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Real Time Arduino Based Depth Sensing for Road Condition Monitoring

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Abstract—This paper presents vibration based road condition detection device, which consists of an Arduino based sensing module and an Android based user interface, is designed and implemented. First, the Arduino based sensing module is designed to evaluate the road conditions in real-time and send the evaluation result to the Smartphone through wireless medium. While the Smartphone receives the data from sensing module, the designed Android user interface APP will mark the position with abnormal road condition on Google Maps utilizing GPS of Smartphone. As a result, the drives can change their route for commute and Government can use this potholes locational data for future repairing and development.

Keywords - *Arduino, potholes, Accelerometer, uneven pavements, GPS.*

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I. INTRODUCTION

In the past few years, a lot of research has been carried out on various automated methods for detecting uneven pavements, for that there are various sensing methods from which to methods standout, Vision based and vibration based. Vibration based methods are known to be resources heavy, requiring sophisticated algorithm whereas Vibration based sensing system requires very less resources, and less power Hence vibration based system becomes more feasible but Which sensing methodology to be used depends on the expected output, image based methods use camera technology, camera captures the images in real time. These images are applied to image processing algorithms like edge detection. This requires lot of processing time and power.

This method has one advantage over the other is, it can sense a pothole without experiencing it i.e. Vehicle does not actually has to pass through the pot hole to sense it. Characterization of pothole can be done on the basis of size of the pothole. In contrast to Vibration based method which employs accelerometer; this is a device that measures total specific external force on the sensor. For example if the device is stationary, it will show some reading corresponding to earth's gravitational force. An accelerometer falling freely in the vacuum will show zero reading. The design of the accelerometer is often very simple. The simplest design can be a mass hanging by a thread and some sensor to measure its deflection for original.

The device is popularly used to measure vibration or inclination. We in our pothole detection system we will be using accelerometer MMA7361 which is +3V accelerometer, for sensing vibration caused by vehicle which embedded our sensing module passing over the pothole. Implemented system consist of two broad area Transmitter and receiver, Arduino based hardware module act as a Transmitter module which sense the potholes in real time send those vibration values (output at X, Y, Z pin of MMA7361) to the user Smartphone connected over Bluetooth transmission as soon as Smartphone receives information packets, Application marks the location of pothole in Google Map which is preloaded in the designated Android Application.

II. EXISTING SYSTEMS

The most common approach for detecting road condition is using sensors to recognize the vibration patterns of the vehicle caused due to any deformity or obstacle on the road. A major part of work is done using the sensors deployed in the mobile vehicles for collecting road roughness data to detect road anomalies. As the number of Smartphone users is increasing, methods using Smartphone sensors are also developing. Most of the methods use tri-axial accelerometer and GPS to collect the data for analysis. This section provides the methods/systems/algorithms for detecting road anomalies like potholes. Part A describes the methods that require dedicated sensors to be deployed on the vehicles. The methods that use Smartphone present in vehicles as the source of collecting sensor data are discussed in Part B. A. Methods using separate sensors Hull et al, CarTel [1], proposed distributed system.

This system includes group of sensors installed on vehicles to collect and process data and send it to Commute and traffic portal, based on that continuous queries which are processed designated continuous query processor on distant nodes. It uses GPS for monitoring the movements of vehicles. CarTel includes, CafNet, a networking stack that uses connection (e.g. Wi-Fi, Bluetooth) to transfer information between portal and remote nodes. These information can be used for various applications such as time of travel, route planning. CarTel currently does not offer a way to aggregate information gathered across different users and it does not include machine learning; it just replies to the queries based upon the data stored in relational database. Pothole Patrol system [2] uses 3-axis accelerometer and GPS mounted on the dashboard to monitor road surface. It is addition of machine learning algorithm to CarTel for automatically classify and verify potholes.

It receives the signals using accelerometer. It uses machine learning algorithm to identify potholes. These signals are then passed through a series of signal processing filters, where each filter is designed in such a way that server processes this vibration data using signal processing and data correlation techniques to assess surface conditions. B. Road Condition Detection Using Smartphone Sensors RCM-TAGPS [3] system collects the data using three-axis accelerometer and GPS.

The sensor data has 4-varibale: current time, location, velocity and three direction accelerations. This system also does the data cleaning before processing or analyzing it to deal with technical challenges like GPS error, transmission error. This system analyses the Power Spectral Density (PSD) to detect pavement roughness using Fourier transform. The International Roughness Index (IRI) is calculated based upon PSD. The pavement roughness is then classified in four levels (excellent, good, qualified and unqualified) according to, the Technical Code of Maintenance for Urban Road CJJ36-2006 [8], one of the industry standards in the People's Republic of China.

This standard evaluates the pavement roughness by Riding Quality Index (RQI). Based upon the value of RQI, the pavement roughness is classified. This system provides the evaluation of a section of road based upon its roughness. This system does not provide the proper location of pothole, bump or manhole.

Nericell [4] utilizes portable Smartphone to screen street and movement conditions. It recognizes potholes, braking, knocks and blares utilizing accelerometer, receiver, GSM radio and GPS sensors present in PDAs. It utilizes activated detecting where the operation a high vitality expending sensor (GPS, mouthpiece) is actuated by a low vitality devouring sensor (accelerometer, cell radio) making the framework vitality effective.

It utilizes most grounded sign (SS)- based confinement calculation, so that the significant area can be labeled with detected data, for example, blaring or knock. It utilizes GSM radios for vitality effective limitation. This framework utilizes Smartphone and its installed accelerometer to identify the different occasions. The telephone can lie at any subjective introduction and, thus, its inserted accelerometer. Subsequently, it must be arranged along the vehicles pivot before breaking down the signs. This framework utilizes a calculation based upon Euler plots for reorientation. The sensor is practically pivoted along the vehicles hub utilizing prorogation, tilt and post-turn points (Euler edges). The post revolution point is figured utilizing GPS, so to keep away from additional vitality utilization the pre-pivot and tilt edges are checked ceaselessly and at whatever point there is any huge change in these edges, GPS is turned on and reorientation procedure is done once more. It distinguishes the braking occasion by examining the y estimation of accelerometer. In the event that the quality is over a specific limit esteem then it will appear as a braking occasion. It gives a false negative rate of 4-11% for braking occasion.

This framework can likewise separate amongst unpredictable activity and people on foot based upon the greatness and recurrence of the estimations of accelerometer. It distinguishes knock based upon the z-estimation of accelerometer. It gives two heuristics based upon the rate of the vehicle. On the off chance that speed is more noteworthy than 25kmph, it utilizes z crest heuristic where a spike along z-esteem over a particular edge is named a knock. At low speed, z sus heuristic is utilized which distinguishes a maintained plunge in z-esteem for no less than 20ms. It gives a false positive rate of under 10% and false negative rate between 20-30%. Mednis et al., [5] proposed a framework which utilizes Android OS based Smart-telephones having accelerometer sensor for recognition of potholes progressively. This framework distinguishes occasions continuously furthermore gathers the information for disconnected from the net post handling.

The information is gathered utilizing 3-hub accelerometer sensor present in Smart-telephones. They have proposed four calculations for recognition of potholes. The initial two calculations (Z-THRESH and Z-DIFF) are for continuous identification and the other two (STDEV(Z) and G-ZERO) are utilized for disconnected from the net post-handling of information. Z-THRESH calculation orders the estimations based upon the qualities above particular limit level for distinguishing the kind of pothole (little pothole, group of potholes, substantial potholes). Z-DIFF calculation figures the contrast between two

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successive values and looks for the distinction surpassing particular limit.

This calculation recognizes quick changes in increasing speed information in vertical bearing. STDEV(Z) calculation ascertains standard deviation of accelerometer information in vertical course over a predetermined window time. This calculation orders the occasions based upon the standard deviation esteem surpassing a particular edge level. G-ZERO calculation utilizes free-fall occasion happening just between entering the pothole and leaving it. This calculation looks for the tuple where all the three-hub information qualities are close to 0g. This information tuple demonstrates vehicle is either entering or leaving a pothole i.e. it is in a provisional free fall. Z-THRESH, Z-DIFF and STDEV(Z) calculations accept that the position of accelerometers Z-hub is known. G-ZERO calculation can break down the tuple without data about z pivot position. This framework gives a genuine positive aftereffect of 90% (approx.).

Wolverine [6] technique utilizes Smartphone sensors for activity state observing and discovery of knocks. It utilizes accelerometer sensor to gather the information. The gadget (telephone) is to be reoriented as it can have arbitrary introduction when kept inside the vehicle. This framework reorients the telephone in two stages utilizing accelerometer and magnetometer. In initial step, telephones tomahawks are adjusted to geometric tomahawks. At that point, a revolution lattice is framed utilizing Gravity Vector given by accelerometer and Magnetic Vector given by magnetometer. This pivot framework speaks to the points of turn of gadgets tomahawks so to adjust to geometric tomahawks. In second step, the new gadgets tomahawks are adjusted to vehicles tomahawks. The heading of movement of vehicle is found utilizing GPS to discover the edge of movement of vehicle with attractive north to change the gadgets tomahawks towards vehicles tomahawks. This framework identifies two occasions i.e. braking and knock. The knock occasion is identified by the standard deviation on window of one second length with examining rate of 50 readings for each second over the z-pivot esteem. The braking occasion is distinguished by utilizing the contrast between the most extreme and least esteem inside a window for y-pivot esteem. The sensor information is arranged utilizing k-implies grouping calculation into two classes which is marked physically as either smooth or rough (for knock discovery) and brake or not (for braking location). This named information is utilized to prepare Support Vector Machine (SVM) for grouping of information focuses amid test stage for vehicle state forecast.

Singh et al., [7] proposed a cell telephone application that utilizations GPS, accelerometer and mouthpiece to gather the information. This application identifies street and movement conditions alongside driving conduct. This application is utilized to identify different occasions based upon the examples watched. This application does not utilize machine learning. It is totally based upon the examples got from the sensor information. The greater part of the above portrayed techniques have utilized accelerometer and GPS for gathering the information and o premise of those information settling on choice. Some of these strategies have additionally utilized machine learning calculations to incorporate self-adjustment usefulness in the framework, to enhance the execution of the framework extra minutes. Position figures and tables at the tops and bottoms of segments. Abstain from putting them amidst segments. Expansive figures and tables may traverse crosswise over both sections. Figure inscriptions ought to be focused beneath the figures; table subtitles ought to be focused previously. Abstain from setting figures and tables before their first say in the content. Utilize the shortened form Table. 1, even toward the start of a sentence. Figure pivot names are regularly a wellspring of perplexity. Use words instead of images. For instance, compose Magnetization, or Magnetization (M) not simply M. Placed units in brackets. Try not to mark tomahawks just with units. In the case, compose Magnetization (A/m) or Magnetization (Am1). Try not to name tomahawks with a proportion of amounts and units. For instance, compose Temperature (K), not Temperature/K.

TABLE I SYSTEM AND IMPLEMENTED SENSORS AND INCORPORATION OF MACHINE LEARNING

System	Sensors	Incorporation of Machine Learning
CarTel [1]	802.11x, Camera	No
	and ODB	
Pathole Patrol [2]	Accelerometer, GPS	Yes
RCM - TAGPS [3]	Accelerometer, GPS	No
Nericell [4]	Accelerometer, GPS,	No
	GSM Antenna, Microphone	
Wolverine [6]	Accelerometer, GPS	Yes
	Magnetometer	

III. IMPLEMENTED SYSTEM

System consist of two major component Part A is hardware side which consist of supporting hardware component and Part B is software side an Android GUI Application. A. Hardware side of system Hardware side or sensor system is consist of Arduino UNO R3 a low power computer with ATMega162 microcontroller on which we implemented Z-DIFF algorithm.3- axis accelerometer MMA7361 has selected from wide ranges of accelerometer available in the market it

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consist of three output pin X, Y, Z which gives out 3 dimensional vibration reading which is tunneled to ADC pin of Arduino UNO R3 and convert analog input from MMA7361 to digital output. For transmitting digital output of Arduino to the smartphone which already installed and running our android application Bluetooth component RN42 has been used. Bluetooth maintain real-time wireless connection between hardware and software side.

B. Software side of system

Software side is a dedicated Android application consisting of Google Map which shows the potholes as soon as detected by the sensing hardware, Application not only pin the position in the Google map, but also create a log file which stores the latitude and longitude of detected potholes. After successful.

IV. SYSTEM IMPLEMENTATION AND WORKING

Whole system is divided into inter-dependent component. Part A consist of hardware implementation, whereas part B deals with Software framework of the Android based GUI.

A. Hardware Connection

On hardware side Arduino ADC0,ADC1,ADC2 pins are directly connected to MMA7361 X,Y,Z pins.MMA7361 three pin X,Y,Z gives out analog vibrational values which directly tunneled to ADC0,ADC1,ADC2 pins of Arduino board. To convert those Analog values to digital one special program is written in microcontroller of Arduino UNO R3 board. Voltage regulator AMS1117 is incorporated to step-down the voltage level for RN42, Bluetooth module, which works on 3.3V The pins TX and RX of RN42 are serially connected to pins RX, TX of Arduino UNO R3 board respectively which transmits and receives data accelerometer which in turn gives output to Arduino where further processing on analog data takes place and if implemented algorithm flag received data to be valid data then that valid data is transmitted to Bluetooth module, through RX. Block diagram can be seen in following diagram Fig.1.

B. Software implementation

An android Application is built in Android Studio which have Google map integrated into it the GUI application contains buttons a login page so each user can be authenticated, the map inside the GUI application gets instantiated when pothole sensor sense its first pothole, the latency rate is very low because GPS is set to High Accuracy mode which by itself set upper bound on error, so the time taken by Sensor to sense pothole and Application to show in Map is very low which makes potholes detection location pinpoint. Following is the working of the system.

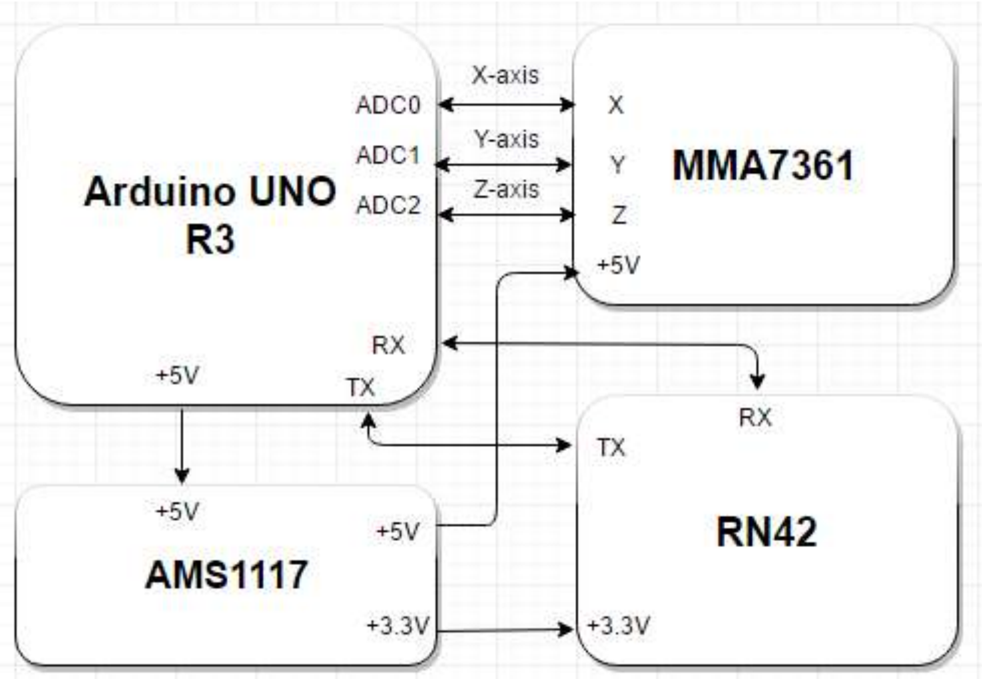

Fig. 1. Block diagram

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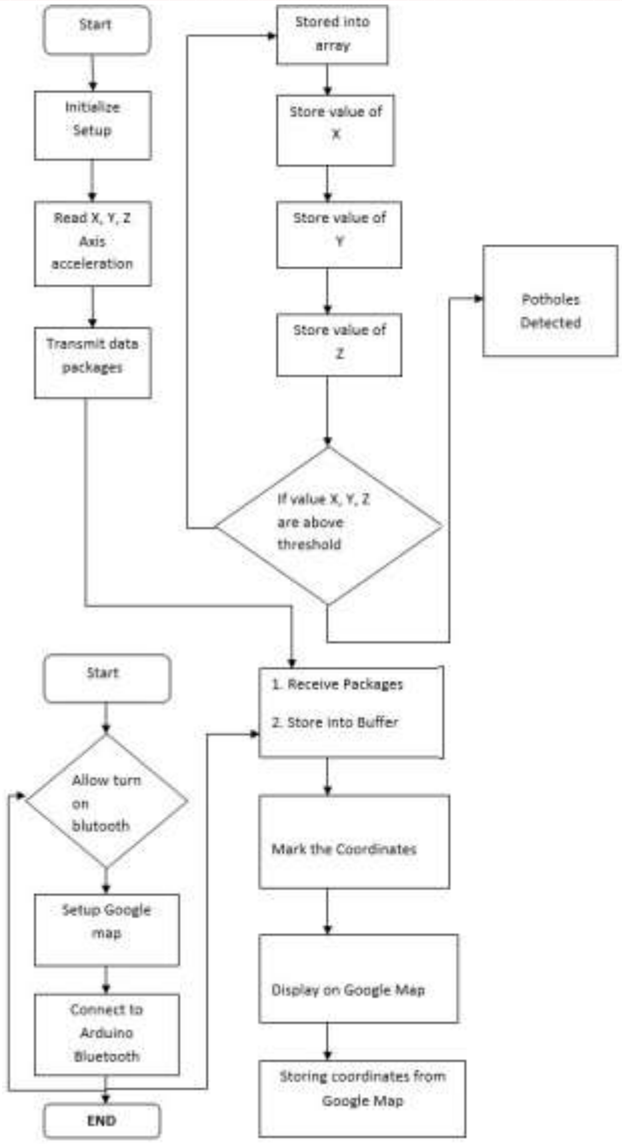

Fig. 2. Flow chart of system

V. RESULTS ANALYSIS

Experimental setup is shown in Fig. in which YUREKA YU Android phone is used. The experimentations are proceeded on the partial section of the road under the Vithallwadi-Kalyan west flyover. In the experimentation, the vehicle traveled the road with constant velocity 30 km/hour and the all threeaxis acceleration is measured in real-time. When the sensing module detects this abnormal road condition, the smartphone will save the driving raw data in user space or SD card of phone immediately and show its position on Google Maps as shown in the fig. Therefore, if all or most vehicles running on the roads install our Arduino based sensing modules, the complete road information can be collected.

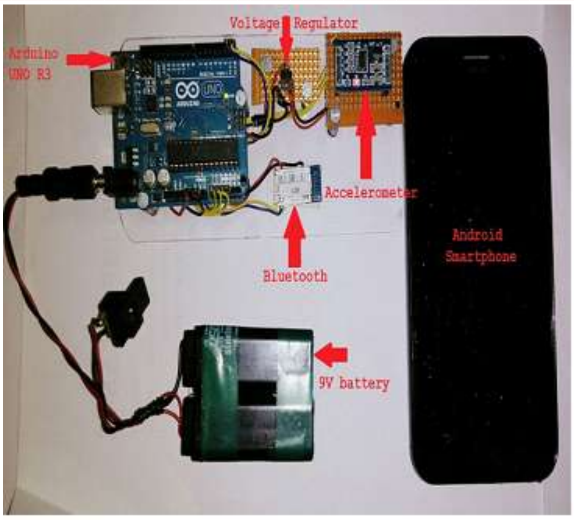

Fig. 3. Experimental Setup

Fig. 4. Stored Text File containing Latitude and Longitude of Potholes

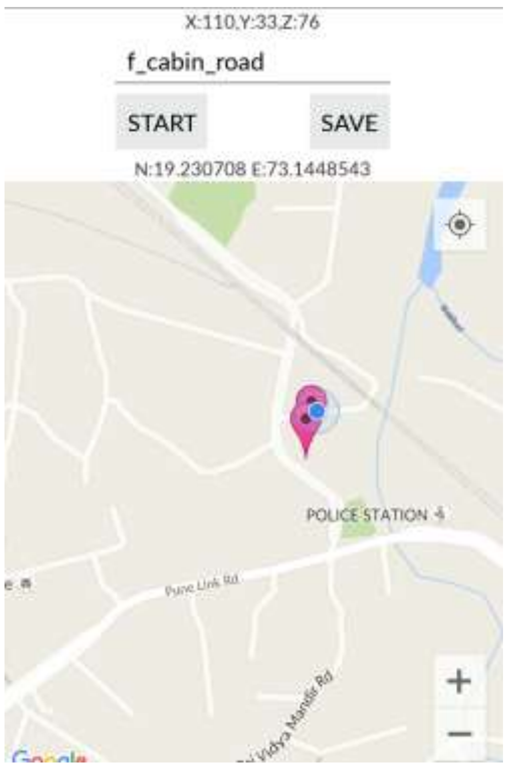

Fig. 5. Detected potholes during experiment

VI. CONCLUSION

The proposed pothole detection system including an Arduino based sensing module and an Android smartphone based user interface is developed for vehicle who has to go ordeal of driving on uneven roads

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are successfully tested and designed. According to the real-time potholes detection, the location of abnormal road condition can be detected and saved in open source traffic data center in the future. Thus, the drivers of the vehicles can obtain nearby road condition information from the other vehicles via wireless signals which user will continuously and repeatedly transmitted to each other or highlighting Google Maps for showing road condition to change their driving routes or driving behaviors for improving driving safety, comfort and efficiency.

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