Pothole and Hump detection system using IoT

Shyam Achary, Niraj Yadav, Sachit Agarwal, Pragya Jain, Deepak Das

Dept. Electrical engineering Atharva College of Engineering Mumbai, India

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****Corresponding author:***
Shyam Achary
e-mail: *shyamacharya16@gmail.com*

Abstract

Road Accidents are severe in developing countries as compared to developed countries, especially in India, where the number of vehicles has increased far more than road lengths. Potholes are one of the factors contributing to road accidents. This paper discusses various previous and ongoing methods on identifying the potholes and humps and also proposes a method that is comparatively cost-effective, easy to implement, robust, and can be used widely. Use of Ultrasonic sensor is used for detection of depth and height. The system is structured to capture geographic location via GPS, along with the dimensions of potholes. The sensed data is produced over the cloud via the open-source application, which can be retrieved via mail or Government server and can be used.

1. INTRODUCTION

India has been part of the Brasilia Declaration and intends to reduce road accidents by up to 50% by 2022. The Motor Vehicles Act intends to reduce road accidents and thus improve safety. From 2000, road networking in India has increased by up to 39%, while the number of running vehicles increased by up to 157%. Therefore steep increase in vehicle numbers on-road and underdeveloped road networks and their condition poses a high risk of road accidents.

According to the "Road Accident in India 2018" Report by the Ministry of Road Transport and Highways, Road accidents in the country have increased by 0.46 % during 2018 with the year having 4,67,044 road accidents with respect to 4,64,910 in 2017. The fatalities during the same period have also risen by about 2.37%, and 151471 persons were killed in 2018 as against 1, 47,913 in 2017. [1] National Highways consists of 1.94% of the total road network of the country, contributed to 30.2% of total accidents in the country, and 35.7% of deaths occurred in 2018. State Highways of the country, which contributed to 2.98% of the road contributed to 25.2% and 26.7% of road accidents and deaths, respectively.

World Health Organization (WHO) reported that accidents caused by roads because significant public health-related problems killing more than 1.25 million people and 50 million injured. 90% of accidents due to potholes causing road accidents are occurring in developed countries.[2]

The above data reflects the issues pertaining to the road. Due importance has to been given in this sector to improve human safety. This will indirectly help in the improvement of the country's economy.

2. RELATED WORK

Artis Mednis, et al [3] have used Android smartphones, which have inbuilt accelerometers that can be applied for real-time detection. Accelerators are based on the magnitude of vibrations. Z-thresh are used for the measurement of the Z-axis acceleration amplitude. The difference between two amplitudes is obtained by using Z-diff. In case of vertical axis acceleration, standard deviation is obtained using STDEV (Z). G-Zero is used for accurate identification of potholes. Sandeep Venkatesh et al.[4] suggested detecting potholes effectively using a laser line striper and camera. A systematic database is created of various pothole locations. Use of Dedicated Short-Range Communication protocol is one for sharing the data via messages to nearby vehicles. Shambhu Hegde, et al [5] suggested clubbing of smart transport system management via Zigbee module with pothole detection using ultrasonic sensors. But this system has some delay time in its process, so a quick alerting system is not easy. Moazzam et al.[6] suggested the use of the Kinect sensor, which is comparatively less costly as it requires less computing work, thus less cost. The Kinect sensor has an RGB camera and an IR camera for capturing RGB images, which can be systematically analyzed using MATLAB. X. Yu et al [7], suggested use of laser technology for potholes detection. Images are captured for any abnormalities on the road, which can be detected with any laser source deformations. Kongyang Chen, et al. [8] suggested use of three axis accelerometer along with GPS sensor. The obtained data for the sensor is being processed using power spectra density which caters the data for the roughness on the road. Zhen Zhang et al. [9] has suggested the use of stereo cameras with distinctive algorithms for the identification of potholes with their location. He Youquan et al. [10] used two Charge Coupled Device cameras along with LED linear light for the creation of a three-dimensional cross-section image. Further digital image processing technologies like preprocessing of image binarization followed by error detection for detailed analysis of pothole. Jin Lin et al. [11], has suggested pothole detection based on Support Vector Machine. The images are categorized based on partial differential equations. This method instructs the Support Vector Machine to create multiple pavement images. Sachin Bharadwaj et al.[12] suggested use of vision-based cameras for pothole detection. These cameras capture only 2-D images of the required potholes, which can further be analyzed using MATLAB. This approach is limited to proper lighting conditions.

In IR based technology has been implemented for pothole detection. Two IR transmitters operating at 38 KHz have been implemented for the detection of two types of potholes. One with less depth and is not critical. The other pothole is the critical one having a larger depth, which requires prompt actions. The trigger of anyone IR would trigger the microcontroller to save the location of the trigger and thus would a database of multiple triggering points, which reflects potholes on pavements. Data sharing is done using GSM to individual networks or government server.

3. COMPONENTS DETAILS

3.1. NodeMCU

NodeMCU is a programmable software kit used to run the program used and give a command to connected hardware. This firmware runs on ESP8266 wifi Module. It is widely used as it is a low-cost wifi module chip and can be connected to the internet [13]. In this chip we don't need to separate components for both Arduino and wifi module since both of them are in the same chip. It is the heart of our system. Both the ultrasonic and IR sensor sends information to the NodeMCU (controller) which is later sent to the server via Blynk application. It also performs the task of controlling the robot via Motor Driver (L298N).

3.2. Motor Driver (L298N)

L298N Motor Driver is a dual bidirectional motor driver. It has an onboard 5V regulator, which it can supply to an external circuit. This module will allow you to easily and independently control four motors' directional and speed control [14]. An H-Bridge is a circuit that can drive a current in either polarity and be a control pulse by Pulse Width Modulation (PWM); this lets you control a DC motor to go backward or forward. The dimension of the H-Bridge driver is 43x43x26mm, and it is 26 gm in weight.

3.3. Ultrasonic sensor (HC-SR04)

HC-SR04 is an ultrasonic sensor module. It consists of two ultrasonic transmitters, a receiver, and a control unit. This sensor works with a regulated +5V supply and the frequency of 40 Hz. The ultrasonic waves are used to measure the distance of the object in the range 2 to 400 cm. The measuring angle of detection is less than 15 degrees, and the ranging accuracy can reach to 3 mm [15]. The distance is determined based on the time taken by the transmitted pulse return to the receiver. This sensor has 4 pin names as VCC, Trigger, Echo, and Ground. The dimension and the range of the HC-SR04 are shown in Fig. 1.

3.4. Power source

A 12V rechargeable battery is used to power the proposed system which can by reduced to 5V suitable for the NodeMCU with the use of L298N. Capacitors to remove DC impulses are implemented along with regulator, so as to protect the main controller of the proposed system.

3.5. IR Sensor

It is a device which consists of a pair an IR LED and a photodiode. The wavelength of IR light is in the range of 700nm-1nm. It has an emitting angle of approximately 20 to 60 degrees and a range of 10cm-15cm [16]. A photodiode is an IR receiver as it starts when light falls on it. A photodiode is called a PN junction diode, which is operated in reverse bias, means when light falls on the diode, it starts conducting the current in a reverse direction. This current flow is proportional to the amount of light, and this property helps for IR detection.

3.6. GPS Module (NEO-6M)

NEO-6M is a well-performing GPS module, and it has an inbuilt 25x25x4mm ceramic antenna [17]. This antenna is capable of powerful satellite search capability. It also has on-board memory chip. This GPS module includes a rechargeable battery; this battery backup is useful in an

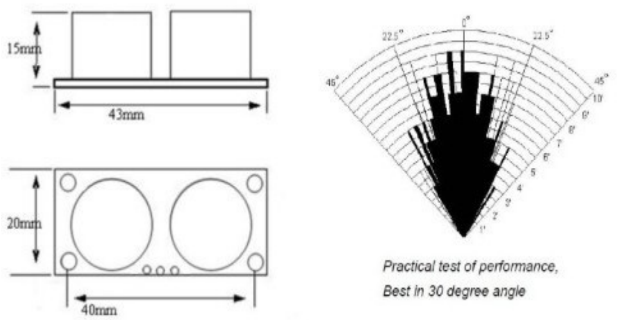

Fig. 1: Geometrical diagram of Ultrasonic sensor

emergency. When the supply is cut down accidentally, the battery backup feature can save the data in the module. This module works with power supply 5V, and the default baud rate is 9600 bps.

3.7. DC Motor

The DC Motor of operating at 12V DC with a maximum speed of 150 rpm. The 12V DC motor is connected to attach plastic Gearbox with the help of shaft. The diameter of the shaft is 6mm with an internal hole, the motor produces 2 kg-cm Torque. The maximum no-load current and load current is 60mA and 300mA, respectively.

3.8. Blynk Software of IoT

Blynk is an Internet of Things (IoT) is a platform with IOS and Android apps to control Arduino, Raspberry Pi, NodeMCU. This software is used to design and implement smart IoT devices quick and easy and can be used to read, store and visualize sensor data and control hardware remotely. It is a digital dashboard where you can build or design a visual interface for your project by simply dragging and dropping widgets. This software works with hundreds of hardware models and connection types. When IoT devices are sending your data to the internet, the communication channel needs to be closed and encrypted, which is possible with the help of this software.[18]

4. ARCHITECTURE AND WORKING

4.1. Working

The proposed system is an IoT based robot that is capable of detecting humps and potholes. The potholes and Humps are detected by the ultrasonic and IR sensors. The robot is controlled as well as monitored by IoT using open source android application, which is capable of designing a graphic user interface (GUI) like a joystick to control it. The microcontroller, which is used in the proposed system, has an in-built wifi module that connects the robot to the internet. The incoming data from the ultrasonic sensor and IR sensor for potholes detection are sent to the controller, and the controller will send this information to the Blynk server. This information contains geographical location, which can be further transferred either to the specific server or government server via email. The block diagram of our proposed system is shown below in Fig. 2. The whole proposed system is classified into three main units i.e., sensing unit, controlling unit, and output unit, respectively.

4.2. Sensing unit

Two sensors are used in the proposed system, i.e., ultrasonic sensor and IR sensor. The threshold value of the proposed system is the measurement of the distance between the bottom surface of the vehicle and the road surface. The measurement of ground clearance is going to be used as a threshold value for the system and executed respectively. The pothole and hump is detected either the measurement of distance calculated by the ultrasonic sensor and IR sensor is greater or less than the considered threshold value. If the distance measured by the system is greater than the threshold value, then it is a pothole and if the value is smaller than the threshold value, then it is the hump. If the measured value is neither greater nor smaller than the considered threshold value, then in such a case, it is a smooth road. The sensors send the data to the microcontroller.

4.3. Controlling Unit

The controlling unit of the proposed system has NodeMCU, GPS module, and inbuilt Wifi module. The motor drive is connected to the microcontroller with the help of the IoT application module command is fed to the microcontroller and then the microcontroller gives command to the motor drive, which is used to run the motors of the system. The sensors and android application modules are used as an input source for the microcontroller. The programming code is also fed in the microcontroller module. The microcontroller sends the information and the geographical location of potholes and humps to the Android application. Since the microcontroller has an inbuilt wifi module, hence there is no need to connect any separate module. It plays an intermediate platform role in between the sensing unit and the output module unit.

4.4. Output unit

The output unit of our system has NodeMCU, Blynk application, and server to which the information is sent.

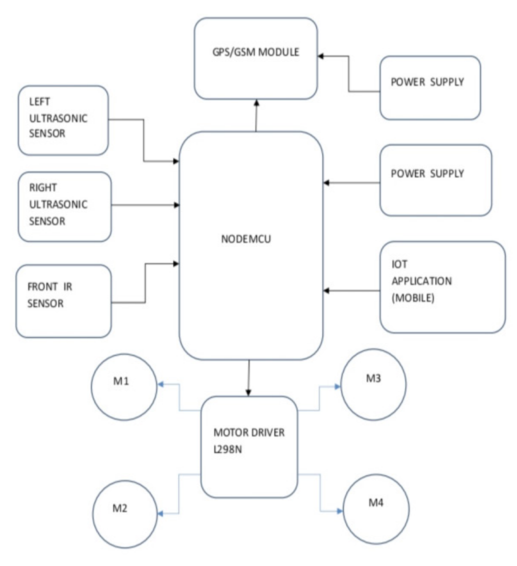

Fig. 2: Block diagram of the proposed system

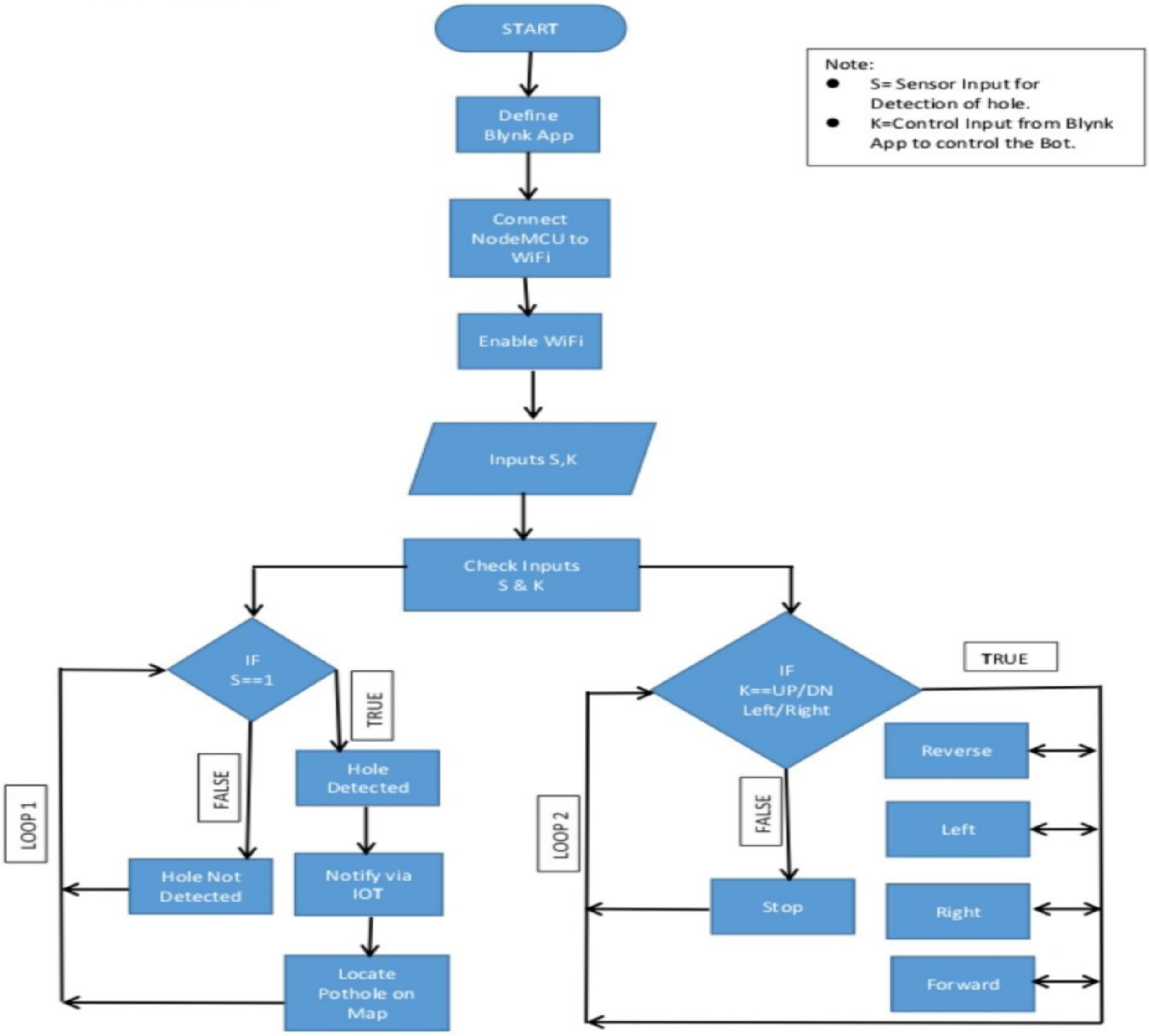

Fig. 3: Flowchart.

When our bot is made to run on poor roads that consist of potholes, the ultrasonic sensor starts collecting the data and send it to the controller (NodeMCU). Now controller matches data with the threshold data and sends it to the server via blynk application. In this way, our bot detects the potholes and humps. The above implementation of system can be represented in the form of flowchart as shown in Fig. 3.

5. HARDWARE IMPLEMENTATION

The proposed system is temporarily implemented for experimental purposes using a bread board and connecting wires. The final system will be implemented on proper PCB using the hitching process with the use of Eagle PCB software. The hardware representation can be seen in Fig. 4.

5.1. Experimental Result

The result of the above paper is subcategorized in three sections a) Co-ordinate locations of the potholes and humps with the use of GPS and NodeMCU interference. This was carried out firstly by constructing a code on Arduino software, which is linked to blink application via mail services. Latitude and Longitude up to 7 decimals are received via mail from the Blynk application. b) Depth of the potholes with the implementation of the ultrasonic sensor with the minimum threshold value of 2 cm. The data received by the sensor is sent to specified mails. c) Detection of a hump or other obstacles with the implementation of

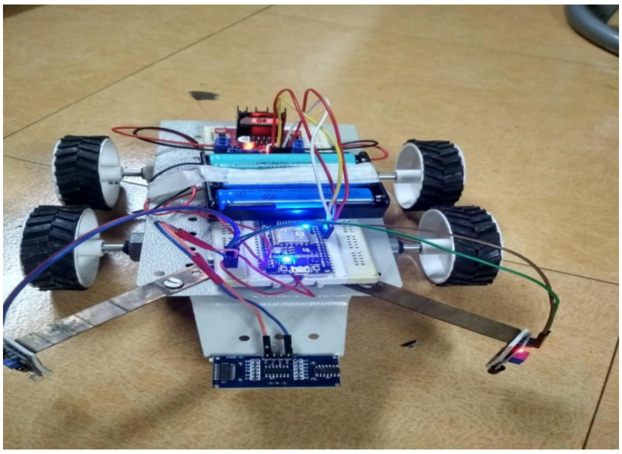

Fig. 4: Hardware

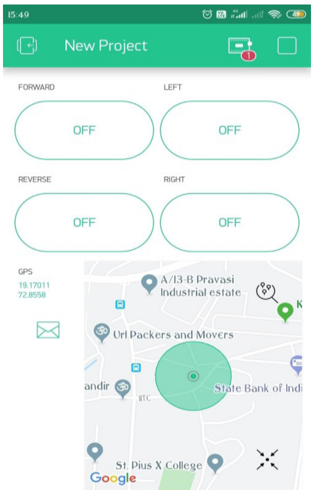

Fig. 5: GUI of Blynk software

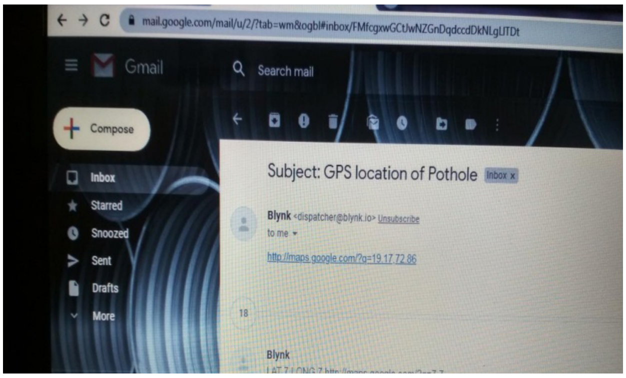

Fig. 6

the IR sensor. Output data received is also shared over mail addresses.

5.2. GUI of Iot app Blynk

In this, we have bot controlling buttons and GPS Latitude and Longitude value and Mail Icon for sending mail of the pothole location detected and a map of the live location of the BOT, as shown in the Fig. 5.

This is achieved when Authorization characters are mailed to the required users using Blynk software. The required Authorization characters code, when used in the program, allows users mentioned in the Blynk software to receive live locations of potholes, humps or any other hurdles along the way. The required data is received in a short delay of just 6seconds to 9 seconds.

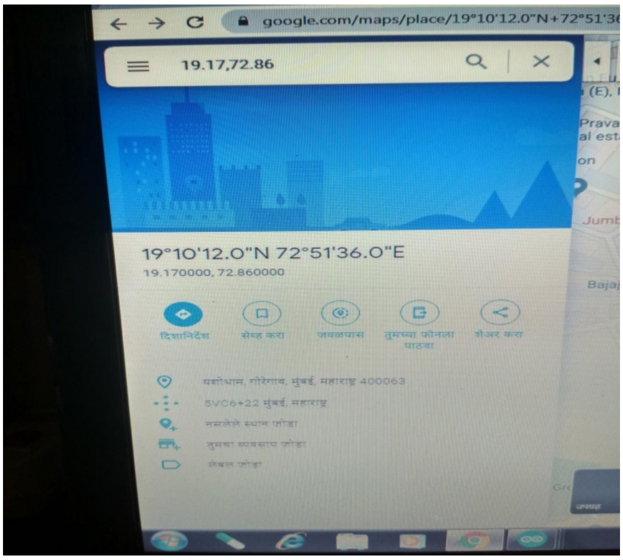

Fig. 7: Actual location when selected by the user shows detailed latitudes and longitudes of the potholes detected. This is represented in Fig. 7.

Table 1: Results from the server is listed on the Table

Pothole	*Hump*	*Location*
18.07 cm	Not Detected	19°10'25.6"N 72°52'18.0"E
18.44 cm	Not Detected	20°11'25.4"N 72°52'15.0"E
20.40 cm	Not Detected	19°10'26.7"N 72°52'18.2"E
15.30 cm	Detected	19°10'25.6"N 72°52'18.0"E
19.86 cm	Detected	19°10'25.5"N 72°52'19.3"E

5.3. Gmail Pothole detected notification

The mail notification, which is triggered by the sensors, is sent by the Blink software to the predefined mail users. The below image illustrates the notification received by one of the users.

The above Table 1 shows the distance between the ultrasonic sensor and the ground in the pothole section of the Table. Hump part of the part denotes any obstacle encountered by the bot system. The location section denotes the pothole locations. This data is received on the preset mail users who are presented in Fig. 6 and 7.

6. ADVANTAGES, LIMITATIONS AND FUTURE SCOPE

The proposed system uses sensors which are economically less costly and can be implemented on a large scale like shopping malls, baby carts for safety, sensors can be mass implemented directly on the government vehicles or at an attractive subsidized scheme on private vehicles to create a mass collection of information on potholes, humps, for which density map can be created to for effective and quick analysis of poorly constructed roads, which further can help Government bodies like BMC or can help commuters in avoiding a particularly bad patch of poor road with the help of density maps of potholes on the servers. As the sensors are cost-efficient, they have their limitations like less range, less accuracy, less direct analysis like image process techniques. Implementation of cameras or laser technology can boost the accuracy of the data collection with their own drawbacks of complexity and more costly. By looking at the data on road accidents, technological developments should be promoted for effective and innovative solutions.

7. CONCLUSION

The proposed system is about a bot that is capable of two applications 1: potholes and hump detection 2: status sharing of the road through email notification. The ultrasonic sensor is placed at the bottom of the vehicle, and it is also assisted with IR sensor in the detection of potholes. The data from the sensors are compared with the threshold values of the normal road surface. The location of the pothole is detected with a GPS receiver, which is sent to the server and authorized person through IoT application and also through email. The conclusion is that whenever the system detects any abnormality on the road surface due to hump or potholes, it immediately sends that information to the authorized department so that it may take the required measures to solve the problem and reduce the risk of accidents on roads.

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