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Automatic Detection and Notification of Humps and Potholes

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***Abstract*— In our day-to-day life Humps and Potholes are the major issue we have to face out there on roads. Most of the population uses Roads as a major transportation medium, We cannot simply ignore this major problem. And because we are still using tar-roads, these are easily damaged due to the heavy rainfall or tires screeching or both. When these roads are messed up, that becomes a Roller-coaster ride and that could ruin our day, cause serious injury, accidents & sometimes even death. Considering this, here we propose a system to build a device which could be fitted in a car or truck and detect any obstacle, uneven hump, pothole or some damaged piece of road.**

***Index Terms*— Mobile Notification, GSM SIM900, GPS, Raspberry-PI, ultrasonic sensor, Cloud Server.**

I. Introduction

INDIA is the world's second most populated country, with a rapidly expanding economy.. It is well-known for its extensive highway system. The most popular way of transportation in India is by road. They convey almost 90% of passenger traffic and 65% of freight in the country [1]. The majority of India's roads, on the other hand, are narrow and congested, with poor road surface quality and unmet road maintenance standards. Driving in India is a breath-holding, potentially life-threatening especially in rural areas of the country..

In the last few years, there has been a tremendous increase in the vehicle population. This increase in car numbers has led in a slew of problems, including traffic congestion, potholes and humps, and an uptick in the incidence of road accidents. Traffic congestion and accidents are exacerbated by poor road conditions. Researchers are working on traffic congestion control [2], which is an important component of today's high-demand vehicular area networks.

Speed breakers are commonly seen on Indian roads, allowing drivers to limit their vehicle's speed and avoid accidents. These speed breakers are unevenly dispersed, with unrealistic heights and are difficult to identify while driving because of improper marking of it.

Fig. 1. Condition of roads with potholes.

Potholes emerge as a result of heavy rains and the movement of large vehicles. According to the ministry of road transport and highways' survey report "Road Accidents in India, 2011," a total of 1,42,485 individuals died in fatal road accidents. Poor road conditions were responsible for almost 1.5 percent of these fatalities, or nearly 2,200 people. Figure 1 depicts the state of roadways with dangerous potholes. To address the aforementioned challenges, a low-cost solution that collects data on the severity of Humps and Potholes while simultaneously supporting vehicles in traveling safely is necessary.The suggested approach aims to encourage vehicles to avoid collisions caused by potholes and higher humps.

Following are the remaining sections of the paper: Section II focuses on the relevant work that has been done and is currently being done in the field of pothole and humps identification. The proposed system's numerous components are discussed in Section III. The suggested system's architecture and implementation are described in Section IV. The suggested work's experimental results are reported in Section V. The conclusion and future scope are discussed in Section VI.

I. Related Work

Researchers have been working on pothole detection algorithms as part of their research on pavement distress detection. This section provides a quick overview of the current solutions for detecting road Humps and Potholes.

Moazzam et al. [3] suggested a low-cost approach for analysing three-dimensional pavement distress images. It delivers direct depth measurements using a low-cost Kinect sensor, which saves money on computing.

An RGB camera and an IR camera record RGB and depth images, respectively, in the Kinect sensor. These images are examined in the MATLAB environment to assess the depth of potholes by extracting metrological and unique information. Youquan et al. [5] created a model for recognising a pavement pothole's three-dimensional cross section. To capture the images, the approach uses LED linear light and two CCD (Charge Coupled Device) cameras to capture the image of the pavement. It uses many digital image processing technologies to detect the depth of potholes, including photo pre-processing, binarization, thinning, three-dimensional reconstruction, error analysis, and compensation. The intensity of the LED light and the surrounding surroundings, on the other hand, have an effect on the results.

An SVM-based technique for detecting potholes was proposed by Lin and Liu [6]. (Support Vector Machine). This approach is used to detect potholes caused by other faults like fissures. Partial differential equations are used to segment the photographs. The method uses a set of pavement images to train the SVM to detect potholes. The training model, on the other hand, fails to detect pavement problems if the photographs are not well lit. Orhan and Eren [7] have demonstrated an Android-based road danger detecting system. Sensing, analysis, and sharing are the three aspects of this proposed initiative.

The sensor component takes raw accelerometer data and synchronizes it with the user interface, making it easy to retrieve. The sensor data is utilized to build analysis modules in the analysis component. This is how the sharing feature works: the built framework is linked to the core application, from which it can directly communicate with the social network. All of the collected data is kept in a central repository for later processing. Although this technique notifies other drivers of traffic incidents, it increases the cost and complexity of implementation.

Mednis et al. [8] suggested an Android smartphone with a real-time pothole detection mechanism based on accelerometers. Modern Android phones have accelerometers built in to detect movement and vibrations. Accelerometer data is used to detect potholes. To locate potholes, various methods are employed, including Z-thresh, which measures the amplitude of acceleration at the Z-axis, Z-diff, which measures the difference between the two amplitude values, STDEV (Z), which calculates the standard deviation of vertical axis acceleration, and G-Zero.

To detect potholes, Zhang et al. [9] used stereo camera pictures and a disparity computation approach. The potholes' coordinates are also captured and saved in the database. Accelerometers were proposed by Strutu et al. [10] to detect road surface defects. It also uses GPS technology to pinpoint where the weaknesses are located. identifying potholes

The method is implemented using an accelerometer, GPS, local computer, and wireless router on a mobile platform (moving autos).

Data is detected and delivered to a central database via primary and secondary access points, where it can be processed. However, setting up access points and installing a wireless router and a local computer on all mobile platforms is quite expensive. A vision-based approach for detecting potholes was proposed by Murthy and Varaprasad et al. [11]. The road surface is photographed using a properly mounted camera.

The potholes in the photographs are then detected using MATLAB. It's a two-dimensional vision-based system that only operates under uniform lighting and has no warning system. The above techniques only address the identification of a pothole. These techniques do not assist the driver in avoiding Humps and Potholes, which might result in accidents.

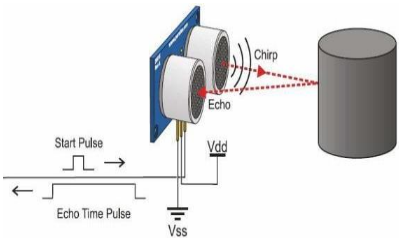
According to Rode et al. [4,] Wi-Fi enabled automobiles gather data about the road surface and send it to the Wi-Fi access point. The access point then sends out this data to other nearby automobiles in the form of alerts.The technology, however, proves to be costly because all vehicles must be equipped with Wi-Fi stations, and a greater number of access points must be built. Venkatesh et al. [12] suggested an intelligent system that detects and avoids potholes using a laser line striper and a camera.

This method keeps track of pothole locations using a centralized database. It also uses the Dedicated Short Range Communication protocol to send out pothole warning signals to surrounding vehicles. An intelligent transportation system for detecting potholes was presented by Hegde et al. [13]. to find out whether there are any potholes, ultrasonic sensors are used. This system also sends warning signals to any vehicles within a 100-meter range using the Zigbee module. However, when the system detects potholes, it sends out signals that do not adequately aid drivers in avoiding potential accidents.

More et al. [15] described a sensor-equipped public transportation system. These sensors record the vertical and horizontal accelerations that cars experience on their route. In order to discover potholes, the GPS device implanted in the vehicle tracks its associated coordinates, and the data is examined to find potholes in the vehicle's previous course For constant speed investigations, a Fire Bird V robot is employed. An IR Sharp sensor and a servo motor that rotates 0-180 degrees are included in the moving robot. Variations in steady speed are detected by sharp infrared sensors.

If a pothole is identified, the rover comes to a halt and the camera goes to photograph the pothole while the GPS device locates its position & sends the accurate location of the pothole to concerned government authorities. Although this is a cost-effective approach, it is limited to gathering data about Humps and Potholes.

Yu and Salari [16] developed a pothole detection method based on laser imagery. When the laser source distortion is visible in the collected photos, it is used to detect pavement deterioration such as potholes. Various approaches, such as multi-window median filtering and tile partitioning, are employed to detect the existence of potholes. The fact that these craters are divided into categories based on their shapes and severity exacerbates the problem.



ig. 2. Working principle of ultrasonic sensor.

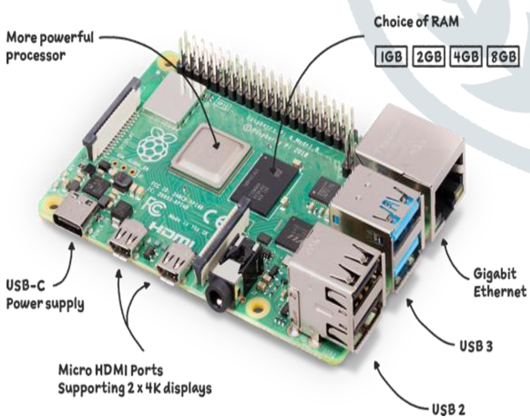
Although this method of detecting potholes is accurate and effective, the cameras acquire unstable images as a result of the uneven road surface, reducing the pothole detection efficiency. Chen et al. [17] suggested a method that uses a GPS sensor and a three-axis accelerometer to identify potholes. The data cleaning approach uses the GPS sensor and three-axis accelerometer outputs. In the second part of the implementation, the inputs to the method are evaluated for power spectra density (PSD) to compute the roughness of potholes. After analysis, roughness is separated into numerous levels.

II. Components Used in the Proposed System

The suggested system provides a mid-cost method of identifying Humps and Potholes on highways and alerting cars to their presence.

The following are the components employed in the proposed work:

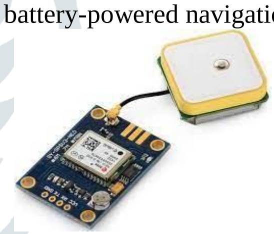
Raspberry-PI A Microcontroller: The RASPBERRY PI 4 is a PI series development board. It can be thought of as a single-board computer that runs the LINUX operating system. The board not only offers a lot of functionality, but it also has a fast processor, making it ideal for complex applications. The PI board was created with hobbyists and engineers in mind who are interested in LINUX systems and IoT. (Internet of Thing)



Ultrasonic Sensors HC-SR04: Non-contact distance measurements from 2 cm to 3 metres are provided by the ultrasonic sensor. It's simple to programme microcontrollers like the BASIC Stamp and Propeller chip because they only have one I/O pin. The sensor transmits an ultrasonic signal and generates an output pulse equal to the time it takes for the burst echo to return to the sensor. The echo pulse width can be used to calculate the distance to the target.

PI Camera - The Raspberry Pi Camera Board is a specially built Raspberry Pi add-on module. Through a bespoke CSI interface, it connects to Raspberry Pi hardware. In still capture mode, the sensor offers a 5-megapixel native resolution. It can record video at up to 1080p at 30 frames per second in video mode.

GPS Receiver: GPS is a satellite navigation system that records geographic location and time. The GPS modules provide a small design with a high-sensitivity, high-performance processor. Up to 20 satellites can be tracked at once by the GPS module. Fast time-to-first-fix and 1Hz navigation update are also features of the module. The unit is ideal for a variety of uses, including handheld, PDA, PPC, and other battery-powered navigation systems.



GSM RS232 :- The SIMCOM Make SIM900 Quad-band GSM engine powers the modem, which operates at frequencies of 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz. It's compact and simple to use as a plug-in GSM modem. The GSM Modem is equipped with RS232 Level Converter hardware, allowing you to connect to a PC Serial port directly. The baud rate can be set anywhere between 9600 and 115200. Initially, the modem is set at Auto baud. Internal TCP/IP stack is included with this GSM RS232 Modem. It can be used for both SMS and data transmission applications.

Motor Driver IC:- Motor drivers serve as a connection between motors and control circuits. The controller circuit operates on low current signals, but the motor requires a large amount of current. The purpose of motor drivers is to convert a low-current control signal into a higher-current signal capable of driving a motor.

ARCHITECTURE & IMPLEMENTATION

Figure 3 depicts the proposed system's architecture. It is made up of three parts: a microcontroller, a server, and a notification module. The microcontroller module collects information regarding Humps and Potholes, as well as their geographic locations, and sends it to the server. The server module gets data from the microcontroller and processes it before storing it in the database. The notification module accesses data from the server database and sends out timely alerts to the driver.

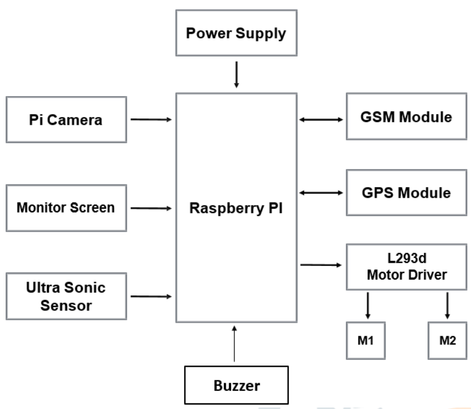


Fig. 3. Architecture of the proposed system

Here, Raspberry Pi is directly connected to Pi camera and Ultrasonic Sensor, which will help us to identify/recognize Humps and Potholes on roads. Ultrasonic Sensors will detect Potholes as well as obstacles or big boulders lying on the road. sensing distance between the rover and the road continuously and feeding that distance as an input to the raspberry pi processor. After analyzing and comparing the data (distances) provided by the ultrasonic sensors Raspberry Pi will decide, is there a pothole or not.

Here we set a threshold distance of a certain centimeter. If the current output of the ultrasonic sensor that is the current distance between rover and the road exceeds the threshold then it will consider it as a pothole and capture a photo of it.

After detection it will also trigger the Raspberry Pi, which will analyze the intensity of the obstacle and let the driver know about the obstacle through Buzzer. Till then the images will be processed for us and the results about the presence of the pothole would also be ready by then.

So now we will take the results and if there is no pothole present, we will simply go ahead and process the next images. But if there is a pothole present on the road, we will hit the GSM module after that we will communicate with the GPS and take the coordinates of the current location passing them on to the host through GSM Module, hence generating an alert.

Here the GSM RS232 module processes the request and contacts the server interrupting for a pothole after checking its severity. Then the server handles the request and notifies the authorities or the individual about the pothole.

Here we chose Rover because it has many advantages in the testing and development stage, as the whole circuitry fits easily on it and it's easy to control using an android application which commands the motor driver. On top of that this Rover stands great for any advancements in the future scope of this project.

So now this whole Mechanism is fixed on a Rover which travels on roads and continuously detecting Humps and Potholes and notifying about the same by sending the accurate location to concerned authorities. This Rover requires the Motor Driver IC to control which we again control using the Raspberry-PI 4 Processor and hence the system completes.

I. EXPERIMENTAL RESULTS

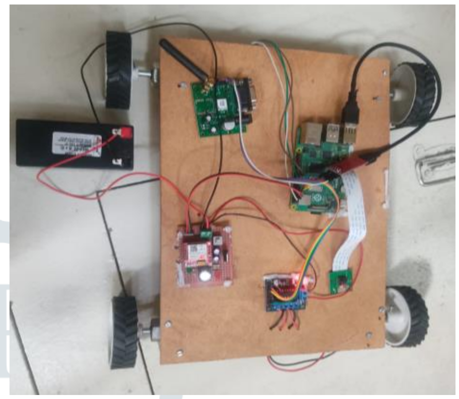


Fig. 4. Hardware Design

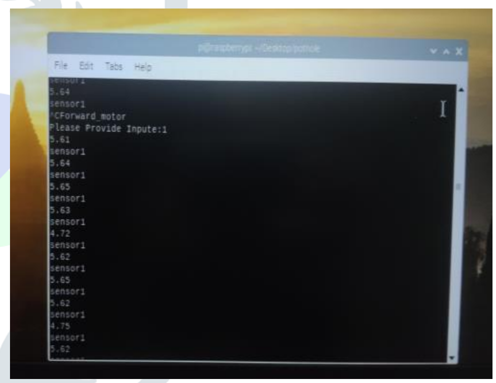


Fig. 5. Output Image (when the pothole is not detected)

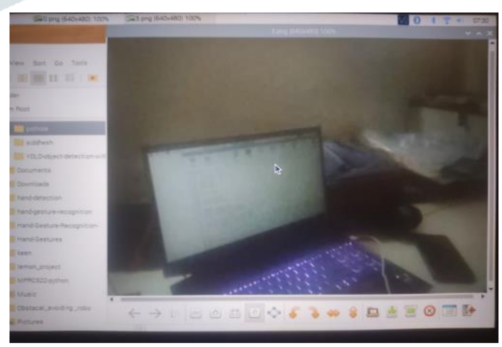


Fig. 6. Camera Output Image (when the pothole is detected)

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