Development of Pothole and Hump Detection Robot Notifying It's Location Via Android App

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Abstract—In areas of the road surface that have split, deteriorated, and eventually formed a depression of varied depths depending on the severity of the damage, there are hollow, negative structural impairments known as potholes. The effectiveness and quality of the road infrastructure may be harmed. In addition to making roads rough, it damages tyres and throws wheels out of alignment. It is the primary cause of traffic accidents and casualties. Road pothole identification by hand can be tiresome, time-consuming, incorrect, and ineffective. Consequently, a reliable automated system for detecting potholes is required. Despite the introduction of numerous pothole detection systems and the projected rapid developments in the coming years, the cost-effective deployment of these techniques still presents a significant barrier. This document compares and summarizes numerous pothole detecting methods using various technologies, along with their advantages and disadvantages. A sensor-based pothole detection system utilizing ultrasonic sensors has been presented in order to construct a cost-effective pothole detecting system. When a pothole is detected, the sensor alerts the driver by sending an alert via a mobile application that must be integrated with the detection system. The information can also be kept on a server to inform the government about road maintenance and repairs. When compared to alternative ways, the suggested method is straightforward and less expensive. It can be used extensively in many different types of cars.

Keywords—ESP32 Microcontroller, Ultrasonic Sensors, Firebase cloud.

I. Introduction

India has a substantial global road network. In reality, a significant portion of India's total rider traffic uses the roadway infrastructure to reduce. With the advancement in every region of the nation, this passage has gradually increased throughout the years. Verifying the quality of roadways becomes crucial due to the rising demand. Road abnormalities should be regularly monitored and primarily fixed. As a result of increasing urbanisation and computerization, traffic congestion is becoming more and more prevalent in large cities. Because it cannot be avoided, it has an inexorable impact on how society functions. This obstruction results in less efficient use of the transportation infrastructure, longer wait times, and, most importantly, traffic accidents. Rapid attention is required for the architecture of the intricate road network in growing nations. Road accidents have recently been a major worry. The Auto Mobile Association reported that potholes are the main reason for sad tragedies. Large potholes often cause motor vehicles to lose their balance. On asphalt surfaces, potholes are a typical sort of discomfort that seem like little depressions in the shape of bowls.

II. Literature Survey

Unsafe road conditions are a key deterrent to comfortable and safe travelling. It is in everyone's best interest to have them fixed as soon as possible, including drivers. However, these requirements must first be recognized [1].

The provision of sustainable transportation through the enhancement of efficiency, quality, safety, and the reduction of the environmental impact of energy use is a top priority for the contemporary transportation sector. Environmental factors are thought to be the root cause of more than 30% of accidents. Therefore, having a sound road infrastructure is a crucial first step towards effective environmental protection and maintaining a low accident rate, especially in large towns [2].

Road humps are designed to slow down moving vehicles, however many of them are constructed at erratically inconsistent heights and irregular spacing. Sometimes there aren't enough road signs to warn motorists to slow down for an approaching hump in the road, which leads to collisions or damage to vehicles. The device is designed to also recognise road bumps and send drivers timely alerts [3].

Jin Lin, et al [4], have suggested a support vector machine (SVM) based approach for detecting potholes. Using this technique, potholes can be distinguished from other flaws like cracks. The partial differential equations are used to segment the images. The technique uses a series of pavement photos to teach the SVM to find potholes. However, if the photos are not well lit, the training model is unable to identify the pavement flaws.

Sudish surandharan et al [5] has suggested a spotter for hazards like potholes. In this method, a sensor is used to record the vehicle's vertical and horizontal accelerations as it travels, and a GPS device records the GPS coordinates that correlate to each acceleration. After processing the data, potholes along the road the car previously travelled can be found.

Youquan et al.[6] have created a model that uses the optical imaging technique of three-dimensional projection transformation to collect visual data on a pothole's cross-section for pothole detection. The series of image analysis and processing employs a variety of digital image processing techniques, such as binarization, image processing, thinning, three-dimensional reconstruction, error analysis, and compensation.

Ajit Danti, et al. [7] have created a model using a method based on image processing. For lane detection, the Haugh Transformation is provided in this work. A pothole detecting technique based on clustering is utilised. In this, a real-time image database is used to test the experimental outcomes.

Kongyang Chen, et al [8] presented a system that uses a three-axis accelerometer and a GPS sensor to identify potholes. The outputs from the three-axis accelerometer and GPS sensor are input into the data cleaning process. The inputs to the method are processed for power spectra density (PSD) in the second stage of the implementation in order to determine the roughness of potholes. Roughness is examined and divided into several levels.

Chang, K. T., Chang, J. Ret al [9] created a model for the 3D laser scanning technique to detect pavement distresses. The accelerometer is used in this vibration-based approach for detection, and a smart mobile phone application was created to process the sensor's output. Due to surface vibrations, this produces an output that is based on vibration and is very unreliable for bridge expansion joints. Moreover, if the phone rings, they delivered a false reading. Due to the Android misinterpreting the accelerometer measurement as a pothole, this model was useless for speed limiters.

W Angorro and A Nasution proposed [10] an example of a pothole detecting system built utilising the Kinect sensor and digital image correlation. This laser scan method made use of a device that analysed images using a 3D projection transform and an LED linear light whose beams fell vertically on the road surface. Although this method produced promising results, it required lengthy calculations and expensive equipment. This sophisticated system made use of a camera and a Kinect sensor. The Kinect sensor has two lenses that are used to determine depth and provide precise results. The total system was very expensive and intricate. Only a 57 degree horizontal view was available. Therefore, a Kinect array was necessary, which was virtually impossible to accomplish.

A model on Damage Detection in Roadways using Ground Penetrating Radar was introduced by D.R. Huston [11]. This method claimed that damage detection was accomplished using radar technology. Under fixed poles or moving vehicles, infrared, radar, and ultrasonic sensors were positioned to continually measure the distance travelled by the reflected wave in order to determine the depth. But it had a number of disadvantages. There was a significant power requirement if they were connected to poles. To be paved beneath the moving truck, it required to be extremely rigid and strong. The cut sensors' horizontal field of view was constrained. The entire system was also very sophisticated and expensive to install. This method's effectiveness was also susceptible to inclement weather.

Potholes Detection Based on SVM in the Pavement Distress Image: Model Proposed by Jin Lin and Yayu Liu [12]. The algorithm was put forth to identify pavement potholes. This method builds a non-linear support vector machine to determine whether a target region is a pothole by using a texture measure based on the histogram as the features of the image region. As a result, a high recognition rate was attained.

In their paper Improving Pothole Recognition via Vision Tracking for Automated Pavement Assessment [13], Ch. Koch and I. K. Brilakis suggested a model for detecting potholes. It was based on image processing's histogram texture measure. The potholes were detected using cameras and image processing techniques in this method.

An effective algorithm for pothole detection using stereo vision was created by Z. Zhang and X. Ai [14].This surface fitting approach employed thresholding for detection and estimated the road plane in the disparity map.

Pothole Detection using Image Processing and Spectral Clustering was a vision-based approach that E buza worked on [15]. In this, pothole detection was based on spectral clustering, and image segmentation was first produced using a thresholding method based on a histogram. The comparison of the textures of the sections inside and outside the pothole was used to accomplish this. In order to extract relevant data from the photos, they must also undergo additional processing. Despite the fact that image processing produces promising results, this technology has significant flaws.

III. Proposed System

The two components of this subordinate engineering are equipment and programming. Microcontroller, ultrasonic sensor, IR sensor, GPS, buzzer, L239D, and DC motor make up an equipment component. The ultrasonic sensor in the suggested system measures the separation between the vehicle and the pothole or hump. The microcontroller receives distance measurements from the sensor. The buzzer receives a signal based on the distance. Additionally, the system uses a GPS receiver to record the geographic coordinates of potholes and speed bumps. The data can then be provided to the MIT Application and is subsequently delivered to Google Firebase Cloud for analysis. The project's architecture is depicted in Fig. 1.

Process

i. The power supply is used to maintain as a source voltage.

ii. The ultrasonic unit may identify potholes by warning the user when the distance between the road and the sensor is higher.

iii. Our model assumes that there is a 5 cm gap between the car and the road, thus any gap larger than that triggers an alert. By setting the ultrasonic device to detect impediments at, say, 10 cm, it can also be used to identify humps. As a result, the user will receive a notification if a hump is discovered by the sensor at a distance of 10 cm.

iv. On the front end of the vehicle, this sensor is mounted.

v. Introduce a method that enables the detector to find the pothole's location using GPS and record and store its coordinates when there is confirmation of a pothole.

vi. The Google Firebase cloud receives an update of the data values.

vii. The MIT application fetches or displays Google Firebase data.

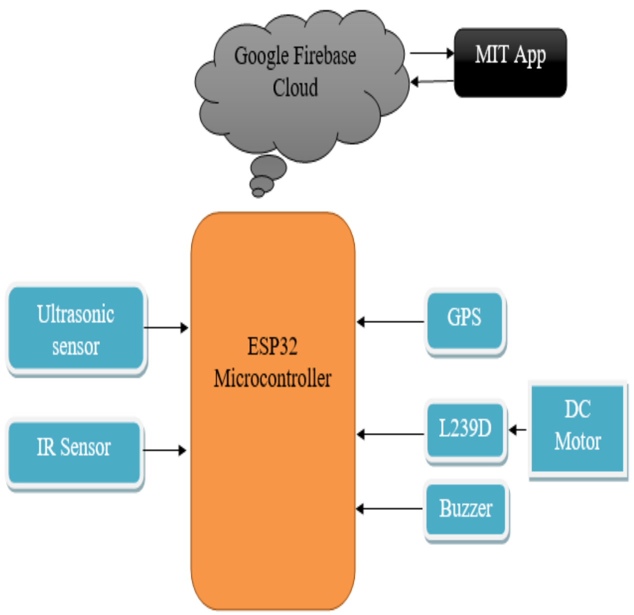

Fig .1: Shows methodology architecture.

IV. System Requriments

a. System Hardware Requirements.

1. Microcontroller – ESP32

Popular low-power system on chip microcontrollers like the ESP32 have built-in Wi-Fi and dual-mode Bluetooth, making them ideal for creating and developing Internet of Things (IoT) applications. This area includes a variety of introductory projects and tutorials for ESP32 NodeMCU-based IoT applications.

There are 34 physical GPIO pins on the ESP32 chip (GPIO0 through GPIO19, GPIO21 through GPIO23, GPIO25 through GPIO27, and GPIO32 through GPIO39). Each pin can be connected to an internal peripheral signal or used as a general-purpose I/O. With just a few printed circuit board (PCB) needs, ESP32 enhances your applications' capability and versatility in priceless ways.

2. Ultrasonic sensor

An ultrasonic sensor is a device that uses ultrasonic sound waves to calculate a distance to an item. An ultrasonic sensor transmits and receives ultrasonic pulses using a transducer to determine the proximity of an item.

3. IR sensor

An IR sensor is a technological innovation that produces light to detect nearby objects. An IR sensor can monitor an object's heat while also spotting movement. Typically, all items emit some kind of thermal radiation in the infrared range. Although these radiations are invisible to the human eye, infrared sensors can detect them.

4. L239D Motor Driver

At voltages ranging from 4.5 V to 36 V, the L293D is intended to deliver bidirectional drive currents of up to 600 mA. Both components are made to drive inductive loads in positive-supply applications, including relays, solenoids, DC and bipolar stepping motors, as well as other high-current/high-voltage loads.

5. GPS

Positioning, navigation, and timing (PNT) services are offered by the Global Positioning System (GPS), a U.S.-owned utility. The space segment, the control segment, and the user segment make up this system's three segments.

6. Buzzer

A buzzer or beeper is a mechanical, electromechanical, or piezoelectric (short for piezoelectric) auditory signalling device. Buzzers and beepers are frequently used for alarm clocks, timers, train announcements, and confirmation of human input such a mouse click or keyboard.

7. DC Motor

A sort of electric machine that transforms electrical energy into mechanical energy is a direct current (DC) motor. Direct current (DC) motors take electrical power and turn it into mechanical rotation.

DC motors provide very high levels of speed control. Wide speed variations can be achieved by adjusting the armature or field voltage, and with this level of controllability, DC motors provide the precision needed by a variety of industrial applications.

b. System Software Requirements.

1. Embedded C
2. Arduino IDE
3. Google firebase for cloud computing
4. MIT app inventor software for android app development

V. Results And Disscussion

As a result, the serial monitor tool of the Arduino IDE programme allows users to observe the pothole and hump readings that Ultrasonic sensors detected. The open-source MIT Application is part of the Internet of Things (IOT), and it records the discovered data from the Ultrasonic sensors in the form of time value charts.

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.

Fig.2.1.1 displays the suggested system's functioning model. It was evaluated in a simulated setting with made-up bumps and potholes. The server database was used throughout the test phase to record and store data concerning potholes and humps. In the second phase, alerts were created based on database information about potholes and humps. The microcontroller module was mounted on a toy car for testing purposes while the threshold value was set to 5 cm. The testing revealed that the microcontroller module identified potholes and humps as expected.

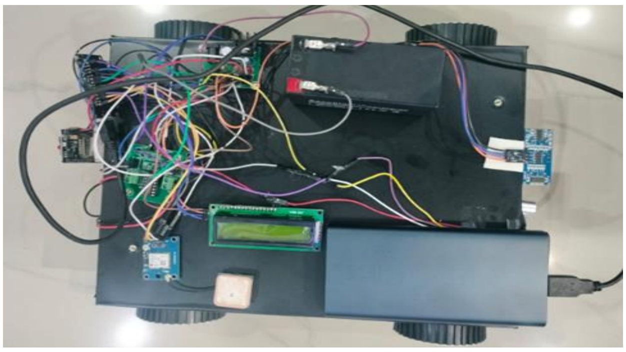

Fig.2.1.1. Working model of the proposed system.

TABLE I: Information About Potholes And Humps Collected In Simulated Test Environment

SL No	Obstacle Type	Height/Depth in CM	Latitude	Longitude
1	P	19.35	12.9563	77.5544
2	H	3.1	12.9406	77.5661
3	H	3.8	12.9421	77.5668
4	P	13.2	12.9411	77.5669
5	P	11.7	12.9434	77.5654
6	P	14.3	12.9523	77.5668
7	H	2.3	12.9547	77.56755
8	P	15.8	12.9575	77.56769
9	H	3.1	12.9417	77.5659
10	P	18.2	12.9567	77.56760

Table I shows a set of potholes and humps identified by the system in the simulated environment. The obstacle type P indicates a pothole and H indicates a hump Information about potholes and humps was successfully sent to the android device (server). The snapshot of these messages can be seen in Fig.2.1.2. The server processed the messages received and stored in the database.

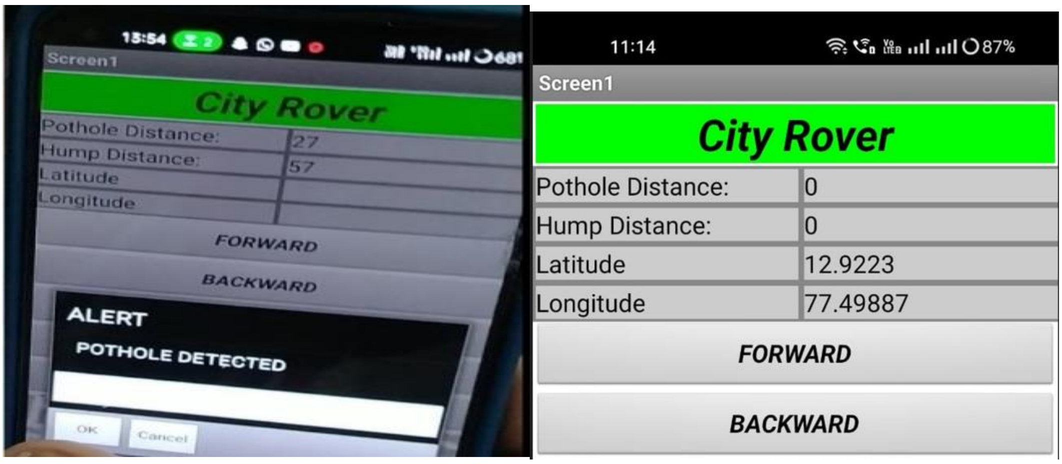

Fig.2.1.2. Pothole alert displayed on the mobile phone.

Coordinates via App - Sent through an Android app when a pothole is detected (distance measured by ultrasonic sensor 1 exceeds the threshold). The coordinates provide the location information of the detected pothole. Fig.2.1.3 shows the location of the pothole detected.

Fig.2.1.3.Location of the pothole

Notification on LCD - Displayed when the distance measured by ultrasonic sensor 1 exceeds the threshold value for pothole detection. It provides a visual alert about the presence of a pothole. Fig. 2.1.4 shows the pothole alert displayed on the LCD display.

Fig.2.1.4 Pothole alert displayed on the LCD Display

Pothole Image - After the detection of the Pothole, the EsP32 Cam captures the pothole and sends it to the telegram when initiated. Fig. 2.1.5 shows the captured image of pothole.

Fig.2.1.5 Pothole image captured by ESP32 cam..

Update in Cloud Server - The information about the detected pothole is updated in a cloud server when the distance measured by ultrasonic sensor 1 exceeds the threshold.

Speed Reduction - When the distance measured by ultrasonic sensor 2 exceeds the threshold value for hump or obstacle detection, the speed of the robot is reduced to ensure safe traversal.

Buzzer Activation - Activated when the distance measured by ultrasonic sensor 2 exceeds the threshold value for hump or obstacle detection, providing an audible alert about the presence of a hump or obstacle.

VI. Conclusion

The model put forward in this research accomplishes two crucial tasks: it automatically detects potholes and speed bumps while warning drivers to avoid potential collisions. The proposed method, which makes use of inexpensive ultrasonic sensors, offers a cost-effective way to identify terrible potholes and uneven humps. A further benefit of this system is the smartphone application, which sends out timely alerts regarding potholes and speed bumps. As notifications are generated using the data saved in the database, the system also functions during the rainy season when potholes are filled with muddy water. We believe that the strategy presented in this research has the potential to significantly reduce the number of fatalities and very ill patients. Based on the amount of potholes present on the roads, the suggested approach can be further enhanced to suggest safer routes. It is not necessary to specify threshold values for every sensor when using machine learning principles. The system may be programmed to automatically learn the threshold values for each changeable threshold value in various automobiles, making it simple for the system to adapt to any vehicle. A mobile application created to gather all the data in one location, track the recorded values in one location, and easily transfer it to road maintenance authorities.

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