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Implementation of Road Roughness Estimation System

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Abstract: ***The road infrastructure is an important aspect of today's society. To ensure the quality of the road surface it should be monitored continuously and repaired as per the need. The excellent distribution of resources for road repairs is possible providing the availability and real-time data about the condition of the roads.***
The paper describes different techniques that are developed by different researchers for efficient detection of the road roughness.
Keywords: Road roughness, roughness condition, condition estimation.

I. INTRODUCTION

To Maintain and monitor the road infrastructure is a challenging task for all governments and road authorities. Unpredictable condition of the road surface is major distractions for safe and comfortable transportation. Both drivers and road sustainers are interested in fixing them as soon as possible. One of the reasons is that the task requires the collection of substantial amount of road network condition data, which is very important for maintenance planning and monitoring, extra time period, in addition to the significant attempt that have to be guided to actual maintenance of the road network.
In developing countries, the focus on data collection is usually ignored and mostly neglected because of the lack of technology and budget. Therefore, this is the reason in these countries; road infrastructure condition is often left outdated, making it difficult for proper planning and programming of the maintenance.
"Road Roughness is frequently considered as one of the most important road condition measures in entire world. The time series recording for roughness data allows to assess the roughness progression rate of the footpath and to take suitable action accordingly" [1]. For many decades Road roughness condition, measured by the International Roughness Index (IRI), has been used widely for road infrastructure maintenance and observation [2]. There are many approaches to measure IRI, however majority of them requires sophisticated profilers and tools, which are expensive to acquire and operate as well as often require skillful operators. On the other hand, visual inspection is also a popular practice in many developing countries. While this is relatively a much cheaper option to implement, it is usually very labor intensive and time consuming.
An automated survey approach could be carried out by either customized embedded sensing devices or smart-phones.

II. LITERATURE REVIEW

The rich research is available on this Road Roughness Estimation System
BusNet [1] 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. The data is collected and stored locally for transmission through wireless network to collection nodes located at the bus stations for later processing. The only algorithm related to pothole detection is based on sensing acceleration and is used to start the data collection to save the limited storage space.

A. Crack Detection.

Most recent work is done in crack detection under more challenging conditions and can be divided into some different branches:
Saliency detection, textured-analysis, wavelet
Transform and so on

B. Salient Detection

Salient regions are visually more conspicuous due to their contrast with the surroundings. Although existing methods [5], [8] demonstrate their effectiveness in detecting salient regions in the Berkeley database [6], they perform poor on the completeness and continuity of detected crack.

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C. *Textured-Analysis*

Since road surface images are often highly textured, textured-analysis methods [3], [10], [12] are introduced in road crack detection. In order to distinguish the cracks and the backgrounds, [3], [10] use the Wigner model, and [12] uses classification method. These methods use a local binary pattern operator to determine whether each pixel belongs to a crack and the local neighbor information is not taken into consideration.

D. Wavelet Transform

Wavelet transform is applied to separate distresses from noises [9]. In [2], complex coefficient maps are built by a 2D continuous wavelet transform, wavelet coefficients maximal values are obtained for crack detection. As a result, differences between crack regions and crack free regions could be raised up. However, due to the anisotropic characteristic of wavelets, these approaches may not handle the cracks with low continuity or high curvature properly.

E. Dedicated-Sensors Based

Ground Penetrating Radar (GPR) used in work [9] uses radar and operates in a wide radio frequency band from 0.05 to 6.0 GHz to detect tiny defects on roads. Furthermore, GPR can detect the potential potholes hidden under the ground. The defect of this system is that GPR is unrealistic to be widely deployed on ordinary vehicles. In work [11], the authors use an on-board vision system to capture the view of the road when driving, and use the image recognition technique to find out potholes and road roughness. In their work, pothole larger than 2 feet in diameter can be detected. Using image recognition technique is mature and easy to deploy but has the problem of line-of-sight limitation.

F. Vibration-Sensor Based

The project [5] utilizes acceleration information to detect car braking, stop-and-go traffic and bumping (caused by potholes or other uneven road surface). The detection algorithms are threshold-based. In work [13], the authors examine the vibration characteristics such as the maximum acceleration values and the variations when hitting potholes and propose thresholds to detect the potholes and the road roughness.

III. PROPOSED SYSTEM

Road Quality and Ghats complexity analysis using android phone proposes to utilize the GPS system of phone and different sensors like accelerometer, magnetometer, etc. of android phone, so we could analyze the road and can upload this information of that road on central server so every application user can use this information during traveling.

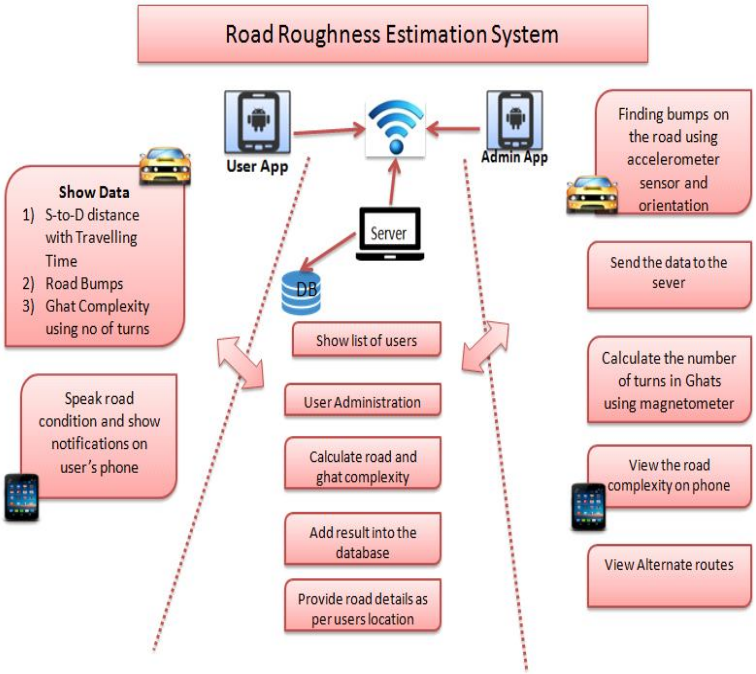

Figure: - System Architecture.

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A. Bump Detection

The lowest layer of the system is on the application running on the Smartphone. The application collects data from the accelerometer, magnetometer and GPS and then processes this to detect braking and bump events. It then attaches a time and Location tag to this event data, and sends it across to the web server for further processing.

Bump is detected using sensor data gathered from admin phone, details of location of bump is stored on the server side for other users.

B. Finding Ghats's Complexity

As we have seen the data which we get from accelerometer and magnetometer, in that we consider y axis for Ghats 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 alarm, and also we can conclude how much they are tough.

C. Evaluation of Road at Server Side

The REST web service on the server receives the event traces of several Smartphone's along with the time and location tags. 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 easy to drive, etc.

D. Make Data Available To Other Users

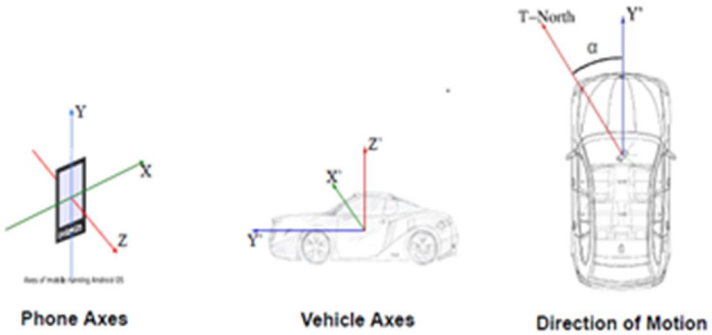
The web service needs to send over the inferred events to the Smartphone running the application. The Smartphone sends over its location, and the web service responds with events of interests in the vicinity of this location. These events are displayed on a map on the phone, so that the user of the application can choose to take alternate routes based on this.

1) Features

a) Capturing sensor data.
b) Get speed information of vehicle.
c) Analysis of the captured information
d) Drawing conclusion from analyzed data i.e. whether road is safe to journey or not
e) Store it on the web server.
f) Display it on users' phone on map
g) Also Display user's current location and alternate routes on map

IV. ALGORITHMS USED

A. Road Bump Detection Logic



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

1) Condition 1: Both of the Y-axis or running direction and Z-axis or vertical direction, 50[ms] Standard deviation is large.
2) 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 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 SDy(i), SDz(i). For the condition 1, simultaneity index is defined SDyz(i), and it is calculated by equation 1.

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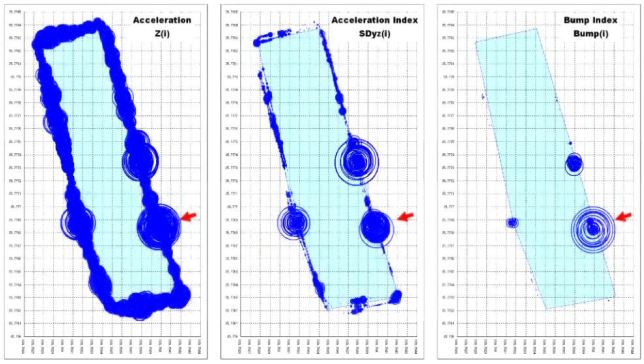
SDyz(i) = SDy(i) * SDz(i) ---------- (equation 1)
Cycle number of wheelbase time is defined Nw. For the condition 2, Bump Index is defined
Byz(i), and it is calculated by equation 2.
Byz(i) = SDyz(i) * SDyz(i + Nw) ---------- (equation 2)
Nw is related with vehicle speed. Vehicle speed is defined V[m/s]. Vheelbase is defined Lw[m].Recording cycle is defined H[Hz]. Nw is calculated by equation 3.
Nw = (Lw/V) * H ---------- (equation 3)

B. Experiment Result

This logic is applied to data. The 50[ms] standard deviation of Z-axis acceleration or vertical direction SDz(i) is drawn in Fig. Simultaneity index SDyz(i) is drawn in

Fig.7. Bump index Byz(i) is drawn below:



Standard Deviation

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

where

$\sigma = the\ standard\ deviation$

$x = each\ value\ in\ the\ population$

$\overline{x} = the\ mean\ of\ the\ values$

$N = the\ number\ of\ values\ (the\ population)$

C. Location Based Distance Calculation

This uses the 'haversine' formula to calculate the circle distance between two points – that is, the shortest distance over the earth's surface – giving an 'as-the-crow-flies' distance between the points.

Haversine formula:
$a = \sin^2(\Delta\varphi/2) + \cos(\varphi_1).\cos(\varphi_2).\sin^2(\Delta\lambda/2)$
$c = 2.\text{atan2}(\sqrt{a}, \sqrt{(1-a)})$
$d = R.c$

Where
φ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371km)
note that angles need to be in radians to pass to trig functions!

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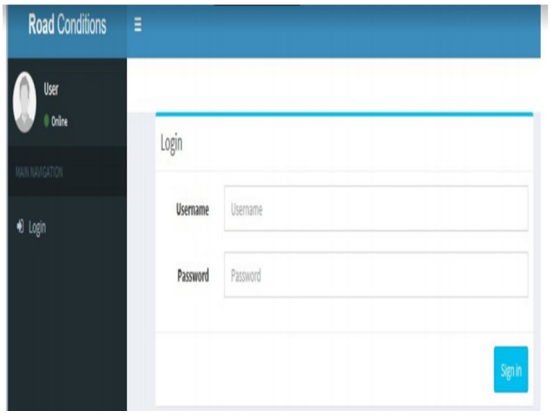
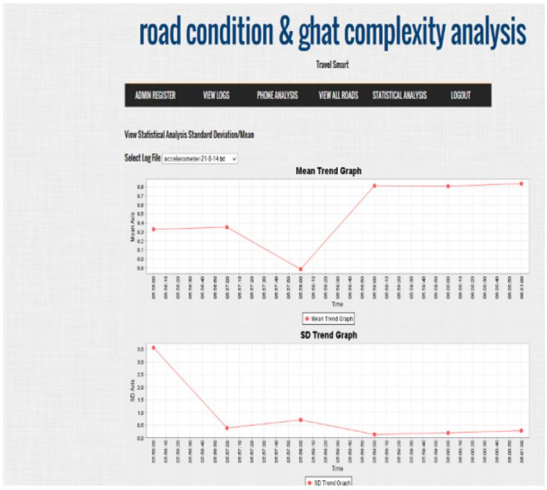
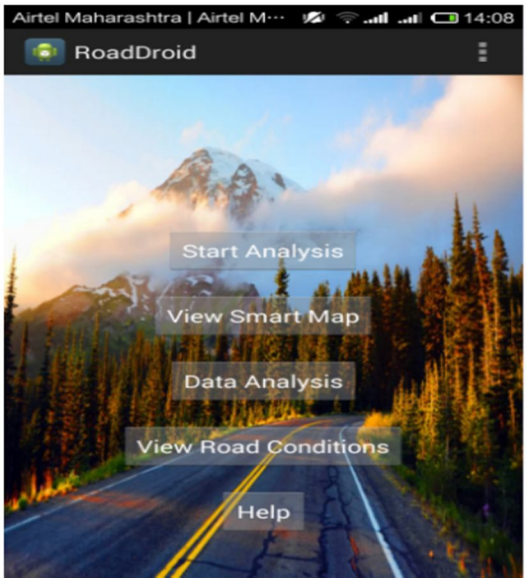
V. RESULT AND DISCUSSION



Login Page



Statistical Analysis



Android GUI

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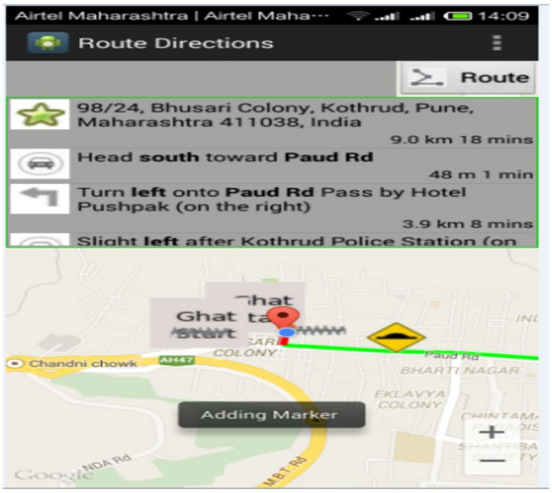
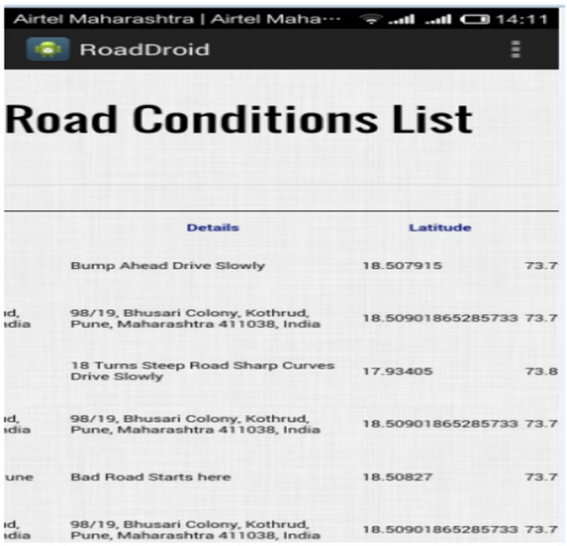


Routes Direction



Road Condition List

Accelerometer Sensor Data

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VI. APPLICATION

Road Quality and Ghats complexity analysis

VII. CONCLUSION

In this paper an attempt is made to estimate road roughness condition (IRI). In order to study the survey, it is necessary to understand the relationship between road roughness condition and the data the data that is obtained

The literature review explores the vast research work that has been devoted by different researchers for Estimating Road Roughness. The closure is efficiency and accuracy reported in the literature survey can be increased with advances sensor and technologies.

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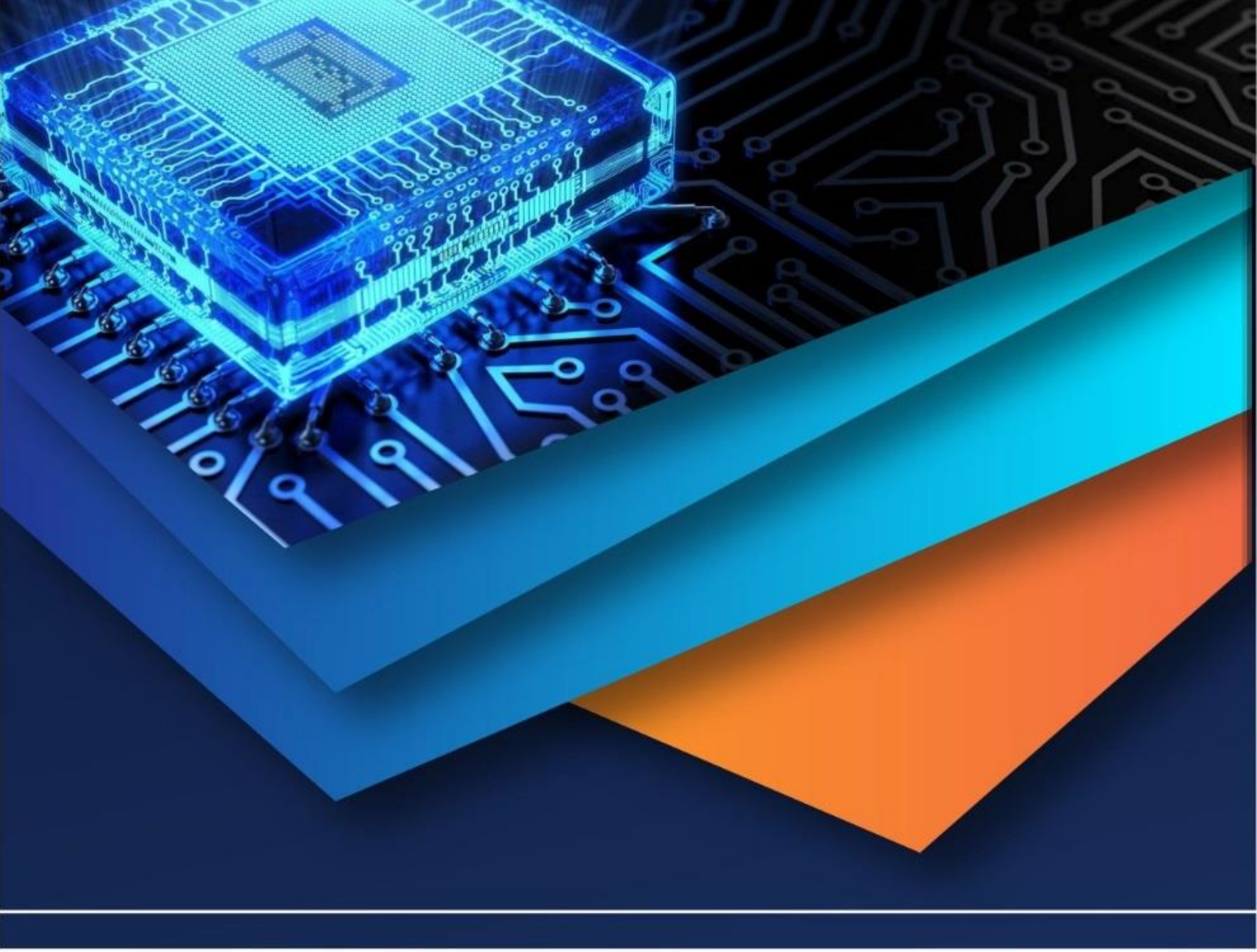

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