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Pothole Detection and Inter Vehicular Communication

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Abstract—**This paper aims at proposing a novel pothole detection system, which assists the driver to avoid potholes on the roads by giving prior warnings. The idea is to build a robot vehicle that is capable of detecting the potholes and transferring this information to the nearby vehicles in the vicinity. By sharing the information about potholes with the nearby vehicles, the probability of accidents or collision can be reduced. Here, we propose a pothole detection model, which can detect the potholes with a minimum depth of 1 inch and share the information within 100 m range. This idea can be extended to design vehicles capable of detecting the humps or other irregularities on the roads. The application illustrated in this work can be effectively used to reduce the problem of increasing accidents caused due to potholes.**

I. Introduction

In recent years, a lot of research has been done in the area of automated vehicles and automatic highway systems. All this research has a common goal: to make driving safer and easier. It is important to find out solutions to reduce the number of accidents. One of the major reasons for road accidents is potholes according to the survey conducted by the Automobile Association [1]. Vehicles tend to lose balance when they come across a larger pothole. Whenever a driver slows down the vehicle to avoid the effect due to pothole, there are chances of collisions with the vehicle following it, whose driver has no idea about the potholes. So information sharing plays a very important role in avoiding the effects of potholes. Here, we establish an inter-vehicular communication model for information sharing. Another problem is, during night times, potholes are not easily detectable by human eye. This problem is eliminated here by using ultrasonic sensors, which give the output independent of light intensity. By making pothole detecting vehicles and establishing an inter-vehicular communication, it is possible to reduce the possibility of accidents[5-8]. To test this model, we have used the following approaches:

- Building a model vehicle which is capable of detecting the potholes in its path.
- Controlling the speed of the vehicle based on sensor value.
- Transferring the information to the vehicles in the vicinity.
- Speed control of other vehicles based on the received value.

The main objective of this work is to detect potholes with a minimum depth of 1 inch and share the information to vehicles within the range of 100 meters. The remainder of this paper is as follows: Section 2 discusses some of the related projects. Section 3 provides the technical details about the components used. The proposed model is presented in the section 4. Section 5 presents the results. And section 6 presents the conclusion of the proposed work and further research work.

II. Related Projects

Several researchers have worked to detect the potholes using different methods. Pothole detection using accelerometers gives the output based on the vibration[4]. Here, cameras were used for detecting the potholes with the help of image processing algorithms [16]. Detection of pavement distress was achieved using 3D laser scanning technology by Chang [9]. Damage detection in roadways with ground penetrating radar was proposed in [11] which illustrates the use of radar technology. A paper by C.Koch and I Brilakis used a method of vision tracking for detecting the potholes [3]. Jin Lin and Yayu Liu proposed a pothole detection model based on histogram texture measure using image processing [2]. In this paper, ultrasonic sensors used to provide light intensity and surrounding temperature. One of advantage this model is that it is cheaper than the above mentioned methods. Real time pothole detection using Android smart phones was proposed by Artis Mednis [4] and FPGA (Field Programmable Gate Array) based system for pothole detection on Indian roads was proposed by Shonil Vijay, which used low cost FPGA. Pothole detection using digital image processing was proposed by Hussain Z [16], which used the image processing algorithms to extract the information about the pothole. In our project, we have used NXP LPC 1768 microcontroller with ARM Cortex-M3 core processor. The existing systems used GPS system for location recognition and GSM for communications. Here, we have used Zigbee modules for communication, which can transmit and receive data within 100 m. Since, we have used Zigbee so there is no need of a mobile network, which is required in the case of GSM system[12-17].

III. Technical Components of the Proposed System

Here, we are discussing some of major components in order to detect pothole over the network.

A. *Ultrasonic Sensor*

An ultrasonic sensor is an electronic device that emits and/or detects ultrasonic radiation in order to sense the objects in front of it. The range and angle of detection depends on the ultrasonic sensor specifications. Value sensed by ultrasonic

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sensor is independent of surrounding light and temperature. For this work, we are using the LV-MaxSonar-EZ0 ultrasonic sensor to detect objects from 0 to 254 inches and provides sonar range information from 6 inches out to 254. Objects from 0 to 6 inches typically range as 6-inches and are said to be in blind range. We are taking analog voltage output from the sensor.

B. Zigbee

Zigbee is a radio frequency communication standard that makes it very simple to transmit digital information between devices. In this work, we are using Tarang F-20 Zigbee modules. These modules integrate an antenna, amplifier, transmitter/receiver, and circuitry that allow us to send and receive data between the Zigbee and microcontroller over a standard serial connection. The modules operate within the ISM 2.4-2.4835 Ghz frequency with IEEE 802.15.4 baseband and has a range of 100 meters[10].

C. Motor Driver - L293d

A motor driver translates the input to higher voltage while maintaining the promised current output, thereby acting as a current amplifier. This current is used to drive the motors, which usually require a larger current for their operation compared to the other peripherals. The motor driver uses L293D to drive 3 DC motors. It is a quadruple H-bridge and can provide bidirectional drive currents of up to 600 mA.

D. Microcontroller

We have used MBED microcontroller, which is based on the NXP LPC1768, with a 32-bit ARM Cortex-M3 core running at 96 MHz. It includes 512KB FLASH, 32KB RAM and a lots of interfaces including built-in Ethernet, USB host and device, CAN, SPI, I2C, ADC, DAC, PWM, other I/O interfaces.

IV. PROPOSED MODEL

For the purpose of illustration, we consider two vehicles namely transmitting vehicle and receiving vehicle. We establish a one way communication between these two vehicles and show how this idea can be extended to achieve multivehicle communication. Block diagrams of transmission and reception systems are shown below.

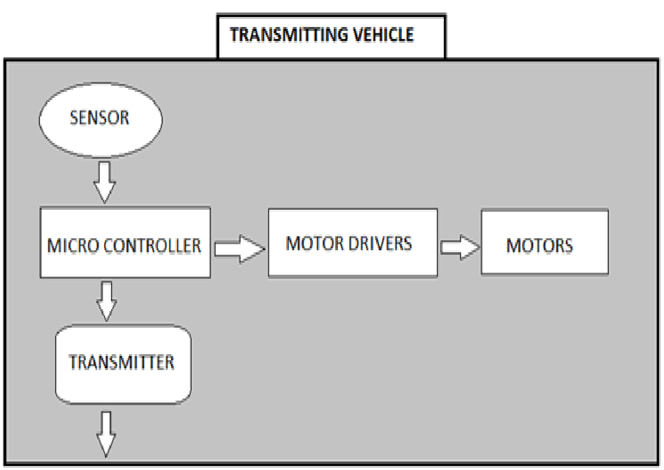

Fig 1. Block diagram of transmission system.

As shown in fig.1, the transmission system consists of a vehicle with sensor attached to it. Microcontroller receives the sensor output and controls the motors through motor drivers. It also transmits the information to the receiving vehicle. The receiving system as shown in fig.2 receives the information, and based on this information, the microcontroller takes decision about the speed of the motors.

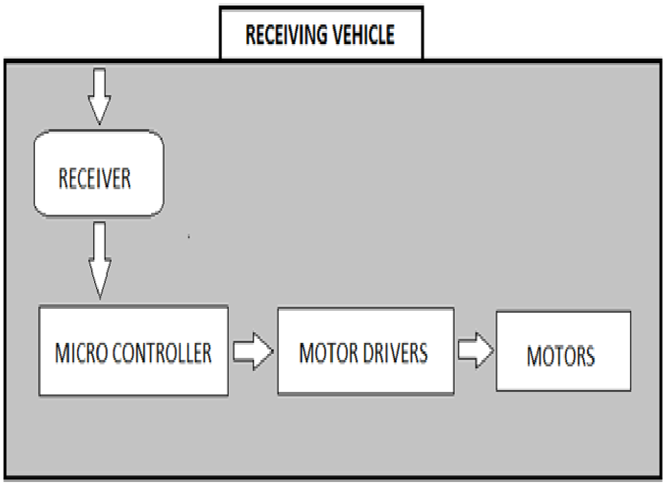

Fig.2. Block diagram of reception system.

Each pothole will have varying width and depth. The effect of potholes on the vehicle depends on the ground clearance of the vehicle and vehicle suspension. Ultrasonic sensors are used to detect the depth of potholes. Ultrasonic sensors work on a principle similar to radar or sonar, which evaluates attributes of a target by interpreting the echoes from radio or sound waves respectively as shown in fig.3.

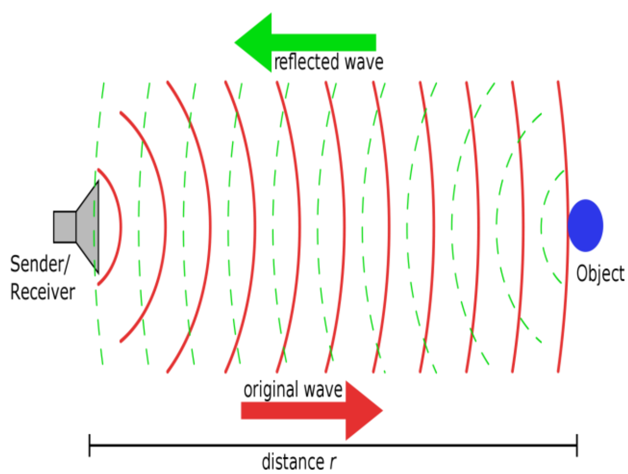

Fig.3. Ultrasonic ranging.

An ultrasonic sensor generates high frequency sound waves and waits for the waves reflected back from the object. The sensor calculates the time interval between sending the signal and receiving the echo to determine the distance to an object [18]. We use an ultrasonic sensor known as LV-MaxSonar-EZ0, which provides sonar range information from 6 inches out to 254 with 1 inch resolution. Figure 4 shows the prototype model designed using Catia software. In the prototype model, for testing purpose, an L shaped stand has been fixed to the chassis having four wheels and sensor is mounted to the stand. But in real vehicles, the ultrasonic sensor is attached in a suitable place depending on the structure and dimension of the vehicle. Here, we have used an ARM Cortex-M3 core microcontroller. Motor drivers are connected to the PWM pins of the microcontroller and are used to control the current flow to the motors. A Zigbee module is connected to the serial communication pins of the microcontroller. The experimental setup is shown in the figures 5 and 6.

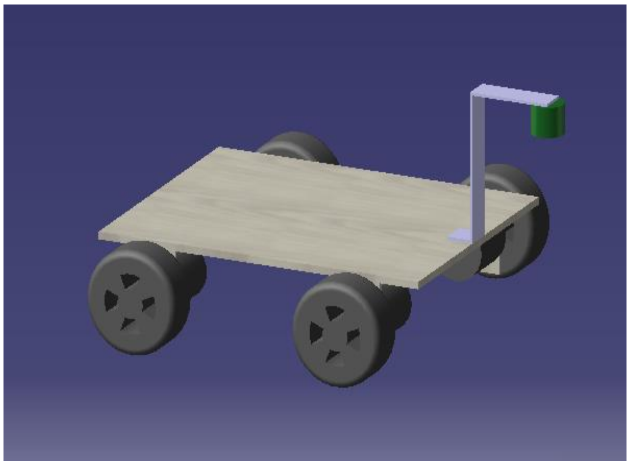

Fig.4. Prototype design of the vehicle.

In fig.6, it shows that the sensor output is given to the analog input pin of the microcontroller. Based on this, the microcontroller takes the decision. We have set a threshold value for the detection of potholes. If the value of the sensor output is more than the threshold value, it means that pothole has been detected. When a pothole has been detected it is better to reduce the speed of the vehicle to avoid the accident. So the microcontroller reduces the speed of rotation of motors using motor drivers. If there is no pothole, then the vehicle continues to move with the same speed. For communicating with the vehicles in the vicinity, a transceiver can be used.

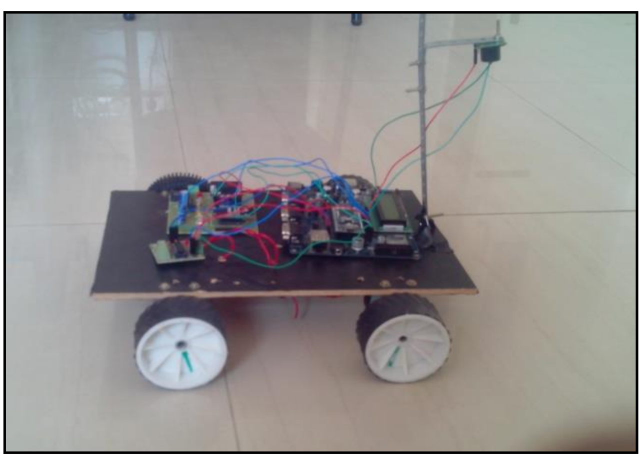

Fig.5. Prototype model setup.

Here, we have used Zigbee modules which has a range of 100 meters. Details about the existence of potholes is given to the Rx pin of Zigbee module from Tx pin of the microcontroller of the transmitting vehicle. Zigbee module of the receiving vehicle receives the signals and transfers the information to the Rx pin of the microcontroller. Based on the information received, speed of that vehicle is controlled. Whenever one vehicle detects a pothole, its speed is reduced and subsequently the speed of the following vehicles in the range of 100 meters will also be reduced. The working of the proposed system was tested using the prototype model shown in fig.6. The test was also performed using a real vehicle on the road. Testing and implementation of proposed system on real vehicles is done on Bangalore roads.

V. EXPERIMENTAL RESULTS

The tests were conducted in an indoor environment using artificial pothole arrangement. The working of the system was tested several times successfully and the reading of one of the test is presented here. Ultrasonic sensor gives the analog output values. To test the working of the model, we have set a threshold value of 3670. But in real time scenario we cannot generalize the threshold value. Depending on the vehicle dimension and suspension, the threshold value can be set by vehicle manufacturers. Based on the sensor value, distance from the sensor to the road surface is calculated and decision is taken by the microcontroller about the condition of the road as shown in table 1.

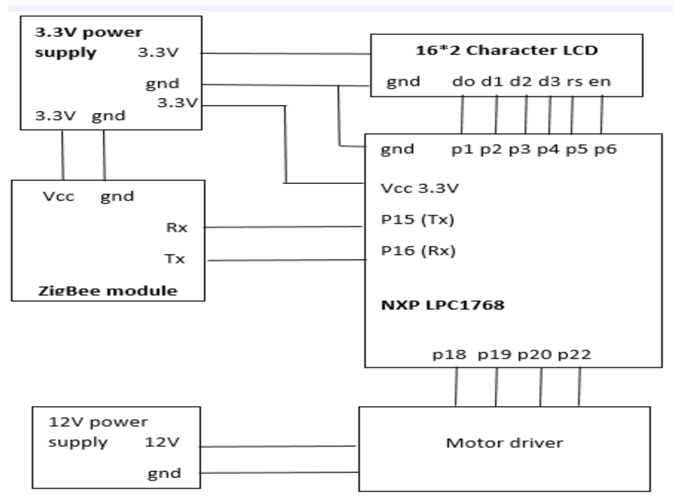

Fig.6. Schematic circuit diagram of proposed work.

TABLE I

SENSOR OUTPUT VALUES AND DECISION TAKEN BY MICROCONTROLLER CONSIDERING THRESHOLD VALUE=3670

Distance from the sensor to surface of road(in inches)	Analog output value of the sensor	Decision taken by microcontroller about condition of the road
1	1200	Clear Road
2	1200	Clear Road
4	1200	Clear Road
6	1200	Clear Road
7	1345	Clear Road
8	1488	Clear Road
10	1803	Clear Road

14	2541	Clear Road
18	3276	Clear Road
20	3670*	Pothole
21	3824	Pothole
22	3997	Pothole
25	4358	Pothole

From the table 1, we can see that when the analog output of the sensor is lesser than the threshold value, microcontroller considers it as clear road and whenever the depth of the pothole is large enough to cause the sensor output to go more than the threshold value, microcontrollers decides that pothole is detected. Thus, the microcontroller reduces the speed of the transmitting vehicle and sends a message to the receiving vehicle so that it can reduce the speed using motor drivers. Thus, in this experiment whenever a pothole was detected both transmitting and receiving vehicles reduced their speed and collision did not happen. Transmitting vehicle continuously decides the condition of the road and adjusts the speed. Accordingly receiving vehicle also adjusts its speed. A LCD is connected to the microcontroller which continuously displays the sensor output x, distance d and the decision of the microcontroller. The LCD display in two cases is shown as an example in figure 7. In vehicles, a display can be attached in the dashboard to show the condition of the road.

Fig.7. LCD display.

VI. CONCLUSION

In this paper, we have discussed the pothole detection and inter vehicular communication. The proposed system uses the ultrasonic sensor for pothole detection and Zigbee module pair for communications. The proposed model uses NXP LPC 1768 microcontroller for taking decisions about controlling the speed of the vehicle. Our goal was to achieve the effective detection of pothole and communication between multiple vehicles. Effective detection of pothole is achieved. Even though we have established efficient communication between two vehicles, multivehicle communication could not be established. But with effective use of Zigbee protocol, communication between multiple vehicles can be achieved. Pothole detection is an important feature of the autonomous vehicles and this idea can be extended to detect vehicles in the vicinity and any type of obstacles on the road.

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