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Remote Monitoring and Warning System for Vulnerable Roads

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ABSTRACT: 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 helps drivers to avoid accidents or vehicle damages but also helps authorities to maintain roads. This project discusses previous pothole detection methods that have been developed and proposes a cost effective solution to identify potholes and humps on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. Ultrasonic sensors are used to identify potholes and humps and also to measure their depth and height respectively. The proposed system captures the geographical location coordinates of potholes and humps using GPS receiver. The sensed data includes pothole depth, height of hump and geographic location, which is stored in the database (cloud). This serves as a valuable source of information to the Government authorities and to vehicle drivers. A Webpage is used to alert drivers and authorities so that precautionary measures can be taken to evade accidents. Alerts are given in the form of a flash messages with an audio beep.

KEYWORDS: GPS, Raspberry Pi, Ultrasonic sensors.

I. INTRODUCTION

India, the second most populous Country in the World and a fast growing economy, is known to have a gigantic network of roads. Roads are the dominant means of transportation in India today. They carry almost 90 percent of country's passenger traffic and 65 percent of its freight. However, most of the roads in India are narrow and congested with poor surface quality and road maintenance needs are not satisfactorily met. No matter where you are in India, driving is a breath-holding, multi-mirror involving, potentially life threatening affair. Over the last two decades, there has been a tremendous increase in the vehicle population. This proliferation of vehicles has led to problems such as traffic congestion and increase in the number of road accidents. Pathetic condition of roads is a boosting factor for traffic congestion and accidents. Researchers are working in the area of traffic congestion control, an integral part of vehicular area networks, which is the need of the hour today. Roads in India normally have speed breakers so that the vehicles speed can be controlled to avoid accidents. However, these speed breakers are unevenly distributed with uneven and unscientific heights. Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. According to the survey report Road Accidents in India, 2011, by the ministry of road transport and highways, a total of 1,42,485 people had lost their lives due to fatal road accidents. Of these, nearly 1.5 per cent or nearly 2,200 fatalities were due to poor condition of roads [1]. Traffic, especially in a country like India, is a common word. People in such countries count the amount of time spent over traffic too. After analysis, one of the reasons for the traffic was the number of potholes on the road. Because of many reasons like rains, oil spills, road accidents or inevitable wear and tear make the road difficult to drive upon. Unexpected

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hurdles on road may cause more accidents. Also because of the bad road conditions, fuel consumption of the vehicle increases; causing wastage of precious fuel [2].

Obstacle detection has been the topic of much research in the past and new ways for avoiding various types of obstacles in various surroundings have been experimented upon. But the focus has been mostly on obstacle avoidance autonomous agents and that too was mostly limited to extruding obstacles. These tended to make the detection mechanism very system-specific and not much suitable for general purposes [3]. A pothole is a type of failure in asphalt pavement caused by a combination of presence of water in the underlying soil structure and traffic passing over the affected area. There has been research in attempting to prevent the formation of potholes, of which one idea is sealing roads in order to prevent moisture from penetrating the road surface and causing underlying damage.

The project holds social importance. Besides this reason, according to study, our country faces the problem of vulnerable roads and the road accidents caused by the road vulnerabilities. The delay time in taking sudden action to reconstruct the destructed roads is one of the main reasons for road accidents. This can be avoided to an accident by implementing the proposed system. The current project focuses on the safety of the vehicles. The driver gets alarmed about any vulnerable roads and humps. So they can take precaution about any unusual events that takes place. Also the drivers in vehicles get alarmed about any danger zones coming nearby; so that they can reduce the speed and can avoid road accidents caused by carelessness.

II. LITERATURE SURVEY

Pavement distress detection is an intriguing topic of research and researchers have been working on pothole detection techniques. This section gives a brief description about the existing solutions for detecting potholes and humps on roads. Moazzam, et al [6] have proposed a low cost model for analysing 3D pavement distress images. It makes use of a low cost Kinect sensor, which gives the direct depth measurements, thereby reducing computing costs. The Kinect sensor consists of a RGB camera and an IR camera, and these cameras capture RGB images and depth images. These images are analysed using MATLAB environment, by extracting metrological and characteristic features, to determine the depth of potholes. He Youquan, et al [7] developed a model to detect the three-dimensional cross-section of pavement pothole. The method makes use of LED linear light and two CCD (Charge Coupled Device) cameras to capture pavement image. It then employs various digital image processing technologies including image pre-processing, thinning, three dimensional reconstruction, error analysis and compensation to get the depth of potholes. However, results get affected by LED light intensity and environmental factors. Jin Lin, et al [8], have proposed a method for pothole detection based on SVM (Support Vector Machine). This method distinguishes potholes from other defects such as cracks. The images are segmented by using partial differential equations. In order to detect potholes, the method trains the SVM with a set of pavement images. However, the training model fails to detect the pavement defects if the images are not properly illuminated. Faith Orhan, et al [9], have proposed a work developed on android platform to detect road hazards. There are three components in this proposed work viz, Sensing component, Analysis component and Sharing component. The sensing component basically works by collecting raw data from accelerometer and synchronizes with interface, hence leading to ease of access. In analysis component, the values obtained from the sensors are used for developing analysis modules. The sharing component works as follows: the developed framework is connected with the central application, where it can directly communicate with the social network. All the collected data is stored at central repository for further processing. Although this method communicates traffic events with other drivers, it increases the cost and complexity of implementation.

Artis Mednis, et al [10] have proposed a real time pothole detection model using Android smartphones with accelerometers. Modern smart phones with android OS, have inbuilt accelerometers, which sense the movement and vibrations. The accelerometer data is used to detect potholes. Different algorithms such as Z-thresh, which measures the acceleration amplitude at Z-axis, Z-diff to measure the difference between the two amplitude values, STDEV (Z) to find the standard deviation of vertical axis acceleration and G-Zero are used to identify potholes. Zhen Zhang, et al [11] have made use of stereocamera images coupled with a disparity calculation algorithm to identify potholes. The location coordinates of the potholes are also captured and stored in the database.

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MirceaStrutu, et al [12] have proposed a method for detecting defects on the road surface using accelerometers. It also makes use of GPS system to identify the exact location of the defects. Pothole detection algorithm runs on a mobile platform (moving vehicles), which is installed with accelerometer, GPS, local computer and a wireless router. The sensed data is communicated to the central database using primary access points and secondary access points which can be used for future processing. However, installing wireless router and local computer on all mobile platforms and setting up access points turns out to be quite expensive. Sachin Bharadwaj, et al [13], have proposed a system that detects potholes based on a vision based approach. The pictures of the road surface are captured using a properly mounted camera. The images are then processed using MATLAB to detect the occurrence of potholes. It is a 2D vision based solution and works only under uniform lighting conditions and also the system does not involve any kind of warning system. The above solutions are limited only to the identification of a pothole. These solutions do not provide any aid to the driver to avoid accidents due to potholes and humps.

Sudarshan S. Rode, et al [14], have proposed a system in which, Wi-Fi equipped vehicles collect information about the road surface and pass it to the Wi-Fi access point. The access point then broadcasts this information to other vehicles in the vicinity in the form of warnings. However, the system turns out to be an expensive one as all vehicles should be installed with Wi-Fi stations and more number of access points have to be setup. Sandeep Venkatesh, et al [15] have proposed an intelligent system that has made use of laser line strip and a camera to detect and avoid potholes. This system maintains a centralized database of the location of potholes. It also sends warning messages to the nearby vehicles about the occurrence of potholes using Dedicated Short Range Communication protocol.

III. PROPOSED METHODOLOGY

The proposed system is discussed in detail. General block diagram of the proposed system is shown in Figure below. The proposed idea is designed in embedded platform. Raspberry Pi platform can be used for developing this system. Since the proposed system stores the image of vulnerable conditions of roads.

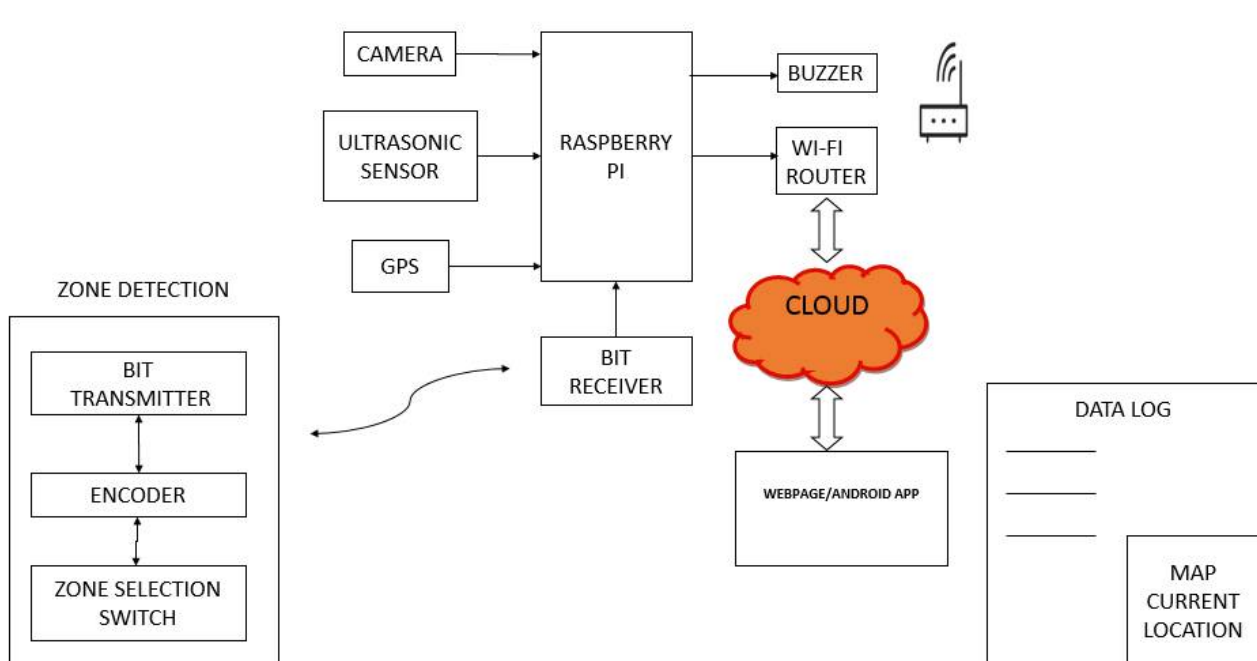


Figure 1: Block diagram of proposed method

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By plotting the road gutters in the path and updating the details in web page will help the authority to take sudden action. Also the vehicle users get alarmed about the gutters and humps and thereby the road accidents by taking careful measures towards zones (School, Hospitals, etc.) so that the driver get alerted at each zone before the vehicle passes the zone. The zones are also periodically updated in the webpage.

IV. COMPONENTS USED IN THE PROPOSED SYSTEM

A. RASPBERRY PI

Raspberry Pi can run on several different flavours of Linux and can be programmed to perform a variety of different functions. It has been widely hailed for its utility as an educational tool, but its flexibility and easy programming also make it an excellent resource for serious developers and for certain applications. It can be expanded with additional hardware, including cameras and other options. Most boards have between one and four USB slots, HDMI and composite video output, and a 3.5 mm audio jack. Lower level output is provided by a number of GPIO pins which support common protocols like I2C. Some models have an 8P8C Ethernet port and the Pi 3 has on board Wi-Fi 802.11n and Bluetooth. The Raspberry Pi may be operated with any generic USB computer keyboard and mouse. The model A, A+ and Zero have no Ethernet circuitry and are commonly connected to a network using an external user-supplied USB Ethernet or Wi-Fi adapter. On the model B and B+ the Ethernet port is provided by a built-in USB Ethernet adapter using the SMSC LAN9514 chip. The Raspberry Pi 3 is equipped with 2.4 GHz Wi-Fi 802.11n (150 Mbit/s) and Bluetooth 4.1 (24 Mbit/s) in addition to the 10/100 Ethernet port.

B. ULTRASONIC SENSOR

Ultrasonic Sensors are transducers which can convert ultrasound waves to Electrical Signals or vice versa. Ultrasonic waves have high pitch that humans could not hear. Ultrasonic Sensors besides being sensors are indeed transceivers because they can both sense and transmit. It is compact in size; higher range and easy usability make it a handy sensor for distance measurement and mapping. The principle of these devices is to evaluate the attributes of a target by interpreting the echoes from radio or sound waves. There are two types of ultrasonic sensors. Ultrasonic sensors which generate high-frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object are Active ultrasonic sensors. Ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions, convert it to an electrical signal, and give it to a computer are Passive Ultrasonic sensors.

C. GPS RECEIVER

Global Positioning System (GPS) is a satellite navigation system and is used to capture geographic location and time, irrespective of the weather conditions. It is maintained by the US Government and is freely available to anyone who has a GPS receiver. It obtains the GPS information from satellites in National Marine Electronics Association (NMEA) format. The GPGGA has defined a standard format for the GPS information. This is followed by all the satellites. The standard defines various codes such as GLL- Latitude/Longitude data, GSV Detailed satellite data and RMC- Minimum Recommended Data. The Global Positioning System consists of a network of 24 satellites they are located on orbits. The GPS system provides necessary and essential information to military purposes, civil and commercial users all around the world and which is easily accessed by anyone in the world by using a GPS receiver. GPS can work in any weather condition; it provides accurate data in any conditions. Normally it does not require any subscription charges or system charges to access GPS. A GPS receiver must require at least three satellites to estimate 2D position (latitude and longitude) of a object to track the movement.

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V. RESULTS AND ANALYSIS

The major aim of this project is to provide a remotely monitoring and warning system for the detection of Vulnerabilities in our Roads. Figure 2 shows implemented hardware model. It contains a Raspberry pi board, GPS

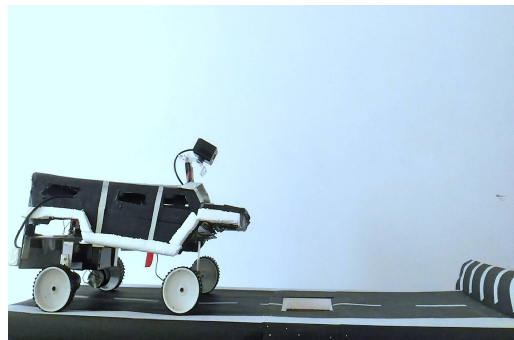


Figure 2: Hardware Model

module, Ultrasonic sensor, camera, buzzer, and RF module. Raspberry pi board is the major part of the system, it contains all programs required to run the developed system. Ultrasonic sensor is used to sense pothole and humps. The GPS module receives the location parameters. The Buzzer alerts when a gutter or hump is found along the path. All the data are stored in a webpage using Wi-Fi. The RF module is used for wireless communication to mark the zones. RF module is used with a pair of HT12E encoder IC and HT12D decoder IC. HT12E IC converts parallel input into serial output and HT12D converts serial input into parallel output. The camera takes real-time videos of vehicles and the image is displayed in webpage.

Raspberry Pi based vehicle monitoring and Warning system has mainly three sections.

1. Tracking section
2. Sensor section
3. Monitoring section

1. TRACKING SECTION

The proposed system uses Raspbian OS based Raspberry Pi. Raspberry Pi contains a memory card. At first Raspbian OS is installed inside the memory card. Then the memory card is stuck into the Raspberry Pi. The longitudes and latitudes

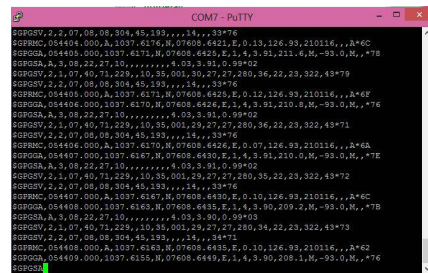


Figure 3: Raspbian OS display

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of a location are obtained by using GPS receiver. GPS data is displayed in different message formats over a serial interface. There are standard and non-standard (proprietary) message formats. Various data formats of GPS modules are shown in Figure 3.

In this work, GPGGA format was selected. In this format, second and fifth elements represent longitude and latitude. The longitudes and latitudes give the exact information where the Pothole and Humps are located and are already stored in SD card of Raspberry Pi as a text file.

2. SENSOR SECTION

The sensor consists of a transmitter and a receiver. The transmitter sends an ultrasonic signal of 40 Hz which hits an object and reflects back. The reflected signal is received by the receiver. The sensor provides the total time of flight of the sound and the distance can be calculated from it. Normally, solid obstacles in the path can be detected in the following way: sensor would face the path and continue giving highest value of time (nothing close enough to reflect the signal) until the sensor experiences an obstacle and provides a shorter time value. Once the sensors are mounted on the vehicle, they align themselves towards the path in such a way that, the signal they emit bounces from the ground right at its critical angle. This results in the signal never coming back to the receiver, thus the sensor provides the highest value of time. Now if a pothole is there on the way, the signal travels a bit farther and almost always hits the ground (the side of the pothole) at a bigger angle than the critical angle and thus reflects back to the sensor which outputs a much lower value of time, and thus, detects the pothole and hump. The reason why this sensor was chosen was that other sensors such as Radar range finder and IR sensor are either very sensitive and will detect the slightest obstruction (like the laser sensor) or they are very costly.

3. MONITORING SECTION

The monitoring section contains a Webpage with an open access, along with Google Map application. Here the detected location is plotted on the map. The live streaming camera view is also seen in webpage. There is also a zooming option provided in the map. The zone and distance at which the obstacle is located is also recorded in the webpage.

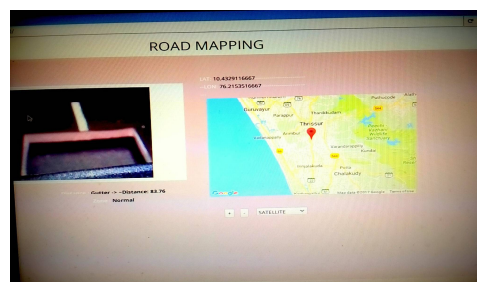


Figure 4: Webpage View

VI. CONCLUSION

The model implemented here serves three important purposes; automatic detection of potholes and humps, zone detection and alerting vehicle drivers to evade potential accidents. The implemented approach is an economic solution for detection of dreadful potholes and uneven humps, as it uses low cost ultrasonic sensors. The Webpage used in this system is an additional advantage as it provides timely alerts about potholes and humps. It can be accessed easily from anywhere at any time using internet. The data stored in the webpage helps drivers in rainy season where potholes are

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filled with muddywater as the system alerts are generated using the information stored in the database. Thesolution provided in this project can save many lives and control the damages occurring to the vehicle due to vulnerable roads.

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