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Detection and Notification of Potholes and Humps on Roads to Aid Drivers Using IoT

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ABSTRACT: Spotted potholes and speed bumps are among the main causes of car accidents. Well-maintained roadways contribute significantly to the country's economy. The importance of road infrastructure in society could be compared with the importance of blood vessels for humans. The road surface quality should be regularly inspected and fixed as needed. In this project, ultrasonic sensors are used to identify potholes and humps to measure their depth and height, respectively. It also incorporates a rain sensor to detect whether or not water is present inside the pothole. When a pothole or hump (speed breaker) has been detected, a buzzer will be alarmed, and a red LED will glow, alerting the vehicle drivers.

KEYWORDS: potholes, humps, ultrasonic sensor, buzzer, rain drop sensor.

I. INTRODUCTION

Potholes accounted for roughly 4.4 thousand incidents in 2022, making them one of the primary accident causes. The number of accidents due to potholes increased and its share in the total causes of accidents due to road features has also increased over the years. One of the biggest obstacles to safe and comfortable traveling is hazardous road surfaces. Fixing them as soon as possible is of interest to both drivers and road maintenance personnel. However, these conditions have to be identified first. Providing sustainable transportation through increases in effectiveness, quality, safety, and energy impact reduction is a top priority for the transportation sector today.

It is estimated that more than 30% of accidents are caused by environmental conditions. Therefore, in order to achieve good environmental protection, and to keep a low accident rate, especially in large towns, having a healthy road infrastructure is a major first step forward. Although the purpose of road humps is to reduce vehicle speed, many of them are constructed at irregular, non-scientific heights and at irregular intervals. Occasionally, there aren't enough timely road signs alerting drivers to impending road humps, which can cause collisions or damage to vehicles.

1.1 Problem Statement

Road infrastructure plays a pivotal role in ensuring the safety and efficiency of transportation for motorists. However, the presence of potholes and speed humps poses significant challenges to drivers, leading to accidents, vehicle damage, and discomfort. The current methods of identifying these road hazards rely heavily on manual inspections, which are time-consuming, inefficient, and often prone to oversight. Consequently, drivers encounter these hazards unexpectedly, jeopardizing road safety and causing financial burdens due to vehicle repairs.

The absence of real-time detection and notification systems exacerbates these challenges, as drivers have limited means to anticipate and navigate around potholes and humps. This situation underscores the urgent need for a more proactive approach to identify and alert drivers about road hazards promptly. Leveraging Internet of Things (IoT) technologies holds immense promise in addressing this issue by enabling continuous monitoring of road conditions and providing timely notifications to drivers.

However, developing an effective IoT-based system for pothole and hump detection presents several challenges. Firstly, ensuring the accuracy and reliability of IoT sensors in detecting variations in road surfaces is critical. Additionally, processing large volumes of sensor data in real-time poses computational challenges, necessitating robust algorithms and data processing techniques. Integration with existing transportation infrastructure and communication networks also requires careful planning to ensure seamless operation and compatibility.

II. RELATED WORK

In their work, Samyak Kathane et al. [1] suggested a wireless anti-theft mechanism that is integrated with a real-time pothole detecting and reporting system. The authors address the pressing issue of potholes in road infrastructure and provide a real-time pothole detection system that can alert owners to the need for immediate repairs. Additionally, they incorporate an anti-theft device to prevent illegal removal or system alteration. Sudish Surandharan et al. has proposed a potholes and pitfalls spotter. The writers commence by delineating the challenges posed by potholes and their detrimental effects on vehicle maintenance and traffic safety. They emphasize that early detection and reporting are critical to effective road maintenance. The project's main goal is to leverage cutting-edge technology to produce an automated system capable of real-time pothole detection.

The authors provide the algorithms and techniques for discovering and identifying potholes, which have been proposed by Savitha M. M. et al. [4]. They discuss signal processing techniques for sensor data analysis, including image-based processing and vibrations to identify surface irregularities and changes. The authors also look at how systems that coordinate road maintenance might use information about potholes that are found. By providing real-time data on pothole locations and severity, road authorities can effectively allocate resources, prioritize maintenance operations, and improve overall road conditions and safety.

An Android smartphone with an accelerometer-based real-time pothole identification system was proposed by Mednis et al.[8]. Accelerometers are a feature of most modern Android phones that allow them to sense vibrations and movement. Data from accelerometers is used to find potholes. Several techniques are used to find potholes: Z-thresh, which calculates the standard deviation of vertical axis acceleration, Z-diff, which measures the difference between the two amplitude values, and G-Zero. Z-thresh measures the amplitude of acceleration at the Z-axis.

A laser imagery-based pothole identification approach was developed by Yu and Salari [14]. The laser source distortion is used to identify potholes and other signs of pavement deterioration when it is visible in the gathered photographs. There are several methods used to find potholes, including tile partitioning and multi-window median filtering. The issue is made worse by the division of these craters into groups according to their forms and intensity.

Ajit Danti and colleagues [9] have created a model that utilizes an Image Processing methodology. This work provides Hahn Transformation for lane detection. A method based on clustering is used to find potholes. This uses a real-time image database to test the experimental outcomes.

A system with a unique Wi-Fi-based architecture for pothole detection and warning system has been devised by Rode et al. [5] to help drivers avoid potholes on the roadways by providing them with advance warning. The system is made up of access points that are positioned along the sides of the road to broadcast data, which Wi-Fi-enabled cars can pick up as they approach the area the access points cover. The application can be connected to the car to sound an auditory alert, display a visual indicator, or even activate the brakes.

Li et al. calculated the root mean square of the z-pivot speed increase for each road segment to determine an intermediate for IRI. This allowed them to evaluate the severity of the street section. Six well-known limit combinatorial heuristics were differentiated by Carlos et al. [10] about datasets of street conditions obtained through the platform. Potholes were found using the best method, the STDEV (Z) strategy, which was suggested by Mednis et al. [11]. It did this by calculating the standard deviation of accelerometer readings along the z-hub. They combined the components these algorithms used to extract highlights in that review, giving SVM new component vectors, and the results outperformed STDEV (Z).

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The Potholes and Pitfalls Spotter system, which is being proposed by Prachi I More et al. [2], includes a reporting mechanism, data processing algorithms, and sensor modules, among other components. The sensor modules gather data on vibrations, temperature, and photographs of the road surface to identify possible potholes and other hazards. The experimental results and metrics for gauging the effectiveness of the Potholes and Pitfalls Spotter system are included in the paper. The authors assess the efficiency of data processing algorithms, the precision of pothole identification, and reporting mechanisms for timely information delivery to the road maintenance authority.

III. EXISTING SYSTEM

In essence, potholes are places on the road surface where a hole has finally formed due to erosion, burst, or wear and tear. Driving on uneven surfaces like potholes can become unstable and lead to collisions. Accidents can be caused by drunk driving, speeding, jumping traffic signals, potholes, speed bumps, and velocity breakers. The design of the remedy to this issue must ensure that traffic on Indian roadways moves logically and securely. This can be accomplished by warning the driver of the pothole or hump that has been found [5][6][7].

IV. PROPOSED SYSTEM

The smart sensor system of the proposed system tracks and updates the road's potholes. To determine the difference between the pothole and humps and the normal road ultrasonic sensor is used. An accelerometer is a vector quality that indicates the direction of an event. The sensor will identify any odd modifications to the car. Three-parameter xyz determines them. In addition, if the car vibrates more than a certain amount, a vibration sensor is employed to detect potholes. The cut-off point is predetermined. The GPS sensor updates the locations where the potholes are located precisely when both of these sensor readings are supplied to the microcontroller. Through IOT, this data is relayed to the web server so that road transport officials can take the appropriate action. The information is used to forecast the state of the roads and prioritize taking the required action. Since the microcontroller is connected to every sensor, the system is small. After the initialization, it is anticipated that the system will operate automatically. The positioning of the Hc-Sr04 ultrasonic sensor allows it to measure the separation between the road and the sensor, which is often mounted beneath the car's chassis. The sensor's algorithm is intended to compute both the distance and the average distance traveled on the route. A reading is considered to be of the highest quality when it exceeds the average calculated value. When a pothole is found, the GPS Module is activated. The exact coordinates are provided by the ultrasonic sensor, which is positioned precisely above the module. The latitude and longitude coordinates are posted to the IOT cloud.

A. Block diagram

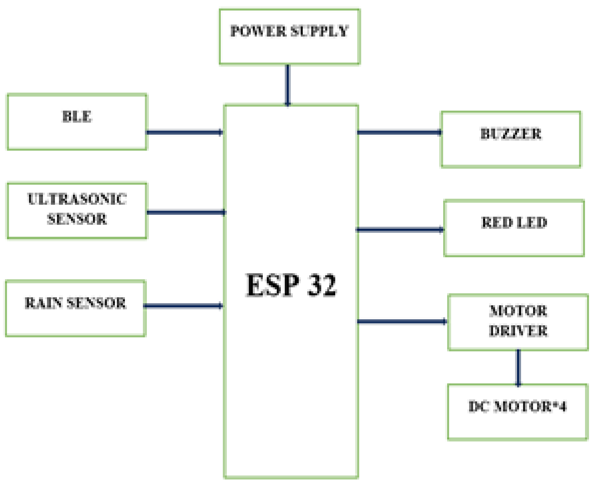

Fig. 1: Block diagram of proposed system

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A. Components used in the proposed system

HARDWARE REQUIRED:

- ESP32
- ULTRASONIC SENSOR
- RAIN DROP SENSOR
- BUZZER
- RED LED
- MOTOR DRIVER
- MOTOR

SOFTWARE REQUIRED:

- ARDUINO IDE
- EMBEDDED C

ESP32

Fig.2: ESP32

Based on a dual-core processor mechanism, the ESP32 is a low-powered, low-cost microcontroller (MCU) board with built-in Bluetooth and Wi-Fi. The first is an ultra-low coprocessor (ULP) with only 8 KiB of memory that is intended to operate when the ESP32(fig 2) is in deep sleep mode. An example of such a processor is the Xtensa LX6 (~240 MHz), which has 512 KiB of memory. Additional parts include about 48 configurable I/O pins; a variety of peripheral interfaces such as capacitive touch, hall effect, and temperature sensors; and an 8-centimeter LCD, which is seen here prominently in a Espressif Systems ESP32-WROVER board(fig 1)

Ultrasonic sensor

Fig.3: Ultrasonic Sensor

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Ultrasonic sensors emit ultrasonic pulses, and by measuring the time of ultrasonic pulse reaches the object and back to the transducer. An item reflects the sound waves that the transducer emits, and the transducer receives the reflected waves back. The ultrasonic sensor will go from emitting sound waves to receiving them. The distance of the object from the sensor determines how long it takes for an emission to be received.

V. RAINDROP SENSOR

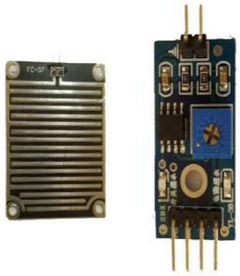

Fig.4: Raindrop Sensor

A device for sensing rain is a raindrop sensor. It has two modules: a rain board for rain detection and a control module for digital value conversion by comparing the analog value. Raindrop sensors are employed in home automation systems, agriculture, and the automotive industry to sense rain and automatically operate windshield wipers.

Buzzer
An audio signaling device, often known as a buzzer or beeper, can be piezoelectric, electromechanical, or mechanical (piezo for short). Buzzers and beepers are commonly used in alarm systems, timers, and to confirm user input, such as mouse clicks and keystrokes.

Fig.5: BuzzeR   A sound device that can translate audio signals into sound signals is a buzzer. DC volts. Alarms, PCs, printers, and other electronic equipment frequently use it as a sound source.

VI. WORKING PRINCIPLE

The controller for this setup is the ESP32. It incorporates an ultrasonic sensor for distance measurement. Additionally, there's a rail fall sensor that detects water droplets falling, also capable of sensing road distances ranging from 6 to 7 units. It's designed to check road conditions such as speed breakers and road patches. Motor control is managed by the LS9800 motor. This car is Bluetooth-enabled, with the Bluetooth name set as 'Bluetooth Car.' Upon connection, it displays green indicators and allows access via front and back drives. If road patches are detected, an alarm triggers. Distance measurements in centimeters are made using the ultrasonic sensor.

The system is powered by a 12V battery. Connections are made as follows: brown wire to red and black wire to black. When powered, lights illuminate in the L298 motor, soil moisturizer, and controller. The soil moisturizer sensor is activated and triggers an alert when necessary. It monitors soil moisture levels and alerts when water is detected in potholes, emitting an alert sound.

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FLOW DIAGRAM

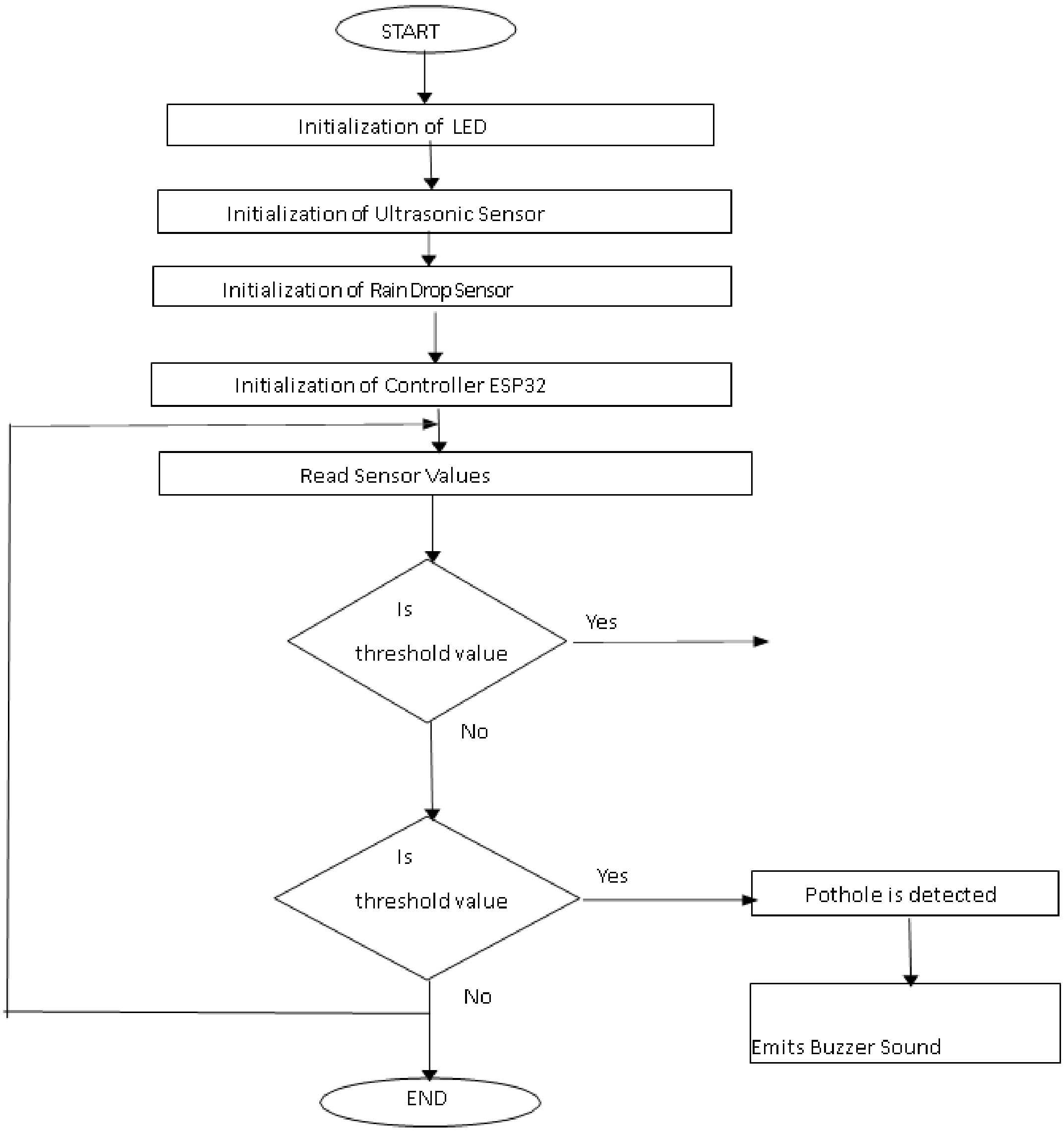

Fig 4.1 FIOW DIAGRAM

ARDUINO IDE: 1.8.5

Arduino is an open-source electronics platform with simple hardware and software Arduino boards can convert inputs, such as a sensor light, a finger pressing a button, or a Twitter message, into outputs, such as starting a motor, turning on an LED, or posting data to the internet. You can control your board's behaviour by sending a series of instructions to the microcontroller on the board.

To accomplish this, the Arduino Software is needed(IDE) based on Processing and the Arduino programming language based on Wiring. Arduino has been the brains behind thousands of projects over the years, ranging from simple household items to sophisticated scientific equipment. Around this open-source platform, a global community of makers—students, amateurs, artists, programmers, and professionals—has come together. Their efforts have added up to an amazing quantity of accessible knowledge that may be very beneficial to both beginners and specialists.

At the Ivrea Interaction Design Institute, Arduino was created as a simple tool for quick prototyping that was intended for students without any prior experience with electronics or programming. Since its introduction to a larger audience, the Arduino board has evolved to meet new demands and overcome obstacles, moving beyond basic 8-bit boards to include solutions for wearables, 3D printing, embedded environments, and Internet of Things applications. Since every Arduino board is fully open-source, anyone can construct one on their own and eventually modify it to suit their specific requirements. Additionally, open-source, the program is expanding as a result of global user contributions.

EMBEDDED C

The C Standards Committee developed Embedded C, a set of language extensions for the C programming language, to overcome commonality issues with C extensions for different embedded devices. Traditionally, embedded C programming required nonstandard C language extensions to enable unusual capabilities such as fundamental I/O operations, multiple memory banks, and fixed-point arithmetic. The syntax and semantics utilized in embedded C include Main (), variable definition, data type declaration, conditional expressions (if, switch, case), loops (while for), functions, arrays and strings, and structures, to name a few. Union, bit operations, macros, etc. During the early stages of microprocessor-based systems, assemblers were used to write programs that were then fused into EPROM. Previously, there was no way to know what the software was doing. LEDs, switches, and other devices were utilized to ensure that the software was functioning properly. However, they were prohibitively expensive and unreliable. Microprocessor-specific assembly-only programming declined in popularity over time, and C emerged as the primary embedded programming language for embedded systems. C is the most popular programming language for embedded processors and controllers.

VII. CONCLUSION AND FUTURE ENHANCEMENT

Conclusion

Thus, this project's detection of potholes and humps on the road and alert system affords a cost-effective solution to detect potholes and humps on the street and imply road preservation authority for the renovation. Additionally, motive force can take the desired action when this device alerts them to a pothole ahead of time.

Future Enhancement

The future enhancement of this project involves integrating advanced technologies like IoT technology, machine learning techniques, multi-sensor integration, voice command integration, adaptive speed management, impediment avoidance, and preventing drink and force cases, etc. By implementing these future enhancements, this project can become a more robust and intelligent solution.

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