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Implementation of Vehicle Speed Reducing System at Speed Breaks by Detecting Patholes and Humps Using Ultrasonic Sensor

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Abstract--- In many developing countries the maintenance of roads are the major problem. A country's economy also determined by the safe roads and the road conditions of the country. India, as a second populous country in the world, also a fast growing country. There are huge network of roads. Even from Kashmir to Kanyakumari broad roads are the dominant means of transportation in India. This work discusses merits and demerits of previous pothole detection methods that have been developed and proposes a cost effective solution to identify potholes and humps on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. Ultrasonic sensors are used to identify potholes and humps. They also measure their depth and height respectively. The proposed system captures the geographical location coordinates of potholes and humps using GPS receiver. The sensed-data includes pothole depth, height of hump and geographic location, which is stored in the database(cloud). This serves as a valuable source of information to the Government authorities and to vehicle drivers. An android application is used to alert drivers so that precautionary measures can be taken to evade accidents. Alerts are given in the form of a flash messages with an audio beep and long beep alarm to the drivers. The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating distance based on the time required. This is similar to how radar measures the time it takes a radio wave to return after hitting an object..

Keywords--- Ardunio UNO, Ultrasonic sensors, patholes, humps, IoT.

I. INTRODUCTION

Internet of Things

Internet of Things is an ecosystem of connected physical objects that are accessible through the internet. The 'thing' in IoT could be a person with a heart monitor or an automobile with built-in-sensors, i.e. objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention. The embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken.

Internet of Things can connect devices embedded in various systems to the internet. When devices/objects can represent themselves digitally, they can be controlled from anywhere. The connectivity then helps us capture more data from more places, ensuring more ways of increasing efficiency and improving safety and IoT security. IoT is a transformational force that can help companies improve performance through IoT analytics and IoT Security to deliver better results[Fig 1.1]. Businesses in the utilities, oil & gas, insurance, manufacturing, transportation, infrastructure and retail sectors can reap the benefits of IoT by making more informed decisions, aided by the torrent of interactional and transactional data at their disposal [1].

IoT platforms can help organizations reduce cost through improved process efficiency, asset utilization and productivity. With improved tracking of devices/objects using sensors and connectivity, they can benefit from real-time insights and analytics, which would help them make smarter decisions. The growth and convergence of data, processes and things on the internet would make such connections more relevant and important, creating more opportunities for people, businesses and industries [2].

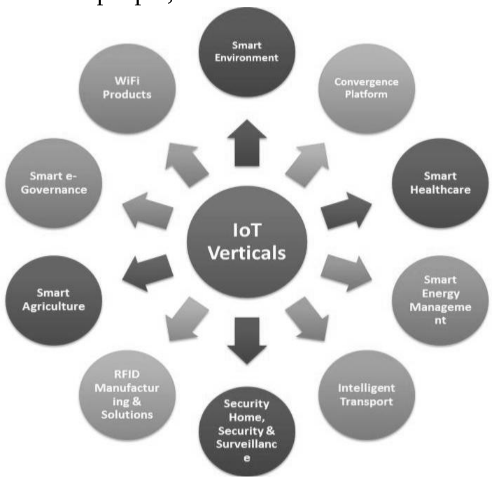

Fig 1.1 Applications of Iot

There are numerous real-world applications of the internet of things, ranging from consumer IoT and enterprise IoT to manufacturing and industrial IoT (IIoT). IoT applications span numerous verticals, including automotive, telco, energy and more.

In the consumer segment, for example, smart homes that are equipped with smart thermostats, smart appliances and connected heating, lighting and electronic devices can be controlled remotely via computers, smartphones or other mobile devices.

Wearable devices with sensors and software can collect and analyze user data, sending messages to other technologies about the users with the aim of making users' lives easier and more comfortable. Wearable devices are also used for public safety.

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For example, improving first responders' response times during emergencies by providing optimized routes to a location or by tracking construction workers' or firefighters' vital signs at life-threatening sites.

In healthcare, IoT offers many benefits, including the ability to monitor patients more closely to use the data that's generated and analyze it. Hospitals often use IoT systems to complete tasks such as inventory management, for both pharmaceuticals and medical instruments.

Roads and Its Conditions

India, the second most populous Country in the World and a fast growing economy, is known to have a gigantic network of roads. Roads are the dominant means of transportation in India today. They carry almost 90 percent of country's passenger traffic and 65 percent of its freight. However, most of the roads in India are narrow and congested with poor surface quality and road maintenance needs are not satisfactorily met. No matter where you are in India, driving is a breath-holding, multi-mirror involving, potentially life threatening affair.

Over the last two decades, there has been a huge increase in the vehicle population. This proliferation of vehicles has led to problems such as traffic congestion and increase in the number of road accidents. Pathetic condition of roads is a boosting factor for traffic congestion and accidents. Researchers are working in the area of traffic congestion control, an integral part of vehicular area networks, which is the need of the hour today.

Roads in India normally have speed breakers so that the vehicle's speed can be controlled to avoid accidents. However, these speed breakers are unevenly distributed with uneven and unscientific heights.

Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. According to the survey report "Road Accidents in India, 2011", by the ministry of road transport and highways, a total of 1,42,485 people had lost their lives due to fatal road accidents. Of these, nearly 1.5 per cent or nearly 2,200 fatalities were due to poor condition of roads. To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and humps and also helps drivers to drive safely. With the proposed system an attempt has been made to endorse drivers to ward off the accidents caused due to potholes and raised humps.

Ultrasonic Sensor

The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package.

Fig 1.2: Ultrasonic Sensor

HC-SR04 distance sensor is commonly used with both microcontroller and microprocessor platforms like Arduino, ARM, PIC, Raspberry Pie etc. The following guide is universally since it has to be followed irrespective of the type of computational device used.

Power the Sensor using a regulated +5V through the Vcc ad Ground pins of the sensor. The current consumed by the sensor is less than 15mA and hence can be directly powered by the on board 5V pins (If available). The Trigger and the Echo pins are both I/O pins and 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 and 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 returned after it getting 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 back to the sensor.

The amount of time during which the Echo pin stays high is measured by the MCU/MPU as it gives the information about the time taken for the wave to return back to the Sensor. Using this information, the distance is measured as explained in the above heading [3].

Previous Work

Stepheena Joseph et al., (2017) demonstrates that, Dangerous road conditions may be the result of natural events, such as tropical rains and flooding, that make driving unsafe. Dangerous conditions can also arise from the poor physical condition of a road and its surroundings. It may cause road accidents. Also while driving in the night just the headlights might not be a sufficient assistance for driver. Unexpected hurdles on road may cause more accidents. Also because of bad road conditions, fuel consumption of the vehicle increases. causing wastage of precious fuel. This proposed system pothole and hump detection and vehicle speed control system to inform the driver about the pothole or hump and controlling the speed of the vehicle. This system uses ultrasonic sensor to sense the potholes and humps and which measure the height and depth of the potholes.

Gnanapriya et al., (2017) One of the major problems faced by developing countries is the maintenance of road condition. Road infrastructure for the society is very important because majority of road accidents takes place due to bad condition of road like potholes. Potholes are caused due to poor quality and badly maintained roads. The constant movement of the overweight vehicles like trucks is also responsible for these ill roads. These ill quality roads will cause severe damage to the vehicles in terms of tire and most important thing is the accidents which are caused due to this. An optimal system should be developed to monitor the road condition and analyses for future work. This system proposes an innovative method to prevent these hazards by using the advanced sensor system. The sensors will be attached to vehicles and from vehicles the data's obtained from sensors and the location obtained by the GPS are transferred to road transport authority by IOT where officials take necessary actions. Using the data's obtained more damaged area can be prioritized and damage control can be reduced.

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Arduino

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc.

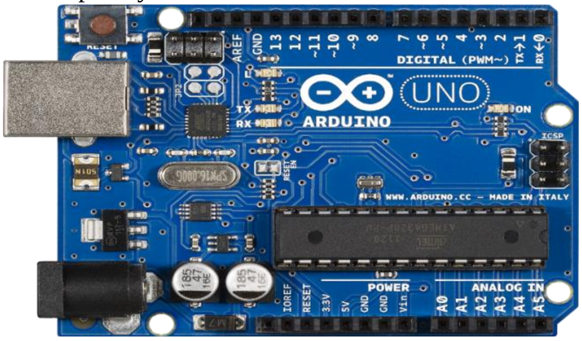

Fig 1.3: Arduino Board

The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE via a type B USB cable. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform. The ATmega328 on the Arduino Uno comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.The Uno also differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter [4].

Technical Specification

Microcontroller : Microchip ATmega328P
Operating Voltage : 5 Volt
Input Voltage : 7 to 20 Volts
Digital I/O Pins : 14 (of which 6 provide PWM output)
Analog Input Pins : 6
DC Current per I/O Pin : 20 mA
DC Current for 3.3V Pin : 50 mA
FlashMemory : 32 KB
SRAM : 2 KB
Clock Speed : 16 MHz

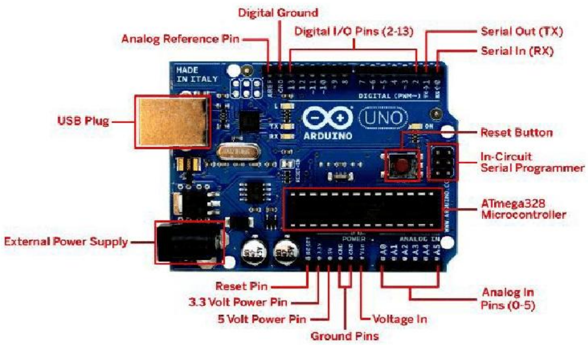

Fig 1.4: Detailed Description of Arduino Board

The Arduino Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3: A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND: Ground pins.

IOREF: This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.

Memory

The ATmega328 has 32 KB (with 0.5 KB occupied by the bootloader). It also has EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.

In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

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External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. There are a couple of other pins on the board:

AREF: Reference voltage for the analog inputs. Used with analogReference().

RESET: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board [5].

II. WORKING PRINCIPLE FOR THE

Implementation of Vehicle speed reducing systems at speed breaks and avoidance of accidents using ultrasonic sensors

2.1 problem Statement

Road is a vital part of people's day-to-day lives. India is a developing country there is a constant requirement for good quality transportation, infrastructure and services. This problem has not been totally addressed in India as it is a huge nation with pretty a sizable population. Potholes, speed breakers, mud pits, grains, garbage and shards of glass are just a number of the things that may be found on the road while driving in India. Roads in India normally have speed breakers so that the vehicle's speed can be controlled to avoid accidents. However, these speed breakers are unevenly distributed with uneven and unscientific heights.

Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and humps and also helps drivers to drive safely. With the proposed system an attempt has been made to endorse drivers to ward off the accidents caused due to potholes and raised humps.

Ultrasonic Sensor

Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating distance based on the time required. This is similar to how radar measures the time it takes a radio wave to return after hitting an object. The ultrasonic distance sensors measures distance using sonar; an ultrasonic (well above human hearing) beat is transmitted from the unit and distance-to-target is determined by measuring the time required for the echo return. Output from the ultrasonic sensor is a variable-width beat that compares to the distance to the target[6].

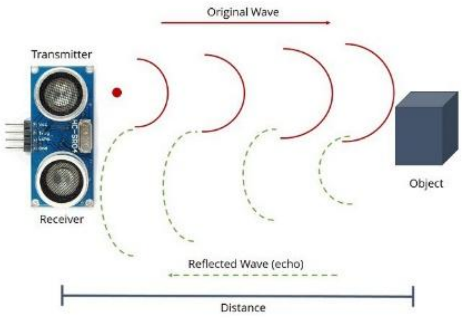

Fig 2.1: Working of Ultrasonic Sensor

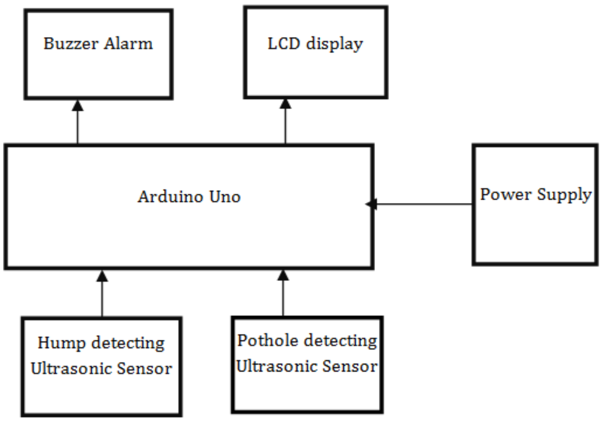

Fig. 2.2: Block diagram of Proposed system

Module Description

Pothole and Hump Detection

Ultrasonic sensors are used to measure the distance between the car body and the road surface and this data is received by the Arduino Uno. The distance between car body and the ground, on a smooth road surface, is the threshold distance. Threshold value depends on the ground clearance of vehicles and can be configured accordingly. If the distance measured by ultrasonic sensor is greater than the threshold, it is a pothole, if it is smaller, it is a hump otherwise it is a smooth road.

The information about pothole collected by the proposed system is displayed on the LCD and also send alerts to the driver. The information includes depth of the pothole or height of the hump. If the distance between the two is within 10 meters, an alert message sends to the driver. This alert is with an audio beep. This proposed system which will detect the potholes and humps on the road and reduce the vehicle speed if needed. Due to the rains and oil spills potholes are generated which will cause the accidents. The potholes are detected and timely information can help to recover the road as fast as possible. This helps to reduce the vehicle speed when pothole or hump is detected. Hence the system will help to avoid road accidents.

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Applications

1. Identification of pathole or hump before 10 to 12 feet of distance to the vehicle.
   Indicates the presence of hump or pathole immediately.
2. Vehicle speed will be reduced
3. Hence damage to the tiers and vehicle also reduced/ stopped.

Procedure for Detecting Hump

STEP 1: Ultrasonic sensors are used to measure the distance between the car body and the road surface.
STEP 2: Arduino measures the distance of obstacle if it is within the fixed distance and detects it as a hump.
STEP 3: Buzzer alerts the driver.

Procedure for Detecting Pothole

STEP 1: Ultrasonic sensors are used to measure the distance between the car body and the road surface.
STEP 2: Arduino measures the distance of a normal road if the distance is increases detects it as a pothole.
STEP 3: Buzzer alerts the driver.

Hardware Setup

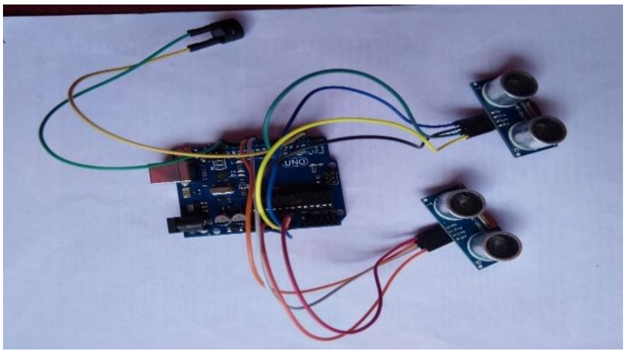

Fig 2.3: Hardware setup of proposed system

Ultrasonic sensor is used to calculate the distance of the hump and pothole. Ultrasonic sensors are connected with the Arduino Uno board. Arduino detect the hump and pothole on the road. Hump and pothole is within the fixed distance buzzer alerts the driver which is connected with the Arduino board. Distance also displayed on the LCD display in meters with obstacle notification.

Source Code

```
Const6. int trigPin1 = 10;
const int echoPin1 = 9;
const int trigPin2 = 3;
const int echoPin2 = 4;
const int buzzPin = 2;
void setup()
{
Serial.begin(9600);
pinMode(trigPin1, OUTPUT);
pinMode(echoPin1, INPUT);
pinMode(trigPin2, OUTPUT);
pinMode(echoPin2, INPUT);
pinMode(buzzPin, OUTPUT);
}
void loop()
{
int duration1, distance1=0,duration2,distance2=0;
digitalWrite(trigPin1, LOW);
delayMicroseconds(5);
digitalWrite(trigPin1, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin1, LOW);
duration1 = pulseIn(echoPin1, HIGH);
distance1 = (duration1/2)/29.1;
Serial.println(distance1);
if (distance1 <= 10 )
{
digitalWrite(buzzPin, HIGH);
Serial.println("Hump Detected");
}
else
{
digitalWrite(buzzPin, LOW);
Serial.println("Normal Road");
}
delay(1000);
digitalWrite(trigPin2, LOW);
delayMicroseconds(5);
digitalWrite(trigPin2, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin2, LOW);
duration2 = pulseIn(echoPin2, HIGH);
distance2 = duration2 / 60;
Serial.println(distance2);
if(distance2 > 8)
{
Serial.println("Pothole Detected");
digitalWrite(buzzPin,HIGH);
}
else
{
Serial.println("Normal Road");
digitalWrite(buzzPin,LOW);
}
delay(1000);
}
```

III. DETAILED DESCRIPTION

Ultrasonic Sensor (HC-SR04)

Ultrasonic sensors measure distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception.

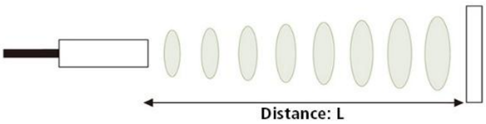

Fig. 3.1: Ultrasonic Sensor distance calculation

HC-SR04 Ultrasonic sensor is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required.

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A sound sensor has a transmitter and receiver, whereas an ultrasonic sensor uses a single ultrasonic element for both emission and reception. In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately. This enables miniaturization of the sensor head.

The distance can be calculated with the following formula:

Distance = 1/2 * T * C

where L is the distance, T is the time between the emission and reception, and C is the sonic speed. (The value is multiplied by 1/2 because T is the time for go-and-return distance). At 20°C (68°F), the speed of sound is 343 meters/second (1125 feet/second), but this varies depending on temperature and humidity. Specially adapted ultrasonic sensors can also be used underwater. The speed of sound, however, is 4.3 times as fast in water as in air, so this calculation must be adjusted significantly [7].

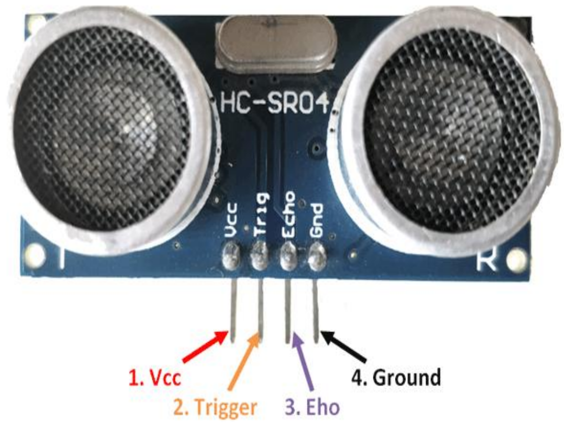

Fig 3.2: Ultrasonic Sensor Pin Diagram

Ultrasonic sensors are a type of acoustic sensor divided into three broad categories: transmitters, receivers and transceivers. Transmitters convert electricalsignals into ultrasound, receivers convert ultrasound into electrical signals, and transceivers can both transmit and receive ultrasound -[8].

HC-SR04 Sensor Features

Operating voltage : +5V
Theoretical Measuring Distance : 2cm to 450cm
Practical Measuring Distance : 2cm to 80cm
Accuracy : 3mm
Measuring angle covered : <15°
Operating Current :15mA
Operating Frequency : 40Hz

IV. RESULT

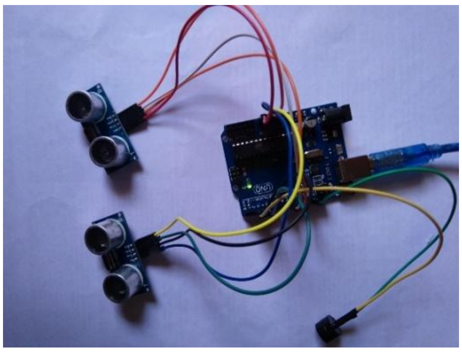

Fig 4.1: Working of Proposed System

Hardware module formed by Connecting Arduino Uno board, Ultrasonic sensor, Buzzer alarm is shown in Figure 6.5.

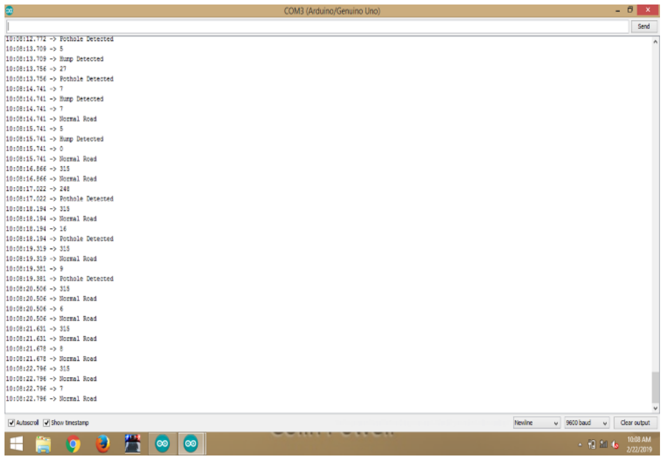

Fig 4.2: Output of Arduino

The above Fig 4.2 shows the output of the Arduino board which detects the pothole and hump with distance.

Comparison between Different communication Systems

Table 2: Comparison between communication approaches

	Entire WiFi coverage	Public transport approach	Hotspot approach
Deployment	Deploy access point wherever you want the coverage	Only on the public transport vehicles	At particular location where vehicle density is high
Coverage	Wherever access points are deployed	Wherever public transport vehicle go	Wherever the vehicle goes
Cost of access point deployment	High	Medium	Low
Cost of client device	Medium	Low	High
Localization	Relatively easy	Difficult	Difficult

V. CONCLUSION AND FUTURE WORK

This system is uses low-cost distance sensor that is able to self-adapt to the environmental conditions. The sensor contains a noise measurement system and an auto-change facility of the signal that is used to drive the transmitter, thus producing the best accuracy under different conditions. The sensor features a simple and costless analog processing of the signal without employing microprocessors. Despite its simplicity and low-cost, the sensor allows resolutions of better than 1 mm to be obtained in quiet conditions. The sensor output is updated every 20 ms, and an additional digital output allows an easy implementation of smoothing techniques by means of the car computing system.

The model proposed in this project serves 2 important purposes; automatic detection of potholes and humps and alerting vehicle drivers to evade potential accidents.

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The proposed approach is an economic solution for detection of dreadful potholes and uneven humps, as it uses low cost ultrasonic sensors. The buzzer alarm 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 detection of ultrasonic sensor. We feel that the solution provided in this paper can save many lives and ailing patients who suffer from tragic accidents.

The proposed system considers the presence of potholes and humps. However, it does not consider the fact that potholes or humps get repaired by concerned authorities periodically. This system can be further improved to consider the above fact and update server database accordingly. Also, Google maps and SATNAV can be integrated in the proposed system to improve user experience.

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Dr.V. Kalpana has completed doctoral degree in the year 2013. She has completed her P.G in CSE in Government College of Technology. She is currently working as an Associate Professor and head of the Department of Computer Science & Engineering in **P.A. College of Engineering and Technology, Coimbatore**. She has published more than 10 papers in this work in 10 different national and 13 international journals. She has guided more than 26 M.E projects and 43 B.E projects. She is grateful to **Dr.P. Appukutty, Chairman, P.A. Institutions, Dr.T. Manigandan** P.A. College of Engineering and Technology, Pollachi, for their continuous encouragement in publishing this research work. She thanks her projects students of Final CSE, **A. Fathima Risvana, Kaleeswari. S, Kaviya. S** for their help to implement and test this device.

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