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Pothole detection using ultrasonic sensor and GPS data collection.

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Abstract — Potholes have been a problem for a long time and there have been various solutions proposed by researchers using different hardware systems. Detecting potholes is important, but it is also essential to display them so that drivers can be aware of them. This system involves a GPS module to collect coordinates and an ultrasonic sensor to determine the distance from the road surface, which is then averaged over several cycles. The data collected is then filtered based on the limit suggested by UK investigators, which is greater than 40mm, and sent to the cloud. This information can be displayed on an Android app using Google Maps, enabling drivers to locate and avoid potholes, and allowing them to be repaired quickly.

Keywords - ***pothole, Road safety, Software, GPS module, Ultrasonic sensor.***

I. INTRODUCTION

This project aims to detect potholes automatically for the purpose of ensuring human safety. It provides a cost effective solution for pothole detection on roads using ultrasonic sensors that can indicate the road maintenance authority. Potholes are a major concern for road maintenance in developing countries, as they can cause accidents and vehicle damage. This paper proposes a solution that uses GPS to capture the geographical location coordinates of potholes and humps, while ultrasonic sensors are used to measure their depth or height. An Android application alerts drivers of the presence of potholes and humps, and Bluetooth is used to transfer the data from the sensor to the mobile application. The sensor data is stored in a cloud database that can be accessed by governing authorities and drivers for better road maintenance. The proposed system is cost-effective and promotes road safety by alerting drivers of the presence of potholes and humps. The architecture of the system involves connecting the sensor and Bluetooth model to the microcontroller, which processes the received data and computes the height, width, and depth of the potholes. The GPS is used to capture the location coordinates of the detected potholes, and the distance between the vehicle location and the pothole location stored in the database is computed.

II. RELATED WORK

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 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 NCMRPE-23 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

Figure.1 Arduino Uno

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 . 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

3.2 Ultrasonic Sensors HC-SR04 is an ultrasonic distance sensor.

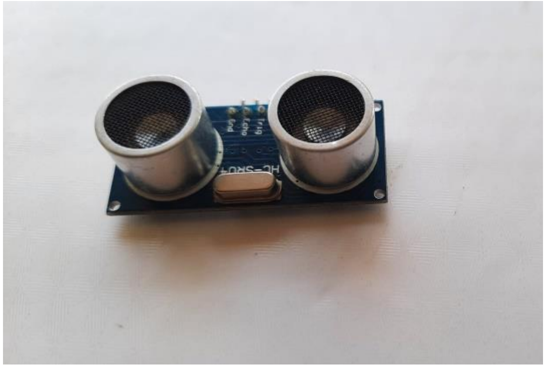

Figure.2 HC SR04 Ultrasonic sensor

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 NCMRPE-23
- Trigger Input Signal 10uS TTL pulse
- Echo Output Signal Input TTL level signal and the range in proportion

3.3 NEO 6m GPS module

Figure.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. 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

3.4 HC-05 Bluetooth Module

Figure.4 Bluetooth module HC-05

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, temperature, atmosphere, geographic condition 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, highconnected; 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. Figure.4 Bluetooth module HC-05

IV. CIRCUIT DIAGRAM AND EXPLANATION

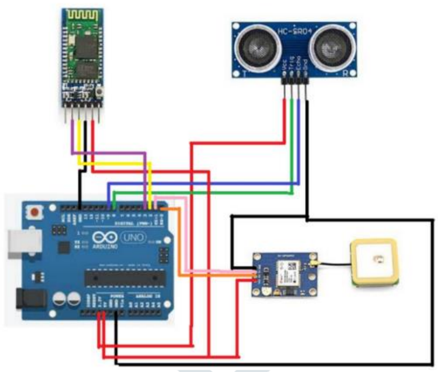

Figure.5 Hardware /circuit design

The system comprises of a microcontroller that connects all the sensors to form a compact system. It operates automatically after the initial setup. One of the sensors used is the Hc-Sr04 ultrasonic sensor, which is situated beneath the vehicle chassis to measure the distance between the sensor and the road surface. The code of the sensor calculates both the distance and the average distance of the road. When a reading exceeds the calculated average value, it is identified as a pothole, and the GPS module, Neo 6m, is activated to obtain precise coordinates. The GPS module is positioned directly above the ultrasonic sensor to obtain accurate coordinates in the form of latitude and longitude. NCMRPE-23 The coordinates are uploaded onto the Firebase cloud, which acts as the IOT cloud. An Android application is used to retrieve the GPS coordinates and display them on a map widget, along with other relevant data such as the depth and location of the potholes. The app provides a userfriendly interface and an easy-to-view map of the potholes

V. METHODOLOGY

5.1 Interface HCSR04 with Arduino In order to connect an HCSR04 ultrasonic sensor to an Arduino, the sensor must first be powered with 3.3v from the power source. The sensor has two pins: Echo and Trigger. Echo emits ultrasonic waves, while Trigger receives them. To calculate the distance, two pins are connected for serial communication. The Echo pin is connected to digital pin 2 on the Arduino, while the Trigger pin is connected to digital pin 3. To obtain readings from the sensor, a basic method involves using the distance-time formula with a standard baud rate of 9600 bauds.

5.2 Interface GPS Module with Arduino To connect a GPS module to an Arduino, the module should be powered by +5V from the Arduino power source. The module's voltage, which includes a coin battery pack and any ground pin, should also be monitored. Two pins are required for serial communication, and the Arduino pin 4 should be connected to the RX pin of the

GPS module, while the Arduino pin 3 should be connected to the TX pin. Reading raw data from the GPS module is a simple task that involves creating a new serial connection using Software Serial and aligning it with the standard baud rate of 9600 bauds for GPS

5.3 Interface Bluetooth module with Arduino The HC-05 Bluetooth module provides essential connectivity services and has six pins for component integration. It serves as the gateway for communication with mobile applications. By using UART, the HC-05 Bluetooth module can be interfaced with any other microcontroller, such as Arduino or 8051. AT Commands can be used by the microcontroller to control the HC-05 module. The pinout connections for the HC-05 Bluetooth module are as follows: Vcc is connected to the output of the Arduino's 3.3v, Rx is connected to Tx of the Arduino, Tx is connected to Rx of the Arduino, and the ground pin is connected to GND.

Application Working

The user interface in Android is primarily based on direct manipulation using touch inputs, such as swiping, tapping, pinching, and reverse pinching to interact with on-screen objects, in addition to a virtual keyboard. Android applications offer the capability of visualizing data through the use of charts, graphs, and maps, which aid in the analysis of complex data and provide numerous benefits across various industries and industrial applications. The integration of cloud and database features facilitates the plotting of data on maps and the collection of data from applications, resulting in a faster and more efficient means of deploying data.

V.WORKING PRINCIPLE

The system comprises of a sensor, GPS module, and Bluetooth module. The raw data from the sensor is used to detect potholes based on international standards, where the data is filtered and coordinated to determine the pothole depth which must be above 40mm. The GPS module is activated to obtain approximate latitude and longitude data using 4-5 satellites and a ceramic antenna. The Bluetooth module facilitates data transfer from the microcontroller to the mobile application, which is then sent to the cloud data storage. The mobile application consists of two parts: one displays the raw data and the other displays the map with the locations of potholes. The pothole locations are stored in a Firebase database with latitude and longitude information. The hardware setup is required for the vehicle, and the android application is built for seamless data transfer from the hardware to the software.

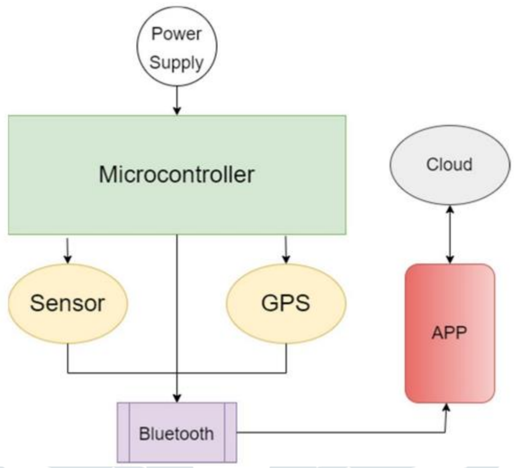

FIG 6.BLOCK DIAGRAM

VII.RESULTS

The experimental outcomes indicate an overall accuracy of 70-80 %. If the calculated average distance is greater than 40 cm, it indicates the presence of a pothole, and the GPS module is activated. The GPS module establishes a successful connection with any of the available satellites and determines the location. The Android application displays the pothole activities on a map and also provides the raw data.

VIII.CONCLUSION

The system is designed to detect potholes in the Information Technology center of the road management service, which will be useful for city authorities. The system was tested in the college premises and the marked potholes. The map gets updated in real-time, providing citizens in the area with immediate information about potholes. The suggested technique has better performance due to multiple experiments conducted under various conditions.

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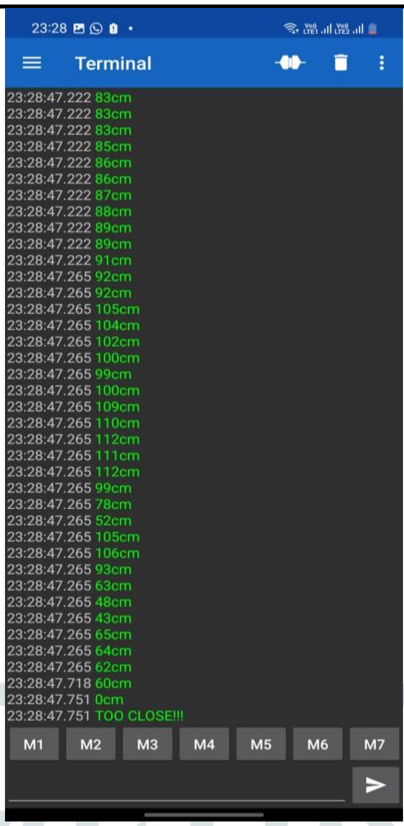

Fig7. Ultrasonic sensor range

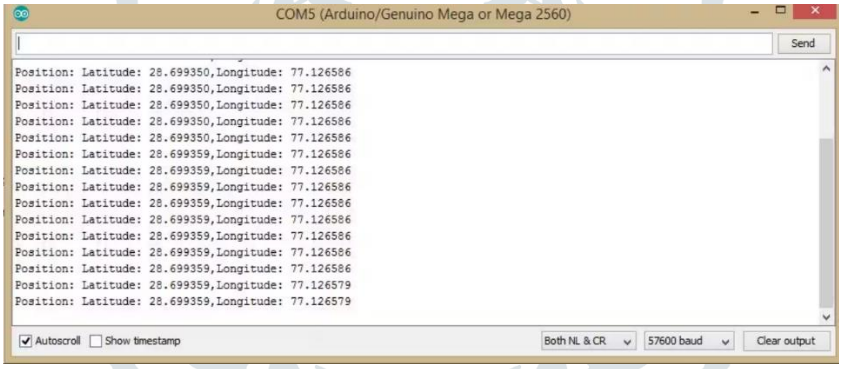

Fig8.Neo 6m GPS module

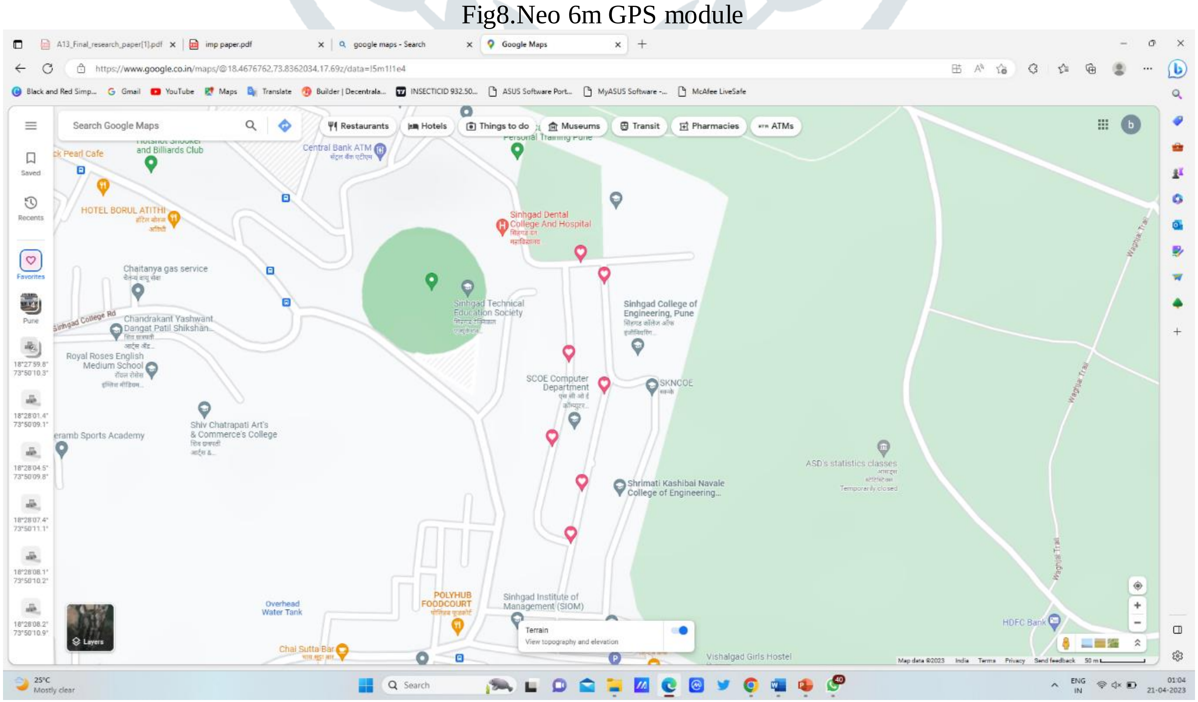

Fig10. Real time GPS data

VIII.MODULE

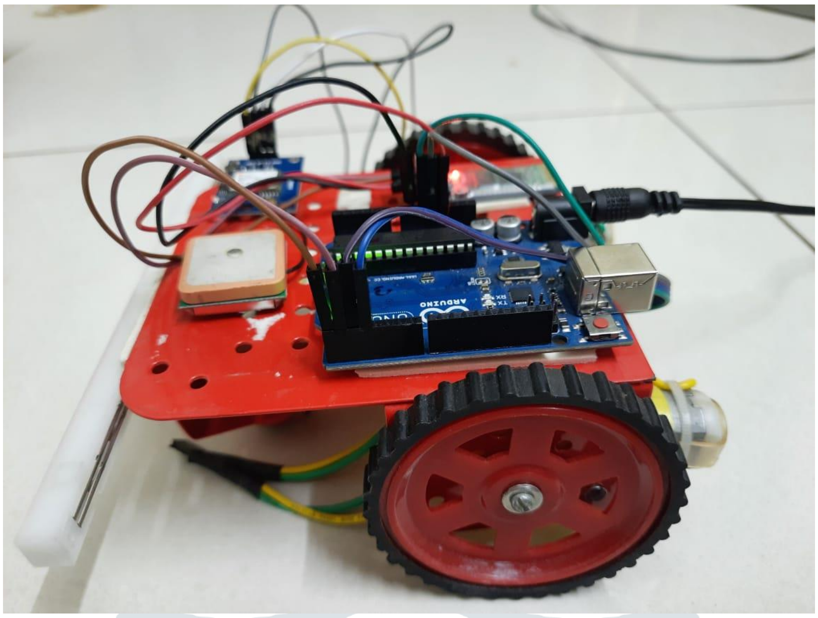

Fig11. working prototype

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