countries is visual inspection. The visual inspection is relatively cheaper option and it is very labor intensive and time consuming.

To Maintain and monitor road infrastructure is a challenging task for almost all governments and road authorities. The reason for this is that the task requires the collection of large amount of road network condition data and which is very important for maintenance planning and monitoring in excess of time, addition to the significant efforts that have to be directed to actual maintenance of the road network. In the developing countries, the 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 difficult for correct planning and programming of the maintenance.

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The use of smartphone to collect the data is a promising alternative because of its low cost and easy to use feature in addition to its potentially wide population coverage as probe devices. In the previous study [3] they explored the use of smartphones fixed to vehicles with predetermined orientation to estimate road smoothness where promising results have been observed. The proposed system will take a further step by attempting to estimate road smoothness from smartphones under more practical settings, which is away from fixed orientation and/or fastening the devices themselves tightly with vehicles while doing collection of data. This means the smartphone are located freely at locations that a driver would be more likely to put their smartphones inside a car while driving.

To estimate road surface condition , the smatphones are a very helpful. Because the smartphones already have sensors that are able to record useful reading for road surface condition estimation likewise to those used in many high-tech profilers. As the number of smartphone users are rapidly increasing, that means the chance of having plenty of data with inexpensive investment is large. For this reason, the approach is not useful only for developing but also for developed countries.

After the collection of data using smartphone phone, the data is analysed with simple techniques. The road surface condition is estimated based on analysed data. The data is available to road condition system for useful to application users.

The system for road smoothness estimation can be viewed as following

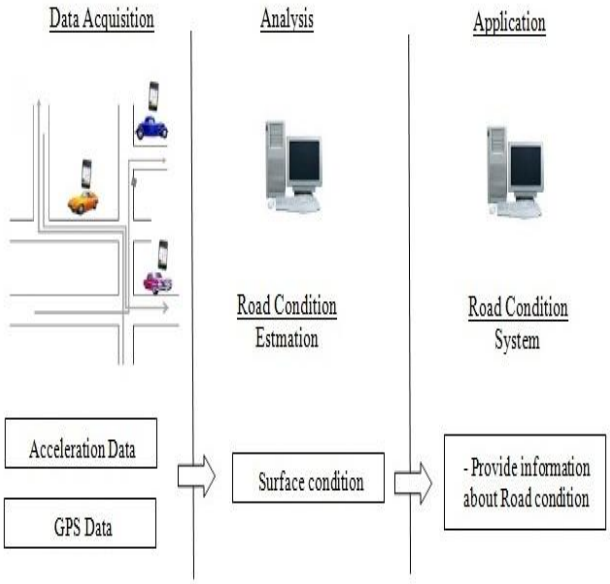

Figure 1: Conceptual image of road condition system

II. RELATED WORK

We present the related research in a systematic manner which enriches our work. The smartphones are used to estimate IRI of road roughness in very limited studies. In previous studies, most of the interest in detecting road bumps and anomalies using mobile sensors.

Cashell, K et al. [4] proposed a system that make the use of a separate accelerometer to fit in a simulation car and use it to assess road roughness condition . The roughness of the road can be estimated from acceleration data obtained from the sensor.

In[5] authors, Eriksson, Girod, , Hull, Newton, Madden, Balakrishnan have developed a system to utilize standalone accelerometers to successfully detect road anomalies. This system uses three axis acceleration sensors and GPS devices deployed on embedded computers in cars.

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Ramjee et al. [6] made the use of many sensing components to monitor road conditions from mobile phone. The potholes, bumps, braking and honking can be detected by analyzing data from the sensors,. Then the information is used to assess road conditions. This system is called as Nericell arranges the smartphones to perform sensing and report data back to a server for aggregation.

Selavo et al. [7] and Strazdins et al. . [8] have uses Android smartphone devices with accelerometers are used to detect potholes location on road. The approaches for detection includes algorithms like Z-THRESH ,Z-DIFF , STDEV(Z) , G-ZERO to detect events in the acceleration vibration data.

Tai, Y. et al. [9] explores the use of mobile phone with a tri-axial accelerometer to collect acceleration data while riding a motorcycle. Both supervised and unsupervised machine learning methods are used to identify road conditions.

In[10] authors, Perttunen, Mazhelis, Cong., Kauppila, Leppänen, Kantola, Collin, Pirttikangas, Haverinen, Ristaniemi have analyze data obtained by smartphone accelerometers in frequency domain to extract features that are corresponding to road bumps. They developed a pattern recognition system for detecting road condition from accelerometer and GPS readings.

III. PROPOSED SYSTEM

The proposed system is used for estimation of road smoothness (Quality) and ghat complexity using smartphone(android phone). It utilizes the GPS system of phone and different sensors like accelerometer, magnetometer of android phone, so we can analyse the road and can upload this information of that road on server so every user can use this information during travelling.

The system take the data as x , y, z co-ordinates and the axes can be viewed as along with vehicle axes .

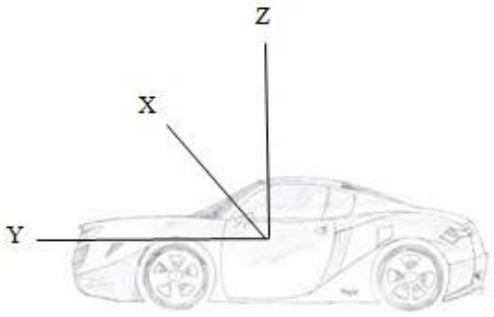

Figure 2 : Axis Direction

X-axis → Horizontal Direction
Y-axis → Running Direction
Z-axis → Vertical Direction

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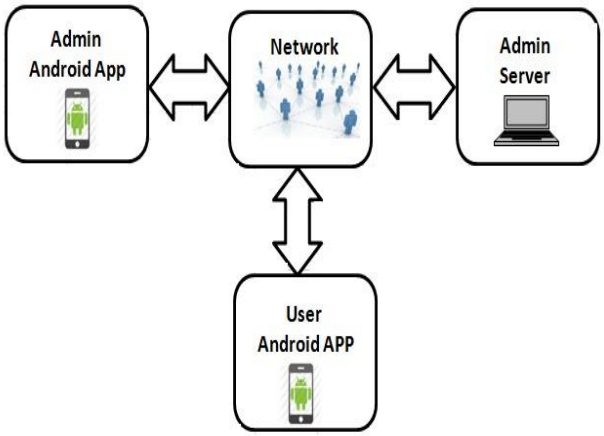

Figure 3: System Architecture

The above figure shows architecture of road smoothness detection system. There are three modules that are connected through internet.

The admin android app collects the data using smartphone sensors in text file. The text file is send to the admin server for analysis. The analysed data is stored in database for later uses. The user android app is useful the user for knowing road smoothness.

IV IMPLEMENTATION

The system can be viewed as to perform various functions like:

1. Detection of Bump

In the detection of bump, the data is collected using accelerometer, magnetometer and GPS system and this data is processed to detect braking and bump events. The data is collected at every millisecond. The data is collected in the form of x, y, z, co-ordinates as txt file. The data is attached with a time & location tag, sending the data across the web server for further processing. For bump detection standard deviation of y and z coordinate are calculated . As , if the bump is occur the y and z coordinates are affected so, need to consider both values. Bump is detected if the deviation is large. Information is stored on server side for other users.

2. Finding Ghat complexity

In ghat complexity estimation, we consider Y-axis for ghat detection. Here we calculate the angle of 'Y' axis with the north direction by which we can get how much car is turned at right or left side. For this we also consider the previous angle of 'Y' axis with north direction. This helps to count the number of turns in specific ghat, and also we can conclude how much they are tough.

3. Evaluation of road at server side

At server side for evaluation consider the data with time and location tags from android phone. The data is processed using statistical analysis and k-means clustering algorithm. From processed data the bumps on road and ghat complexity is analysed. Using this information, the web service infers higher level of evaluation such as road is smooth or it is with too much speed bump, Ghats are too complex or they are simple to drive, etc.

4. Make data available to other users

The information about the road is displayed to the user as per requested location. These events are displayed on a map on the mobile, so that the application user can choose alternate routes based on this.

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IV. EXPECTED RESULT

The bump calculation for the proposed system is depicted in the figure.4. The data is collected from phone in the form of x, y, z co-ordinates and is given to the system for calculation of bumps on road. The graph shows time on X-axis and standard deviation value on Y-axis. The bump detected is shown by eclipse shape.

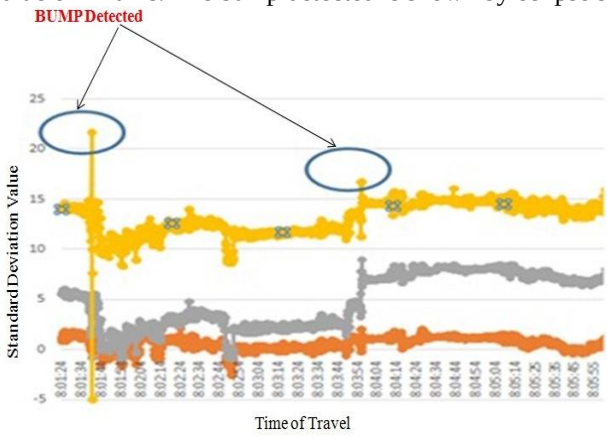

Figure 4. Road Bump Calculation Graph

X co-ordinates value
Y co-ordinates value
Z co-ordinates value

V. CONCLUSION

We all use Google maps and its application for navigation during travelling, but these applications couldn't able to tell you any road's condition or its complexity. We can use the accelerometer , magnetometer and GPS system and use this information to estimate road roughness/quality and Ghat complexity. The use of smatphones because of its low cost and easy to use feature in addition to its potentially wide population coverage as survey devices. The data about road condition is necessary for proper maintenance and programming of road. Road surface condition information is very useful for road users because with the availability of such information, road users can avoid or be careful of the bad road ahead. This information is useful to user during travelling. This information can be helpful to user at the time if there are multiple routes and for destination and he can choose one of the finest and shortest route.. It is useful for user whether road is safe to journey or not.

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