Smart-phone App for Smooth Path Detection

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***Abstract* — Smart-phone Application for Smooth Path Detection works by utilizing the GPS and various sensors like tri-axial accelerometer, magnetometer, etc. of smart-phone. These sensors are used for analyzing the road irregularity, sharp turns, this data will be uploaded on centralized server so every application user can use this information during travelling. The implemented system is a route suggesting real-time Android Application. The system is based on Road Quality (measured previously) which tells about complexity of road on which we are driving. This complexity is based on sensors data and previous records while the GPS provides location. System is considering standard deviation of accelerometer for y and z axis respectively to determine the bumps and humps on the road. While the magnetometer deviation is used to identify the number of turns in route. Using this information several alternatives will be suggested to the user where he/she can choose for one of the favourable route from source to destination based on road quality and time constraints. Using this system, we can do analysis of the road's smoothness on the basis of number of potholes and bumps and number of turns for the desired path. System provides updated quality of the road to users and government bodies as well. Also, Road Managing Authorities like MSRTC can get advantage of this application to evaluate the state of their road network, and improve road quality.**

***Keywords* — IoT Sensors, Magnetometer, Smart-Phones, Accelerometer, GPS**

I. INTRODUCTION

In today's world smart-phones can be listed as one of the necessities. Everyone uses smart-phone for work, education, etc. In the Pandemic the use of smart-phones increased very much as their importance as well. Smart-phones can be used for collection of the data which is a low cost and easy to use in today's world. In addition to Smart-phone's potentially wide population coverage as probe devices they are embedded with various sensors like Accelerometer, Gyroscope, etc. In the previous systems, various sensors were used and they were attached to vehicles with predetermined orientation. This has been done to estimate road roughness where promising results have been observed.

This application system will take a next step by attempting to estimate road roughness from Smart-phones under extreme realistic settings, which is beyond particular orientation, i.e. the Smart-phone will be loosely fixed inside the monitoring vehicle. Avoiding the bad road condition is a very difficult and challenging task. One of the reasons is that the task requires the precise collection of substantial data and also the amount of road network condition data, which is very important for maintenance, planning and monitoring over time, in addition to the considerable efforts that have to be directed to actual maintenance of the road network.

In many developing countries, the data collection is difficult as they lack in technology. Therefore, the maintenance of road infrastructure is un-attended, making the road quality lesser by the time. Road Roughness is one of the most important measures in the developing countries. The data collected of the road roughness helps the concerned persons to assess the condition and accordingly take the appropriate actions. Road roughness condition is measured by the International Roughness Index (IRI) which has been used widely for road infrastructure maintenance and monitoring for many decades.

II. RELATED WORK

The study conducted by Amita Dhiman and Reinhard Klette [1] Techniques for identifying potholes on road surfaces aim at developing strategies for real-time or offline identification of potholes, to support real-time control of a vehicle (for driver assistance or autonomous driving) or offline data collection for road maintenance. Some of them are gear shifts and overall road conditions which consist of bumps, rough road, uneven road, and smooth road.

The study conducted by Chellaswamy C [2] an internet of things based road monitoring system (IoT-RMS) is proposed to identify the potholes and humps in the road. The IoT-RMS automatically updates the status of the road with location information in the cloud. Each road vehicles can access the information from the server and estimate the speed according to the pothole sand humps present on the road.

Pit-free : Pot-holes detection on Indian Roads using Mobile Sensors [3] by Gaurav Singal proposes a system which makes use of Smart-phone sensors (such as Accelerometer and Gyroscope) to identify the pot-holes on road and GPS for the location of the pit. In this system SVM (Support Vector Machine) had been used to classify the raw data

The study conducted by Azza Allouch [4] is to create a real-time Android Application Road Sense that automatically predicts the quality of the road based on tri-axial accelerometer and gyroscope, show the road location trace on a geographic map using GPS and save all recorded workout entries. A Decision tree classifier is applied on training data to classify road segments and to build our model.

M. Ghadge et. al. [6] used an accelerometer and GPS to analyse the conditions of roads to detect locations of potholes and bumps using a machine learning approach, defined by K-means clustering on training data and a random-forest classifier for testing data. The data is divided first into two clusters of “pothole” or “non-pothole”, and then a random forest classifier is used to validate the proposed result provided by the clustering algorithm. It is reported that clustering does not perform well when clusters of different size and severity are involved; size and severity of a pothole are the major properties considered in the system.

III. ARCHITECTURAL DESIGN

Using Smart-phone’s to collect the data has proven a promising alternative because of its low cost and easy to use features in addition to its potentially wide population coverage as probe devices. Previously, the results are taken when the Smart-phones are arranged by predetermined orientation and fixed on the data collection vehicle for the précised results.

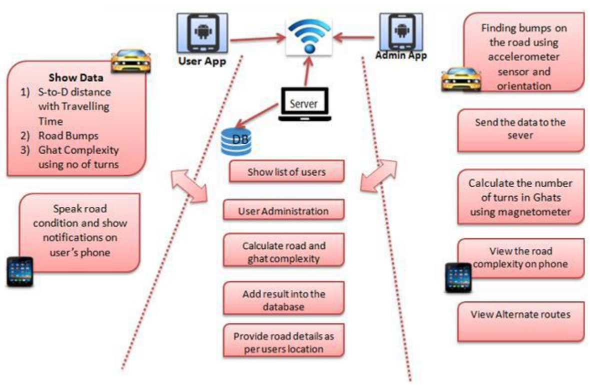

Fig. 1 : System Architecture

Our application will take a further step by attempting to estimate road roughness when the Smart-phones are not fixed in the predetermined orientation. This way we get the more realistic data readings. The Smart-phones will be kept on the seat of car or in the pocket of bike rider, etc. to take the readings in the real-world.

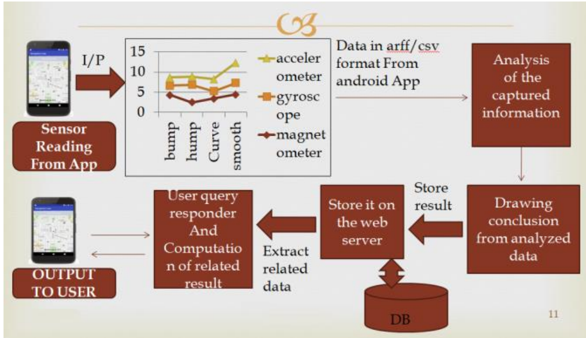

Fig. 2 : Flow Diagram

Application running on the Smart-phone is the lowest layer of implemented system. It collects data from various Smart-phone sensors like accelerometer, gyroscope, etc. to find bad road, bumps, humps, etc.

Afterwards time-stamp and GPS location is attached to data and sent to web server for further processing. Detected bump using the Smart-phone of the admin is then stored onto web server for other users.

To find the turn we use magnetometer of the Smart-phone. In this, a previous angle of Y-axis with North direction is stored and compared with the live one to get the turn as left or right. It is again stored onto web-server to be available for the other users.

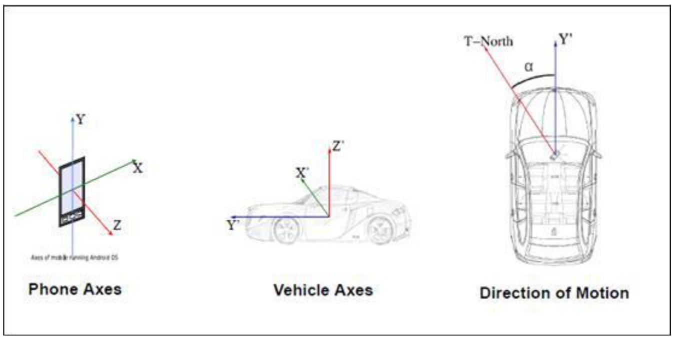

Fig. 3 : Tri-axial Accelerometer, Magnetometer Readings

The more the number of turns, bumps and humps on the road the less is its quality and vice-versa.

Smart-phone sends the accelerometer and magnetometer data with its time-stamp and GPS location over to the web-server which will be received by the REST API’s.

Web service evaluates the data and infers the results in the form of the quality of the road. Quality is represented as, are there many bumps, humps or are there many turns on the ghat road, etc.

The web-server after evaluating the details, shares the data with the users through the running Smart-phone application.

IV. TECHNICAL REQUIREMENTS

The following technical requirements were chosen as a basis for bumps detection system:

- Collection of raw data for offline post-processing is an additional feature.
- Smart phone must have the accelerometer and GPS sensors.
- The system running on a smart-phone should be able to perform its native communication tasks at an adequate quality level.
- Vehicle type should not affect the data collection process.

V. EVALUATION

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 : The sections are appeared with wheel base time. Here, each variable is defined as follows. A recording order number is defined by 'i'. An acceleration data are defined by 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 $SD_y(i)$, $SD_z(i)$. For the condition 1, simultaneity index is defined as $SD_{yz}(i)$, and it is calculated by Equation1,

$$fSD_{yz}(i) = SD_y(i) * SD_z(i) \qquad \text{... Equation1}$$

Cycle number of wheelbase time is defined by N_w. For the condition 2, Bump Index is defined by $B_{yz}(i)$, and it is calculated by Equation 2,

$$fB_{yz}(i) = SD_{yz}(i) * SD_{yz}(i+N_w) \qquad \text{... Equation2}$$

N_w is related with vehicle speed. Vehicle speed is defined as V [m/s]. Wheelbase is defined by L_w [m]. Recording cycle is defined H [Hz]. N_w is calculated by Equation 3,

$$fN_w = (L_w/V) * H \qquad \text{... Equation3}$$

VI. EXPERIMENTAL RESULTS

The logic explained earlier is applied onto the collected data. The 50[ms] standard deviation of Z-axis acceleration or vertical direction $SD_z(i)$ is drawn in following figure, Simultaneity index $SD_{yz}(i)$ is drawn in figure, and Bump index $B_{yz}(i)$ is drawn below:

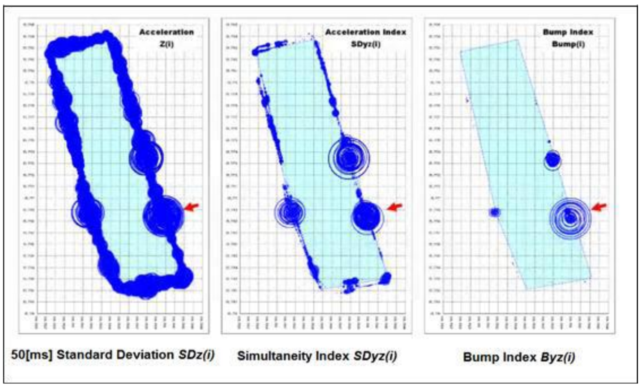

Fig. 4 : Readings of $SD_z(i)$, $SD_{yz}(i)$ and $B_{yz}(i)$ at instance 'i'.

Users get the choice of route based on factors like the quality of the road, maintenance status, accident prone roads, etc. User can choose the road according to his/her relevance.

VII. FUTURE SCOPE

As the data collection is done in the relistic settings, we bound to get many error inputs. In further editions of system our goal is to minimize these errors.

In future, we will try to implement subset of routes to get better at data collection.

Fuel consumption of a particular road based on the quality, this functionality can also be added in future.

VIII. CONCLUSION

Successful data collection can be done using Smart-phone sensors like Accelerometer, Gyroscope and Magnetometer to detect roughness of road as bumps, humps and no. of turns on the road.

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