POTHOLE DETECTION SYSTEM USING IoT

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***Abstract* - The roadways constitute the major part of the transport system, but the major drawback in hassle-free road transportation in the presence of potholes which are formed due to heavy rains and vehicle movement. Due to the presence of potholes, large numbers of road accidents take place in India every year. To overcome this fatal problem of accidents on roads the accident detection system can be used to save the lives of the injured people by spotting the accident-location and alerting the nearest ambulance. But there is always a chance of life-loss. Instead, the emphasis should be on preventing the pothole-caused accidents by locating the potential potholes. This project aims to produce a pothole detection and notification system. Our proposed model mainly deals with detection of potholes using vibrational techniques in which sensors like accelerometer, ultrasonic sensor and Arduino etc. are employed to detect a change in the motion of the vehicle. Once a pothole is encountered, the detected location is determined using a GPS module and sent to the cloud storage which can be informed to the road authorities for repairing if needed.**
***Keywords* -** Potholes, Ultrasonic sensor, Accelerometer sensor, Arduino UNO, GPS module, Cloud storage.

I. INTRODUCTION

The development of a country is measured with the condition of its roads and their maintenance. Good road conditions offer an ease in transportation and ensures the dynamic nature. But, road accidents, which occur due to a variety of reasons, pose a major problem in smooth operation of transportation system. One such reason which brings hurdles in a hassle-free road transportation is the presence of potholes, which multiplies the risk of such accidents. Hence it implies to the need for an immediate repair of potholes by the authorities.

The increase in the number of pothole caused road accidents often leading to fatal injuries, poses a need for an urgent solution to the problem. According to a survey, a total of 3597 deaths occurred due to potholes in the year 2017 and the count is increasing every year. This requires efforts from the government side to be more cautious. Moreover, providing pothole location information to the government officials will help them in repairing the damaged roads which can bring down the count of pothole caused casualties. A lot of research is presently being carried out to estimate the road surface to determine the presence of potholes. To achieve the same, there are two different approaches, which include, the vision- based approach and the vibration-based approach. Out of the two, the vision based technique revolves around capturing the road images and applying complex image processing algorithms to detect the potholes. The vibration-based approach or the sensor-based approach deploys the usage of sensors to detect the potholes by actually passing through it. This method can also be used to determine the intensity of pothole apart from just detecting them. One advantage of this over the other is, it doesn't require complex algorithmic approach or large processing power.

The project's hardware consists of an Arduino-based sensing model working with ultrasonic sensor and accelerometer sensor or g-sensor. Based on the sensor data, the pothole locations can be determined and sent to a cloud storage, which can be accessed by the government officials in order to rectify them.

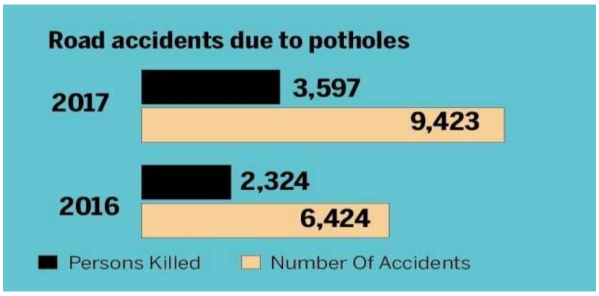


Fig.(1) : An increase in the number of pothole- caused accidents in two successive years.

II. EXISTING SYSTEMS

The most common approach for detection of potholes is by using sensors, which detect the abnormalities on roads. As a part of understanding the existing systems, we studied a few related works and came up with the following conclusion that, vibrational technique, in general sense is a cost-effective and simple approach for road-condition monitoring. One such work is [1], which aims at detecting potholes and avoiding road accidents, by using ultrasonic sensor, accelerometer sensor, Arduino UNO, GPS module, GSM module along with an Android smart phone and software requirements like IDE and Android Studio 2.3.3. The other related work [2], makes use of single sensor, namely the accelerometer sensor and the Arduino board along with smart phone based user interface, where the data is transferred using Bluetooth. Similarly, [3], has an approach based on an android app as a user interface to display the location of potholes detected by the G-sensor, Arduino and Bluetooth-enabled communication. Another related work [4], describes the pothole-detection process by using ultrasonic sensor, PIC microcontroller, IoT board, voice IC, LCD display and speaker to alert the driver about the pothole.

Here it is observed that, all related works are clearly aimed at alerting the driver of the vehicle. From the above observation, the common approach followed in the existing techniques, can be explained in three sub-parts:

i) Sensing Subsystem: It refers to collection of sensor data in order to detect the pothole.

ii) Centralization: A centralized remote database is used to store and access the location coordinates of the potholes detected.

iii) Localization: Sending the pothole location details to alert the driver.

But the accuracy of the sensing subsystem decreases as the sensors are mounted over the user-vehicles, which often move at high speeds. So, by the time, the sensors detect a pothole, locate it and alert the user, the vehicle will actually cross the pothole.

III. IMPLEMENTED TECHNIQUE

The proposed model in this paper provides a solution to the pothole problem by adopting vibrational methods which operates by means of sensors mounted on the vehicle. The figure below depicts the entire concept.

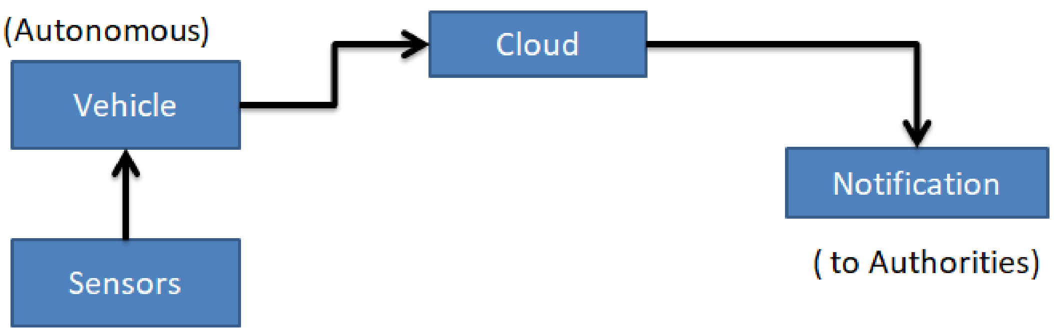


Fig.(2) : Generalized diagram of the implemented technique.

The main aim of the suggested method is to increase the effectiveness of the existing technique, i.e, instead of alerting the driver, if the pothole location co-ordinates are sent to the government authorities responsible for road maintenance, it becomes an easy task to repair the damaged roads.

To achieve the same, instead of a user-driven vehicle, an autonomous, slow-moving vehicle(like the Municipality sweeping machines) with sensors mounted on it can be used to detect the potholes over large stretches of roads. The location data can be continuously monitored by the government officials who are provided the access to the cloud storage. The location readability can be further improved by using Google maps and entering the location co-ordinates manually.

V. BLOCK DIAGRAM

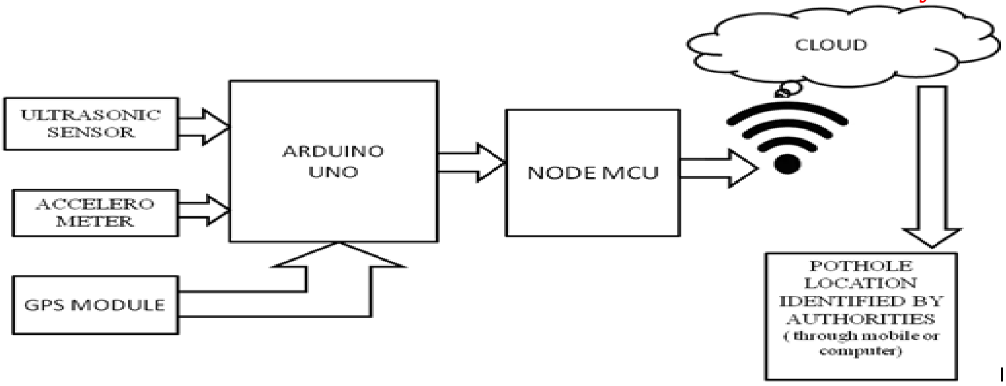


Fig.(4): Block diagram of Real time pothole detection and notification system

HARDWARE SPECIFICATIONS :

The hardware components used to build the above –mentioned prototype, are described below:

Ultrasonic sensor (HCSR04):

It is a distance sensor, used to determining the proximity of an object without any physical contact involved. It consists of two special pins namely 'trig' and 'echo', which send the ultrasound signal and receive (after colliding an obstacle) respectively. The below mentioned basic equation, can be used to determine the distance.

Distance = Speed x Time

where, speed = speed of sound

time = time for which the 'echo' pin is high.

Ultrasonic sensor operates at a voltage of 5v, connected to the 5v pin of Arduino UNO and the ground terminal connected to the Arduino ground pin. Practically, it can measure distances ranging from 2cm to 80cm and operates at a frequency of 40kHz.

Fig.(5) : An ultrasonic sensor

Accelerometer sensor (ADXL335):

It is an electro-mechanical device, that will measure the accelerometer force. It is the triple-axis accelerometer, with signal conditioned output voltages, to measure the static acceleration of gravity in tilt-sensing applications, resulting from shock or vibrations etc. The resulting X,Y,Z voltages are analog in nature. This sensor operates within a voltage range of 1.8v to 3.6v.

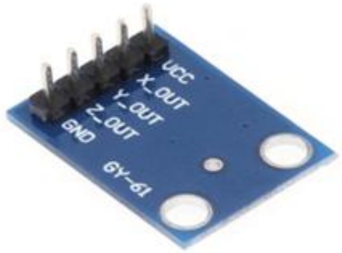


Fig.(6) : A triple-axis accelerometer sensor

Arduino Uno:

The Arduino Uno is a microcontroller board based on the ATmega328.It has 14 digital input/output pins in which 6 of them can be used as PWM output pins, 6 analog pins, 16MHZ crystal oscillator, a USB connection, a power jack, ICSP pins and a RESET pin. It contains everything which is needed to support the microcontroller by simply connecting it to a computer with a USB cable we can start the process in the Arduino. Connecting it to a PC (personal computer), with a USB cable , the code can be dumped in the board and the desired functionality is performed.

Fig.(7) : An Arduino Uno board

Node MCU :

The nodeMCU is a development board, particularly used for IoT applications and hence also referred to as IoT board. It communicates the data over the internet with the help of an on-board ESP8266 wifi chip, designed by Espressif systems. It can be programmed by the Arduino IDE, by changing the board configuration to nodeMCU. In this project, the nodeMCU directly sends the sensor data to the Blynk cloud.

Fig.(8) : Node MCU board

GPS module :

The GPS is short for "Global Positioning System",a space based radio navigation system owned by the government of US. It is a global navigation satellite system, that provides the geo location and time information to the GPS receiver anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. The GPS module, NEO-6M acts as a GPS receiver, which continuously tracks the GPS satellites and receives location information in the form of NMEA sentences.

The NEO-6M GPS module operates at a voltage of 5v, and has, two separate pins for transmission and reception of location data. It consists of a patch antenna connected through a UFL connector. A tiny LED present on the module indicates the satellite-fix. The below shown, is the image of it:

Fig.(9): GPS NEO-6M module

SOFTWARE SPECIFICATIONS :

To build any particular project, the software plays an equal and important role, as the hardware, since any desired functionality can be performed by the software tools. The two software tools utilized in this project are described below:

1) Arduino IDE :

An Integrated Development Environment (IDE) is a software which is used to program, various boards of the Arduino family and others. It consists of editor, compiler etc. for writing code and compiling it. Arduino IDE has a serial monitor, where the outputs of the code are displayed. Arduino IDE is compatible for many development boards and also supports software libraries. The IDE version used is 1.8.12 of the Arduino software.

2) Blynk application :

Blynk is a platform that allows users to, quickly build the interfaces for controlling and monitoring the hardware projects from iOS and Android device, remotely. It is also an open source platform for both the Blynk server and Blynk library. In Blynk we can create a local blynk server, which allows users to keep everything within our own network. As it is free and open-source under an MIT license.

VI. SCHEMATIC CIRCUIT DIAGRAM

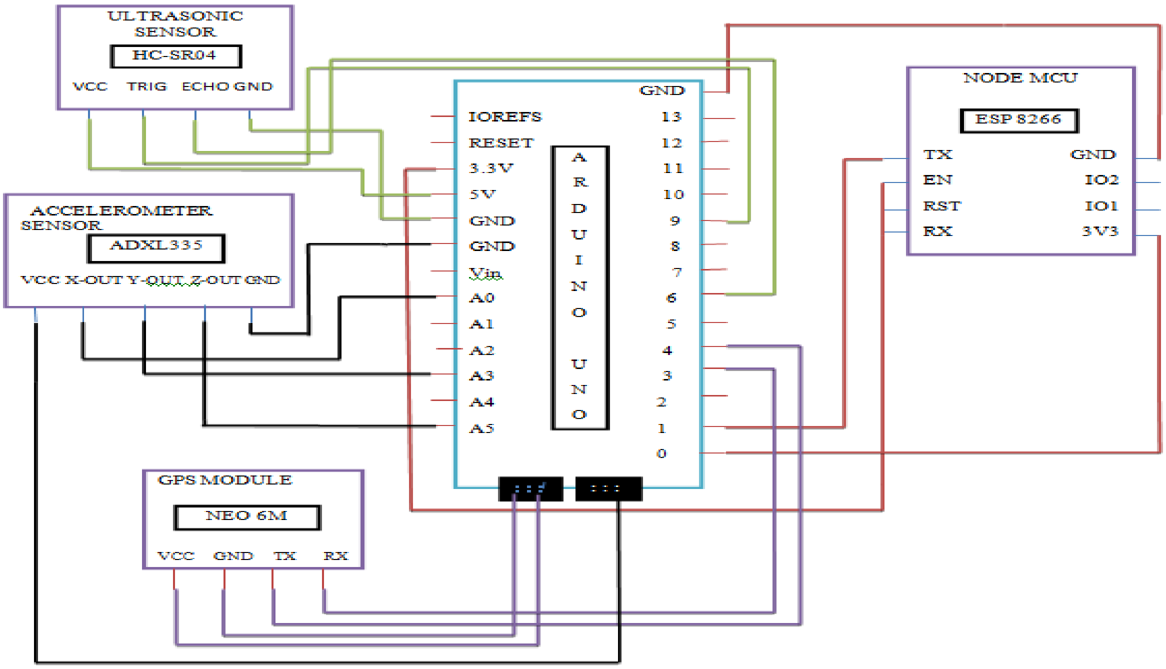
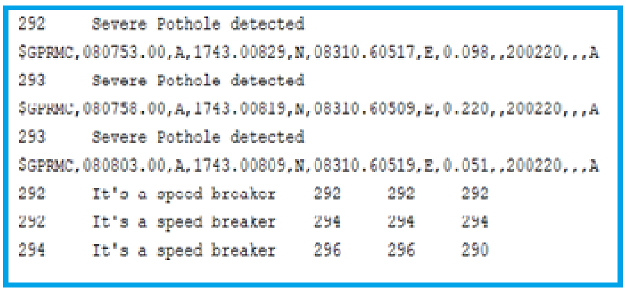


Fig.(10): Schematic of Proposed Hardware

The above schematic circuit , shows the actual connection of hardware used in the project. Any basic sensor consists of I/O pins apart from the supply and ground. As per the required supply voltage, ultrasonic & accelerometer are connected to 5v and 3.3v respectively. According to the connections mentioned in the code, hardware connections of trigger, echo, X, Y and Z are also made. GPS module (NEO-6M) connected to 5v supply, Tx and Rx pins connected as per code. The nodeMCU is connected to a 3.3v pin and data transfer takes place through Tx-Rx pins.

VII. RESULTS

The results obtained in the implemented technique are the ones obtained on slightly uneven road with a few critical potholes. After building the complete prototype, it was made to move over a road near our college premises of length 10m and 6 feet wide in dimensions, having a few potholes of sizes ranging from 15cm to 20cm of depth. This prototype gave accurate results. The glimpses of the outputs obtained, are shown below :



```
292    Severe Pothole detected
$GPRMC,080753.00,A,1743.00829,N,08310.60517,E,0.098,,200220,,,A
293    Severe Pothole detected
$GPRMC,080758.00,A,1743.00819,N,08310.60509,E,0.220,,200220,,,A
293    Severe Pothole detected
$GPRMC,080803.00,A,1743.00809,N,08310.60519,E,0.051,,200220,,,A
292    It's a speed breaker    292    292    292
292    It's a speed breaker    294    294    294
294    It's a speed breaker    296    296    290
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Fig.(12): Location details displayed in Serial monitor

While programming the prototype, the working can be directly monitored with the help of a serial monitor available in the Arduino IDE. It is best suited for debugging, since it displays the outputs. Fig.(12) shows the output, i.e the location details of the pothole along with differentiating it with a speed breaker. As per the prototype, the potholes detected can be classified as severe & small and also differentiates a pothole from a speed breaker. The fig.(13) shows the pothole location details being displayed in the terminal window of the Blynk app. This makes it easy to note the location details of the pothole.

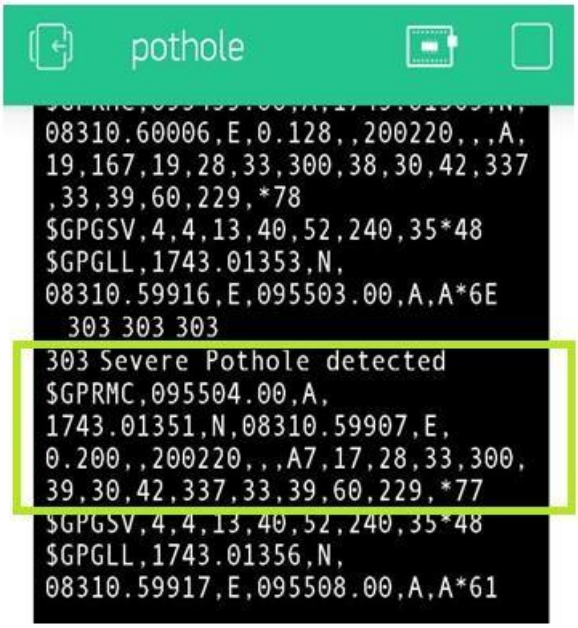

Fig.(13): Location details displayed in Blynk terminal

As mentioned earlier, the main aim is to send the pothole location details to the road authorities. This is achieved by wirelessly sending data through the WiFi module (nodeMCU) and Blynk app. The person-in-charge can access the data by a device connected to internet, which can be a smart phone. The Blynk terminal directly displays the location details, simultaneously storing data into the cloud. The obtained location details (including date, time etc.) in terms of NMEA sentences can be manually decoded easily.

EX: $GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230220

$	Every sentence starts with '$'
123519	Current time
A	Status active
4807.038	Latitude
01131.000	Longitude
022.4	Speed
084.4	Angle
230220	Date

TABLE 1- Table showing the parsing details of NMEA sentences

Here, NMEA stands for "National Marine Electronics Association", which is the standard form of the location data received by the GPS module. It is the protocol supported by all GPS manufacturers.

VIII. CONCLUSION

The proposed model makes use of the vibrational technique for the detection of potholes on roads. This method primarily makes use of sensors and other modules to detect the presence of deadly potholes. The sensors like ultrasonic and accelerometer are used for this purpose, where the former measures the pothole intensity and the latter detects the sudden tilt occurred in vehicle due to pothole.

The location coordinates of the corresponding detected potholes are determined by utilising the GPS module at the instant of pothole occurance. These are then sent to a remote server(cloud) wirelessly through WiFi by making use of a nodeMCU board.

The cloud is provided by the Blynk, which also acts as the user interface and is made accessible to the government authorities responsible for road maintenance. The entire model described is more feasible for an autonomous , slow-moving vehicle with on-board sensors. Overall, it is an attempt made to reduce the number of potholes, in order to nullify the count of pothole-caused accidents, by notifying the issue to the road authorities.

IX. FUTURE SCOPE

This model can be further extended to predict the occurance of majority of potholes ,i.e, at the edges or in the center of the roads by using machine learning tools.

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