IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, July 2022
Impact Factor: 6.252

Pothole Detection System

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Abstract: *Potholes are known from long ago and their solutions are also found from different angles. While doing the literature survey there were many researchers and solutions which can be applied with help of different hardware systems. Detection of potholes is not the one thing which can be used to avoid them. Displaying potholes is also important which can make drivers aware of them. System consists of a GPS module which will be collecting coordinates and an ultrasonic sensor will sense the distance which will be then taken to find the average distance from the road after every few cycles. Getting these two data which will be coordinated and filtered out according to the limit suggested by the investigators of the UK which is more than 40mm will be sent to the Cloud and can further be displayed on an android App with the help of google maps. This system will not only help to detect potholes but also by locating them they can be avoided as well as soon repaired for the future scope.*

Keywords: GPS: Global Positioning System, UK: United Kingdom, App: Application, Cloud: Cloud storage is a cloud computing model that stores data on the Internet through a cloud computing provider who manages and operates data storage as a service

I. INTRODUCTION

One of the major problems in developing countries is maintenance of roads. Well maintained roads contribute a major portion to the country's economy. Identification of pavement distress such as potholes and humps not only help drivers to avoid accidents, helps to avoid any vehicle damages, but also helps government authorities to maintain roads. This paper discusses pothole detection methods that have been developed and also proposes a cost-effective solution to identify and locate the potholes or humps on roads and provide alerts to drivers to avoid accidents or vehicle damages.

The proposed system captures the geographical location coordinates of the potholes or humps using a global positioning system receiver. Where the ultrasonic sensors are used to identify the potholes or humps and it also measures their depth or height. An android application is used to alert drivers so that precautionary measures can be taken to avoid any misfortune. Alerts are pinned on the google map in the application location of the pothole. With the help of Bluetooth data is transferred to the mobile application in the form of raw data from the sensor and at that particular trigger point where a pothole is detected the location will get captured. Sensor data includes pothole depth and height, as well as geographic location, which is stored in a cloud database. Governing authorities and drivers can benefit from this valuable information.

II. LITERATURE SURVEY

Pothole detection system using black box proposes that using a black box camera and specified algorithm one can detect potholes in certain weather with accuracy of around 77%-88%. However, this system can also detect manholes, crack, objects and vehicles due to sensitivity and remove likewise to get potholes detected correctly.[1]

Real time pothole detection using android smartphones with accelerometers which is using mobile based accelerometers is used to detect the anomalies occurring on roads as data collected by the smartphones gives the positive accuracy of around 90%. Algorithm specifies and gets the data collection from android smartphones.[2]

Pothole Detection using Machine Learning that is Implementing the technology of Inception of V3 and Transfer Learning gets the flexible way for an application which determines the shape ,bump and type of anomaly on the road. Using convolution neural networks and big data , the problem is handled well for the implementation and cost .[3]

This paper will examine whether information technology solutions can contribute to the work of road repair and ITS. The aim of the research is to develop a device for identification of potholes and road conditions. Thus, accurately and quickly

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detecting potholes is one of the important tasks for determining proper strategies in ITS (Intelligent Transportation System) service and road management system. Several efforts have been made for developing a technology which can automatically detect and recognize potholes . This paper proposes a pothole detection system for real time identification of surface irregularities on roads using Internet of Things (IoT). Device uses IoT sensors to detect potholes in real time while an end user is driving vehicles on the road. The location of these potholes would be available on a centrally hosted map which can be accessed by both end users and civic authorities using the system as well as on mobile apps.

By designing it this way, it would function as both a warning system for all users as well as a database of potholes along with their location for the authorities to address immediately.[4]

The issues that potholes present may be alleviated by addressing the following two issues: detecting and reporting potholes to the city, and warning motorists of existing potholes so that they may be avoided. Potholes are a universal inconvenience that affect all roadways. As of May 2014, there have already been 13,000 potholes reported in the Washington D.C. area for 2014. Right now, the system only uses a g-force threshold to trigger pothole detection, but by testing the system with actual data gathered from vehicles driving over potholes one could properly profile the data using machine learning algorithms. This idea was explored by Mednis, et al, in their experiments with potholes detection using smartphone accelerometers. With this feature a user would be warned when a pothole is approaching on the road on which they are traveling and they could take the necessary precautions to avoid it.[5]

Challenges and problems to be solved. Research questions have been led out to increase the knowledge to fill potholes or repair it. Aim of this research is to develop software solutions for the road which are covered or made with asphalt and provide useful solutions to the road potholes volume calculation for the asphalt or concrete technology implement and cover or repair it. In order to judge ultrasonic sensor`s sensitivity and usefulness to avoid the road potholes and identify the measurements in a simulated environment were carried out. The following environments were used for measurements: a bright light environment; b heightened humidity environment; c variable height environment. Graph shows that distance from ultrasonic sensor till object is more than 100 cm in some places; besides, despite possibilities for visual detection of imitated road potholes, location anomalies which are fixed in the district will not allow precise data about pothole`s depth. The following pothole volume calculation algorithm has been developed in order to implement road potholes volume detection in real-world situations. To determine which file's data array is subject to further processing; determine the min and the max values; for the measurements are sliced down into layers and taken one step. The pothole binary image is created; count the previously calculated ones and multiplied by a step of one layer to get the pothole volume is in centimetre units.[6] If there are severe weather events, transportation infrastructure can be directly or indirectly damaged. This can pose a threat to human safety, and cause significant disruptions related to the economic and social impacts of flooding. To address these issues, in this study, the implementation of integration with road and environmental monitoring as support to road monitoring is based on the Internet of Things as a supervising system. This system is an integration of several sensor devices connected to embedded systems and communication devices that are attached to the vehicle. Data is sent to the data centre and evaluated using machine learning algorithms that can analyse the collected data. The categorization of SVM and DT in the computation using Confusion Matrix shows that SVM has an accuracy rate of 98% with an error rate of 10-hole holes and eight bumps, while DT has an error value of 4 for holes and 1 for bump and eight bump readings and 11 holes. Data from VaaMSN is sent via the MQTT protocol to the Big Data platform and analysed by decision trees and machine support vector algorithms. MSE values from the decision tree can be 6.2% and 5.5% for the SVM algorithm.[7]

III. COMPONENTS

1. Microcontroller- ATMEGA 328p
2. HCSR 04 Ultrasonic Sensor
3. HC-05 Bluetooth module
4. NEO 6m GPS module

3.1 Microcontroller ATMEGA 328p

ATmega328P is a high performance yet low power consumption 8-bit AVR microcontroller that’s able to achieve the most single clock cycle execution of 131 powerful instructions thanks to its advanced RISC architecture. It can commonly be found as a processor in Arduino boards such as Arduino Fio and Arduino Uno.

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Specifications

- Program Memory Type Flash
- Program Memory Size 32
- CPU Speed (MIPS/DMIPS) 20
- SRAM (KB) 2,048
- Data EEPROM/HEF (bytes) 1,024
- Digital Communication Peripheral 1-UART, 2-SPI, 1-I2C
- Capture/Compare/PWM Peripheral 1 Input Capture, 1 CCP, 6PWM
- Timers/Counters 2 x 8-bit, 1x 16 bit
- Number of Comparators 1
- Temperature Range -40 to 85deg
- Operating Voltage Range (V) 1.8 to 5.5V
- Pin Count 32
- Low Power Yes

Figure.1 Arduino Uno

3.2 Ultrasonic Sensors

HC-SR04 is an ultrasonic distance sensor. This durable sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. the HC SR04 is the cheapest and sturdy ultrasonic module in the market.

Specifications

- Operating Voltage is +5V
- Working Current 15mA
- Working Frequency 40Hz
- Max Range 4m Min
- Trigger Input Signal 10uS TTL pulse
- Echo Output Signal Input TTL level signal and the range in proportion

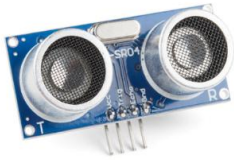

Figure.2 HC SR04 Ultrasonic sensor

3.3 NEO 6m GPS module

A complete GPS module with an active antenna integrated, and a built-in EEPROM to save configuration parameter data. NEO 6m GPS module is one of the cheapest GPS modules in the market and it is a very compact module that can be used into a small form factor system.

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Specifications

- Built-in 25 x 25 x 4mm ceramic active antenna provides strong satellite search capability.
- Equipped with power and signal indicator lights and data backup battery.
- Power supply: 3-5V
- Default baud rate: 9600bps.
- Interface: RS232 TTL

Figure.3 NEO 6m GPS Module

3.4 HC-05 Bluetooth Module

HC-05 is a Bluetooth module used for wireless communication. It can be used in slave configuration as a master. It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard and many more consumer applications. It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions

Specifications

Software features:

- Default Baud rate: 38400, Data bits:8, Stop bit:1,Parity:Non parity, Data control: has. Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.
- Given a rising pulse in PIO0, the device will be disconnected.
- Status instruction port PIO1: low-disconnected, high-connected; PIO10 and PIO11 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PIN CODE:"0000" as default Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection.

Hardware features:

- Typical -80dBm sensitivity
- Up to +4dBm RF transmit power
- Low Power 1.8V Operation ,1.8 to 3.6V I/O
- PIO control
- UART interface with programmable baud rate
- Integrated antenna
- Edge connector

Figure.4 Bluetooth module HC-05

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3.5 Circuit Diagram and explanation

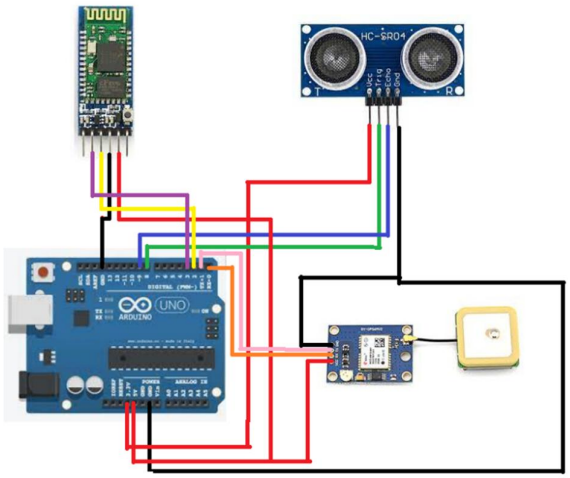

Figure.5 Hardware /circuit design

All the sensors are connected with the microcontroller making it a compact system. The system is assumed to work automatically after the first initialization.

The Ultrasonic sensor, Hc-Sr04 is placed in such a way that it detects the distance between the road and the sensor; commonly placed under the chassis of the vehicle. The code of the sensor is designed to calculate the distance and simultaneously calculate the average distance of the road. When a reading is above the average calculated value, the value is said to be of the pothole. From there, the GPS module is called.

The GPS Module, Neo 6m, is initiated after a pothole is detected. The module is placed directly above the ultrasonic sensor which gives us the precise coordinates. The coordinates in the form of latitude and longitude are uploaded in the IOT cloud.

The IOT cloud here is Firebase. The coordinates from the GPS Module are retrieved in an android application and projected in a map widget.

The android application provides a user-friendly interface and provides a projected view of the potholes on a map. Along with this, the app will also provide the raw data of the potholes which includes the depth of the pothole and their coordinates.

IV. METHODOLOGY

4.1 Interface HCSR04 with Arduino

To connect an ultrasonic sensor to an Arduino, there is need to power up HCSR 04 with 3.3v from the power side; as in ultrasonic sensors there are 2 pins echo and trigger. Echo is an emitter of ultrasonic waves. Trigger is the receiver of ultrasonic waves. For the data of distance calculation there is connection of two pins which will work for serial communication. Echo of the sensor is connected to the digital pin 2 of the Arduino and the Trigger is connected to the digital pin 3 of the Arduino. Getting readings from ultrasonic very basic by using distance time formula by using standard baud rate which is 9600 bauds.

4.2 Interface GPS Module with Arduino

To connect your GPS module to Arduino, power of +5V from the Arduino power side; one also need to monitor the voltage of the GPS module which consists of a coin battery back and any ground PIN. Any two pins will work for serial communication:

- Connect the Arduino pin 4 to the RX pin of the GPS Module.
- Connect the Arduino pin 3 to the TX pin of the GPS Module.

Reading raw data on GPS is a very small matter: simply create a new serial connection using Software Serial and align it with your standard baud rate for GPS which is 9600 bauds.

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4.3 Interface Bluetooth module with Arduino

Bluetooth module which is HC-05 consisting of all the basic required parameters for providing connectivity services. The Bluetooth module is our gateway for mobile application communication. It consists of 6 pins for the integration of components. The HC 05 Bluetooth module can be interfaced to any other microcontroller (like Arduino or 8051) through UART and with the help of AT Commands, the Microcontroller can control the HC 05 Pinout connections are given below:

- Vcc of Bluetooth module is connected to output of 3.3v of Arduino
- Rx is connected to Tx of Arduino
- Tx is connected to Rx of Arduino
- Ground pin is connected to GND

4.4 Operation of Cloud

Cloud Storage is a service for storing your objects in Google Cloud. An object is an immutable piece of data consisting of a file of any format. As cloud storage is a convenient and widely used system. Perks of cloud storage is that one need not to carry our storage devices like Hard drives or floppy disks to access data as it is accessible as well as editable or updatable from anywhere with internet connection. Google Cloud is the most well-known cloud storage network that not only saves data but also has various features and tools to make data more usable and also interactive for advanced programming. One of the parts of the google cloud is firebase. It consists of various features the same as google cloud but the main feature it attracts more is that it is integratable with android application or any website and hardware system which makes it smarter.

Database

A database is an organized collection of structured information, or data, typically stored electronically in a computer system. Small databases can be stored on a file system, while large databases are hosted on computer clusters or cloud storage. The most known database is real time database which is a database system which uses real-time processing to handle workloads whose state is constantly changing. Real-time processing means that a transaction is processed fast enough for the result to come back and be acted on right away. With the help of cloud features uploading and accessing data at real time has become data thriving. Data collection from the Arduino is all the hardware proposes. Data can be displayed on an android application using standard procedure.

Application Working

Android's default user interface is mainly based on direct manipulation, using touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects, along with a virtual keyboard. Data Visualization on android application involve the graphical representation of the data in the form of charts, graph, and maps which make the analysis of the complex data easier to the user, due to this android application has a huge benefit in different sectors of industry along with this it is also helpful in industrial applications. Using cloud and database features plotting on maps and gathering data from applications has become easier as well as faster means of data deploying.

V. WORKING PRINCIPLE

System consists of a sensor, GPS module and Bluetooth module. The Data which is the raw data where the bare minimum is calculated and according to the standards the pothole is detected according to International sensors. Getting the raw data and taking out the average of those two data which will be coordinated and filtered out according to the limit suggested by the investigators of the UK which is more than 40mm. As it detects the pothole the gps module is turned on to receive and transfer the data. According to gps module specifications which is currently in use it uses 4-5 satellites to get the latitude and longitude. These latitude and longitude are approximate data captured through the ceramic antenna which is attached to the module with a single cord . The Bluetooth module acts as a transfer medium between the atmega microcontroller and the mobile application. The raw data is directly transferred to the mobile application which is then further sent through the application to the cloud data storage. The application consists of 2 main parts . One part contains

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all the raw data which is visible on the application window. The other part is where the map is visible where potholes are located .These locations are stored in a firebase which is where one has latitude and longitude where potholes are detected. For this procedure there are few dependencies which are needed for a vehicle where the hardware setup is required. With the android application build where the data can be transferred for smooth data transmission through hardware to software.

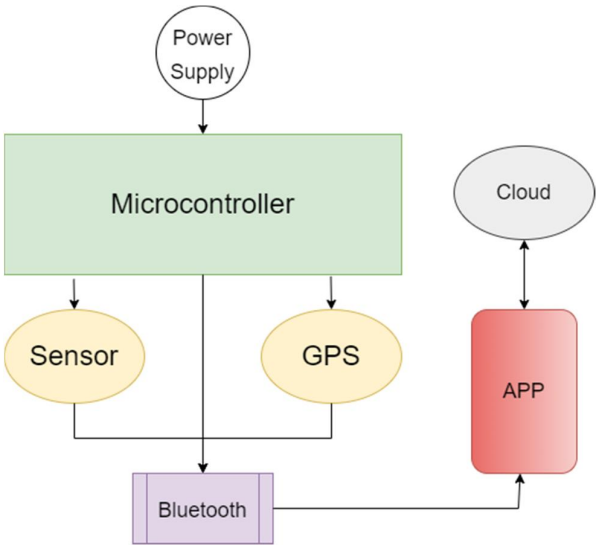

Figure.6 Block Diagram

VI. RESULTS

1. The experimental results reaching an overall accuracy of 72%, with 79% precision and 74% recall, which is better than the performance of the existing method having an overall accuracy of 44%, with 54% precision and 35% recall.
2. Ultrasonic sensor working with its maximum range till 1m. Which is kept at distance from the vehicle whose average gets calculated .
3. When the average is greater than 40cm anomaly is detected and gps is triggered.
4. GPS successfully connects to any of the satellites and locates.
5. IOT cloud calibration Stable readings in the cloud database. Sent through application.
6. Android application displaying map pothole activities as well as raw data.

VII. ADVANTAGES

1. Easy to fill the potholes as the location is known.
2. Prevents accidents as the application can be used by citizens as well .
3. Automatically the data sensed and data plotted.
4. Cost effective as the basic model sensors are used.

VIII. DISADVANTAGES

1. Approximate location can be detected as the gps is of basic model.
2. Vehicle with mobile application is needed at the approximate speed of 20-25 Kmph.
3. Detection would be difficult to use in the rainy season.

IX. CONCLUSION

1. A pothole detection system for the Information Technology centre of the road management service to city authorities .
2. Below image figure 7 shows the marked pothole in our college promises was tested using this system. This is getting updated in real time so that even the citizens around there will get an immediate update from the map

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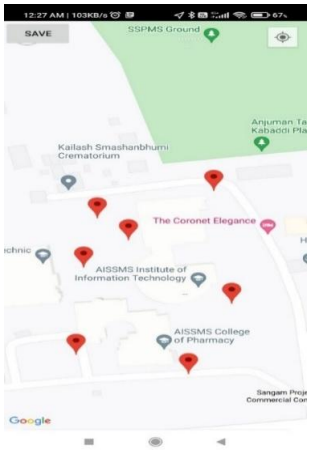

Figure .7 Application screenshot

1. The proposed method has more improved performance through more experiments under a variety of circumstances carried.
2. Below image figure 8 shows that the system was tested on two-wheeler vehicle having a plastic rod which was then attached to the hardware system.

Figure .8 Hardware setup

X. FUTURE SCOPE

In the future some of the improvements like the mark size and the design of the mark in particular manner. Highway lane potholes can also be detected by using high tech sensors and gps locators for speedy detection and display. By increasing the sensing range for the detection of potholes and also using advanced GPS modules will increase the accuracy in locating potholes. Adding more sensors for detecting potholes accurately will increase the efficiency. Applying hardware setup to local government body vehicles will help in covering more roads for pothole detection

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