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Automatic Detection and Notification of Potholes and Humps on Roads using IoT

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Abstract - *One of the prime reasons for vehicular accidents is due to undetected potholes and road humps. Well maintained roads contribute a major portion to the country's economy. The importance of road infrastructure society could be compared with importance of blood vessels for humans. To ensure road surface quality it should be monitored continuously and repaired as necessary*

In this paper ultrasonic sensor are used to identify potholes and humps to measure their depth and height respectively. This provides a prototype of an IoT based potholes and hump detection system that can be integrated with the vehicle and provide timely information to maintenance authorities so that necessary steps can be taken for safety of drivers.

Key Words: IoT, NodeMCU, ultrasonic sensor, GPS module.

1. INTRODUCTION

Dangerous road surface conditions are major distractions for safe and comfortable transportation. Both drivers and road maintainers are interested in fixing them as soon as possible. However, these conditions have to be identified first[1].

A prime concern of the current transport industry is the provision of sustainable transport through the improvement of efficiency, quality, safety & the reduction of the impact of energy use on the environment. It is estimated that more than 30% of the accidents are caused by environmental conditions. Therefore, in order to achieve a good environmental protection, and to keep a low accident rate, especially in large towns, having a healthy road infrastructure is a major first step forward[2].

Road humps are made to curb vehicle speed, but many humps are made with uneven and unscientific heights and in unexpected intervals. Sometimes timely road signs are not provided to warn drivers to slow down for an upcoming road hump, which results in accidents or vehicle damage. The system is made to also detect road humps and provide timely alerts to drivers[3].

2. Litreature Review

Jin Lin, et al [4], have proposed a method for pothole detection based on SVM (Support Vector Machine). This method distinguishes potholes from other defects such as cracks. The images are segmented by using partial differential equations. In order to detect potholes, the method trains the SVM with a set of pavement images. However, the training model fails to detect the pavement defects if the images are not properly illuminated

Sudish surandharan et al [5] has proposed a potholes and pitfalls spotter. In this method the sensor which is used to record the vertical and horizontal accelerations experienced by the vehicle on its route while a GPS device separate logs its corresponding GPS coordinates. The collected data can be then processed to locate potholes along the path traversed earlier by the vehicle

Youquan et al.[6] have developed a model which employs optical imaging principle of three dimensional projection transformation to obtain pictorial information of pothole's cross-section in pothole detection. Multiple digital image processing technologies, including: binarization, image processing, thinning, three-dimensional reconstruction, error analysis & compensation are conducted in the series of image analysis and processing.

Ajit Danti, et al. [7] have developed a model based on Image Processing approach. In this paper Haugh Transformation is given for lane detection. Clustering based algorithm is used for detection of potholes. In this, experimental results are tested with real time image database.

Kongyang Chen, et al [8] proposed a system for detecting potholes using GPS sensor & three-axis accelerometer. The outputs are taken from the GPS sensor & three-axis accelerometer and fed into data cleaning algorithm. In the second part of the implementation the inputs to the algorithm are processed for power spectra density (PSD) to calculate the roughness of potholes. After analysing, roughness is classified into different levels

3. COMPONENTS REQUIRED

The components required and the proposed system.

3.1 Arduino Compiler

Arduino IDE is a GUI based Software that supports all the Arduino based microcontrollers. It is a cross platform application written in the programming languages C, C++ & Java. It runs on various operating systems like Windows, Mac OS and Linux.

3.2 NodeMCU

The NodeMCU (Node Micro Controller Unit) is an open source software & hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains all crucial elements of the modern computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for IoT projects of all kinds.

However, as a chip, the ESP8266 is also hard to access and use. One must solder wires with the appropriate Analog voltage to its PINs for the simplest tasks such as powering it on or sending a keystroke to the "computer" on the chip and you must program it in low level machine instructions that can be interpreted by the chip hardware. While this level of integration is not a problem when the ESP8266 is used as an embedded controller chip in mass-produced electronics, it is a huge burden for hobbyists, hackers, or students who want to experiment with it in their own IoT projects.

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area.2. AES is a symmetric block encryption algorithm. The size of the encrypted block can be 128 bit, 192 bit or 256 bit [9].

3.2 Ultrasonic Sensor

HC-SR04 ultrasonic sensor is a 4 pin module, whose pin names are Vcc, Trigger, Echo & Ground respectively. It has two projections, one to transmit the ultrasonic waves, and the other receives the echo that is reflected back from an obstacle. The distance is calculated based on the time taken by the ultrasonic pulse to travel a particular distance as follows

$$\text{Distance} = (\text{Time} \times 343\text{m/s})/2$$

We power the Sensor using a regulated +5V through the Vcc and Ground pins of the sensor. The current consumed by the sensor is less than 15mA & hence can be directly powered by the on board 5V pins. The Trigger & the Echo pins are both I/O pins & hence they can be connected to I/O pins of the microcontroller.

To start the measurement, the trigger pin has to be made high for 10uS & then turned off. This action will trigger an ultrasonic wave at frequency of 40Hz from the transmitter and the receiver will wait for the wave to return. Once the wave is reflected by any object the Echo pin goes high for a particular amount of time which will be equal to the time taken for the wave to return to the sensor. The amount of time during which the Echo pin stays high is measured by the MCU as it gives the information about the time taken for the wave to return to the sensor.

3.3 Bluetooth Module HC-05

The Bluetooth module HC-05 is a master/slave module. By default, the factory setting is slave. The role of the module can be configured only by AT COMMANDS. It typically has -80dBm sensitivity and up to +4dBm RF transmit power. It has a voltage range of 3.3 to 5 V I/O. The module has PIO control and UART interface with programmable baud rate. HC-05 comes with an integrated antenna and edge connector

4. PROPOSED METHODOLOGY

The proposed system consists of an ultrasonic sensor that senses the distance between the vehicle & the pothole/hump. The sensor provides the distance values to the microcontroller. Based on the distance, an indication is provided to the driver through voice commands. Further,

the system also captures the geographical location coordinates of potholes and humps using GPS receiver. The data is then pushed to ThingSpeak cloud for analysis and can be sent to maintenance authorities

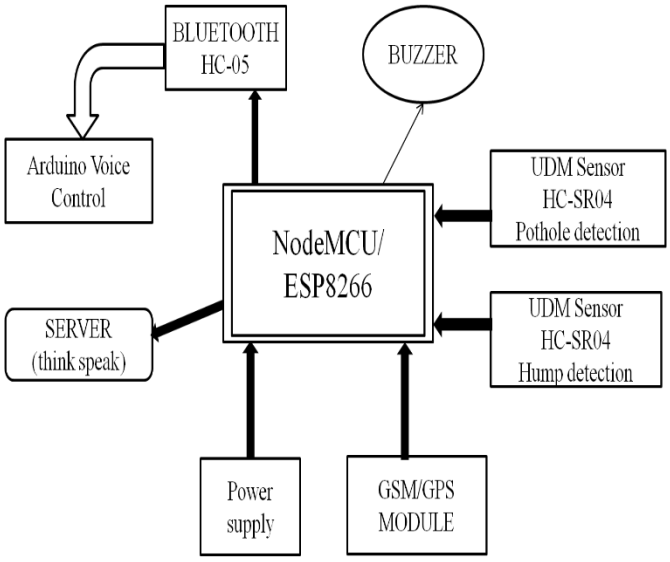

Fig -1: Block diagram of proposed system

Fig. 1 shows the elemental block diagram of the system. NodeMCU is the microcontroller used to integrate all the components together. The microcontroller is powered through a USB cable connected to the computer. It can further be made wireless by use of alkaline batteries. HC-SR04 is the ultrasonic sensor used to measure distance to an obstacle.

To detect potholes, we programme the HC-SR04 unit to alert the user when the distance is greater than the distance between the sensor and the road. In our model, the distance between the vehicle and the road is 5cm so any distance greater than 5cm is programmed to send an alert.

Similarly, HC-SR04 unit can also be used to detect humps by programming it to detect obstacles at, say, 10cm. So, if a hump is detected by the sensor at 10cm distance, an alert will be sent to the user. This sensor is attached to the anterior end of the vehicle.

Using the Bluetooth module HC-05 we can connect to Arduino Voice Control application which is an open source application that can be used to receive voice signals. So, the driver would have to connect to the Bluetooth module of the system before starting his/her journey & the system is programmed to send voice commands that alert him/her about humps to avoid & potholes that are detected. Even alerts to check the tires of the car will be received through this application. The below Fig. 2 shows Flow diagram of proposed system.

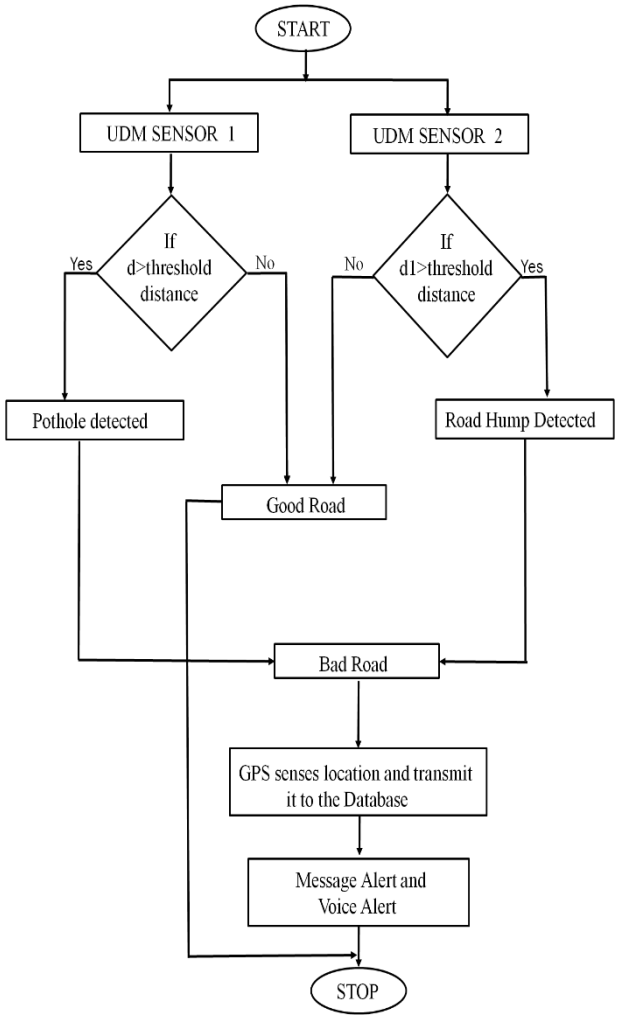

Fig -2: Flow diagram of proposed system

5. Expermental results

As per the result, the pothole and hump measurements detected by Ultrasonic sensors can be viewed on the serial monitor tool of the Arduino IDE software as shown in Figure 3 and 4.

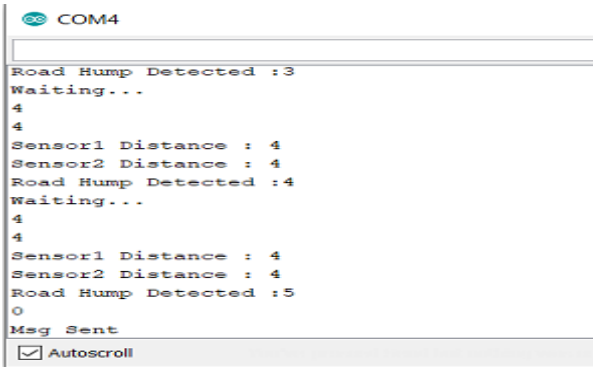

Fig -3; Detection of Road Hump in serial monitor

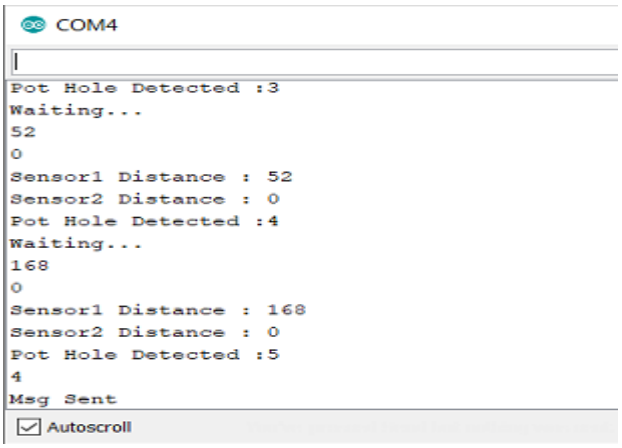

Fig -4: Detection of Pothole in serial monitor

Fig. 5 & Fig. 6 are images of the prototype vehicle. The microcontroller is mounted on the vehicle, two ultrasonic sensors are attached to the vehicle – one is attached on the anterior end of the vehicle that is used to detect humps, and another is attached below the vehicle facing the road to detect potholes.

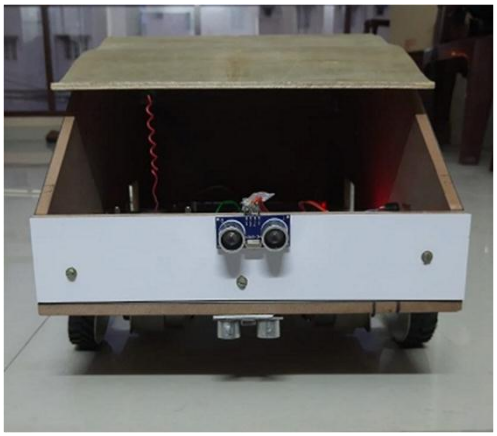

Fig -5: Front view of the prototype vehicle

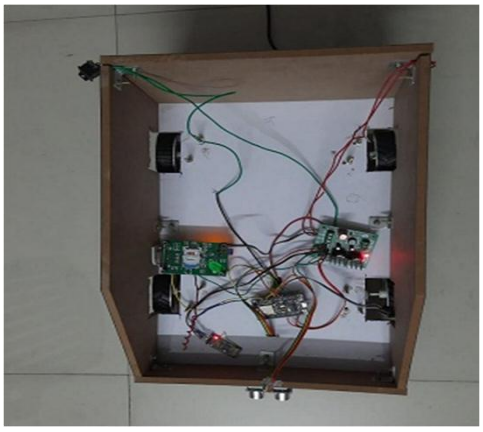

Fig -6: Top view of the prototype vehicle

ThingSpeak is an open-source Internet of Things (IOT) application, Fig. 7 represent the ThinkSpeak channels that record the detected data received from the Ultrasonic sensors in the form of time value plots as shown below.

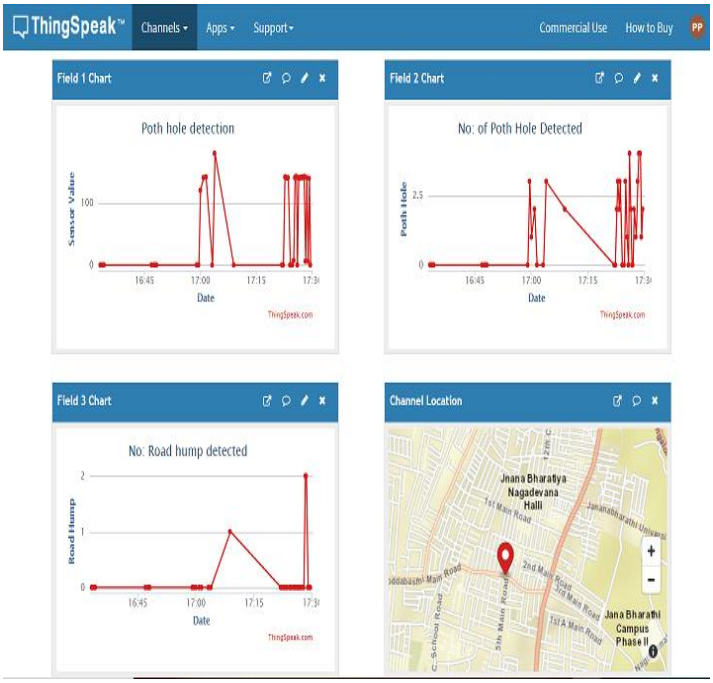

Fig -7: ThinkSpeak channels to visualise data recorded by Ultrasonic sensor HC-SR04

The Fig. 8, Fig. 9 & Fig. 10 represent the Mobile application of GSM model which is make the Audio call & send the text message to registered mobile number. The recorded data in the server can be taken by manually in the form of Excel sheet.

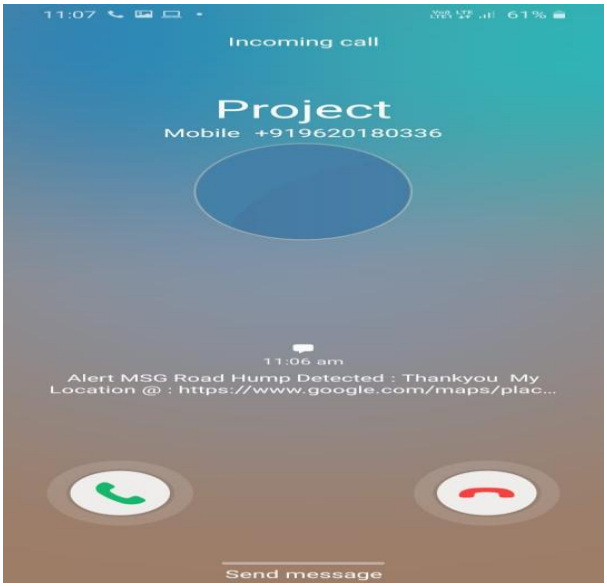

Fig -8: Audio call from GSM model

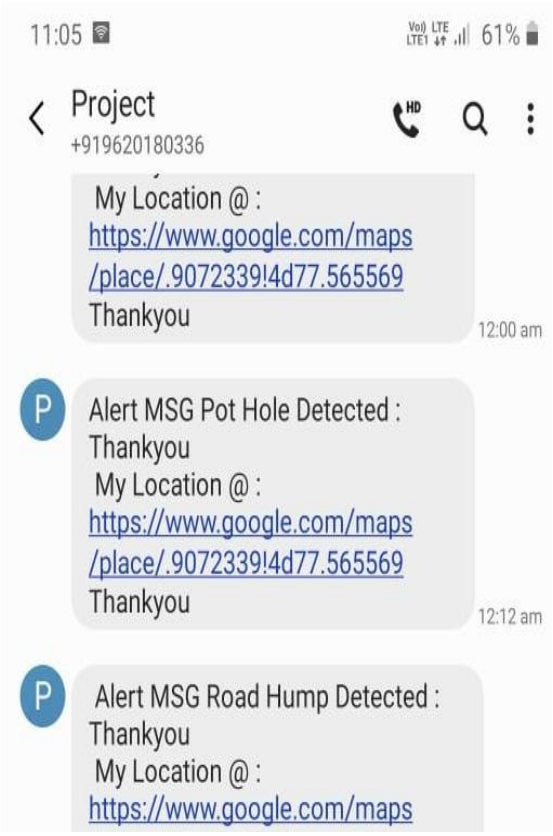

Fig -9: Text Message received in mobile from GSM Modem SIM800

	A	B	C	D	E
1	created_a	entry_id	field1	field2	field3
2	2020-05-2	510	5	0	0
3	2020-05-2	511	5	0	0
4	2020-05-2	512	5	0	0
5	2020-05-2	513	6	0	0
6	2020-05-2	514	6	0	0
7	2020-05-2	515	6	0	1
8	2020-05-2	516	6	0	2
9	2020-05-2	517	7	1	0
10	2020-05-2	518	5	3	0
11	2020-05-2	519	5	3	0
12	2020-05-2	520	5	3	0
13	2020-05-2	521	0	3	0
14	2020-05-2	522	0	3	0
15	2020-05-2	523	0	0	0
16	2020-05-2	524	0	0	0
17	2020-05-2	525	0	0	2
18	2020-05-2	526	0	0	0
19	2020-05-2	527	0	0	0

Fig -10: Excel sheet report from the Server Database.

6. CONCLUSIONS

The model proposed in this paper serves 2 important purposes; automatic detection of potholes and humps and alerting vehicle drivers to evade potential accidents. The proposed approach is an economic solution for detection of dreadful potholes & uneven humps, as it uses low cost ultrasonic sensors. The mobile application used in this system is an additional advantage as it provides timely alerts about potholes and humps. The solution also works in rainy season when potholes are filled with muddy water as alerts are generated using the information stored in the database. We feel that the solution provided in this paper can save many lives and ailing patients who suffer from tragic accidents.

The proposed system can be further improved to recommend safer routes based on the density of potholes on roads. Using concepts of machine learning, threshold values need not be set for each sensor. For all the variable threshold values in different vehicles, the system can be made to learn the threshold values automatically to make the system adapt to any vehicle easily. A mobile application made to collect all the data in one place and can be used to track the recorded values in one place & pass it on to road maintenance authorities for ease of use.

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