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Detection and Notification of Potholes and Humps on Roads

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Abstract

Roads are the one of the main transportation system amongst the other, especially when we are talking about developed and developing countries. India is said to be the fastest developing countries today, our road network is gigantic and said to be only after the USA. But one of the striking underlying facts is the condition of the roads. Since roads indirectly contribute to the economic growth of the country, it is extremely essential that the roads are well laid out and strong. India is home to several bad roads it the metropolitans, the cities or the villages. 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 paper discusses previous pothole detection methods that have been developed and proposes a cost-effective solution to identify the potholes and humps on the roads and provide timely alerts to drivers to avoid accidents or vehicle damages. For that ultrasonic sensors are used to identify the potholes and humps and also to measure their depth and height, respectively. The proposed system captures the geographical location coordinates of the potholes and humps using a global positioning system receiver. The sensed-data include pothole depth, height of the hump, and geographic location, which is stored in the database (cloud). This serves as a valuable source of information to the government authorities and vehicle drivers. An Android application is used to alert drivers so that precautionary measures can be taken to avoid accidents. Alerts are given in the form of flash messages with an audio beep.

Key Words: Android application, GSM SIM900, GPS, PIC16F877A, Ultrasonic sensors

INTRODUCTION

India is the second largest road network in the world. At 0.66 km of roads per square kilometers of land, the quantitative density of India's road network is similar to that of the United States (0.65) and far higher than that of china (0.16) or Brazil (0.20). Our main objective is to a cost effective solution for detecting potholes and humps on roads and notifying drivers about their presence. To accomplish above objective, the proposed system uses GSM, GPS module PIC Microcontroller, Ultrasonic sensor, database application and mobile phone. However, qualitatively India's roads are a mix of modern highways and narrow, unpaved roads, and is being improved. As we know roads are the dominant means of transportation in India today. They carry almost 90 percent of country's passenger traffic and 75 percent of its goods [1]. However, most of the roads in India are narrow and congested with poor surface quality and road maintenance needs are not satisfactorily met. 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 detection techniques. This dissertation gives information about the existing solutions for detecting potholes and humps on roads Several researchers have worked to detect the potholes using different methods. Pothole detection using accelerometers gives the output based on the vibration [4]. Here, cameras were used for detecting the potholes with the help of image processing algorithms. Detection of pavement distress was achieved using 3D laser scanning technology [9].Damage detection in roadways with ground penetrating radar was proposed in which illustrate the use of radar technology [11].

RELATED WORK

Rajeshwari Madli [1] el al in "Automatic Detection and Notification of Potholes and Humps on Roads to Aid Drivers" Ultrasonic sensors are used to detecting the potholes and humps and also to measure their depth and height, respectively. The proposed system captures

the geographical location coordinates of the potholes and humps using a global positioning system receiver. Alerts are given in the form of flash messages with an audio beep.

Moazzam et al. [2] "Metrology and visualization of potholes using the Microsoft Kinect sensor," have proposed a low cost model for analyzing 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 an RGB camera and an IR camera, and these cameras capture RGB images and depth images. These images are analyzed using MATLAB environment, by extracting meteorological and characteristic features, to determine the depth of potholes.

Youquan et al. [3] "A research of pavement pothole detection based on three-dimensional projection transformation," 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, binarization, thinning, three dimensional reconstruction, error analysis and compensation to get the depth of potholes.

Orhan and Erin [4] "Road hazard detection and sharing with multimodal sensory analysis on smart phones," 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 an 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 development framework is connected with the central application, where it can directly communicate with the social network.

Mednis et al [5] "Real time pothole detection using Android Smartphone's with accelerometers," have proposed a real time pothole detection model using Android Smartphone 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 h measures the acceleration amplitude at Z-axis, Z-dig to measure the difference between the two amplitude values, STDEV (Z) to find the standard deviation of vertical axis acceleration and G-Zero is used to identify potholes.

DESCRIPTION OF SYSTEM

The given of the proposed system is shown in figure It consists of 3 parts; microcontroller module, server module and the mobile application module. Microcontroller module is used to gather information about potholes and humps and their geographical locations and this information is provide to the server. Server module receives information from the microcontroller module, processes and stores in the database. Mobile application module uses information stored in the server database and provides timely alerts to the driver.

The proposed approach is an economic solution for detection of dreadful potholes and uneven humps, as it uses low cost ultrasonic sensors. The mobile application used in this system is an additional advantage as it provides timely alerts about potholes and humps. The solution also works in rainy season when potholes are filled with muddy water as alerts are generated using the information stored in the database. We feel that the solution provided in this paper can save many lives and ailing patients who suffer from tragic accidents.

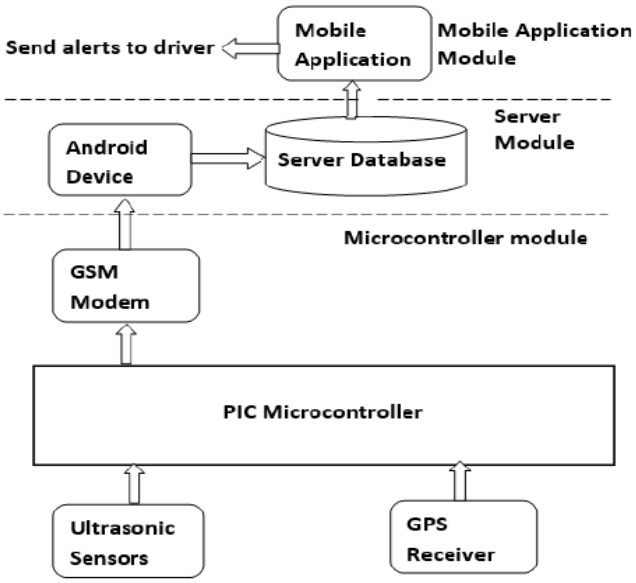

Figure 1: Block Diagram of whole system.

The proposed system considers the presence of potholes and humps. However, it does not consider the fact that potholes or humps get repaired by concerned authorities periodically. This system can be further improved to consider the above fact and update server database accordingly. Also, Google maps can be integrated in the proposed system to improve user experience.

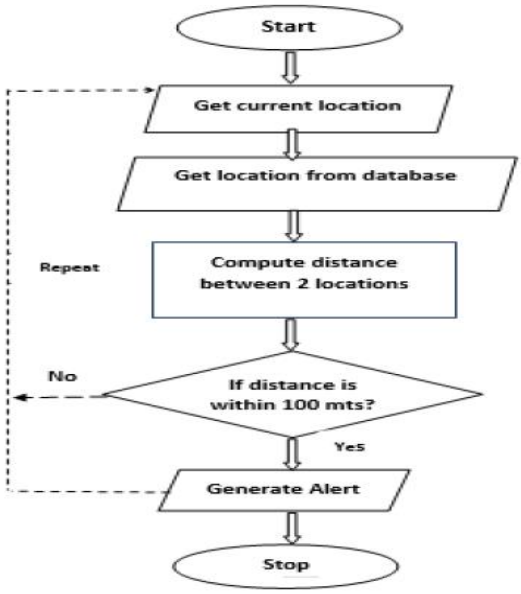

Figure 2: Work flow application

REQUIREMENTS

Requirement of system development or the material requirement is as follows;

PIC 16F877A Microcontroller:

Peripheral Interface Control (PIC 16F887A) is a 40 pin microcontroller with 8k program memory. It is widely used due to its low cost, high application support and wide availability. Microcontroller is the heart of the proposed system and is responsible for performing various tasks starting form processing all the sensor inputs to alerting the driver.

- 100,000 erase/write cycle Enhanced Flash program Memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

Ultrasonic Sensors HC-SR04:

The HC-SR04 is an active ultrasonic sensor and contains a transmitter and a receiver. It is used to measure distance at which, objects are placed in front of it. The ultrasonic sensor transmits high frequency sound waves and waits for the reflected wave to hit the receiver.

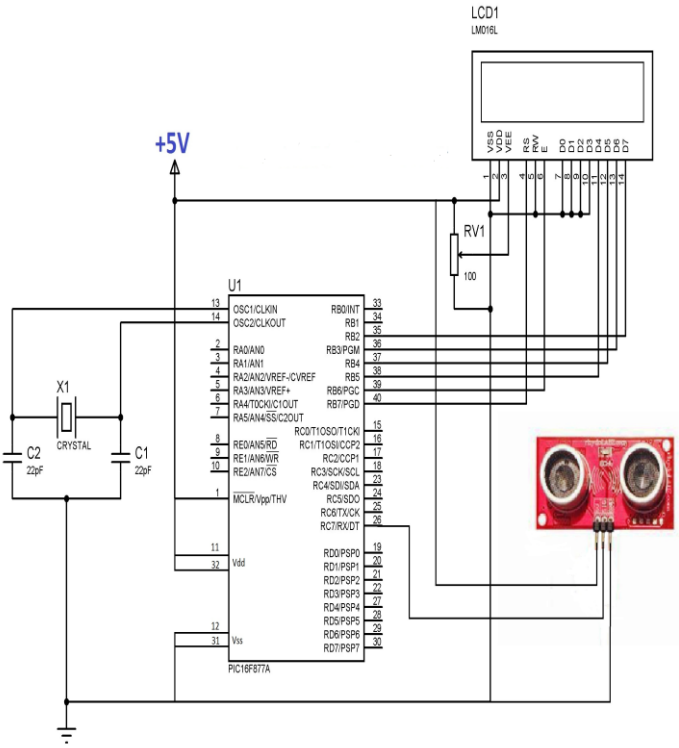

Figure 3: Circuit diagram of ultrasonic sensor

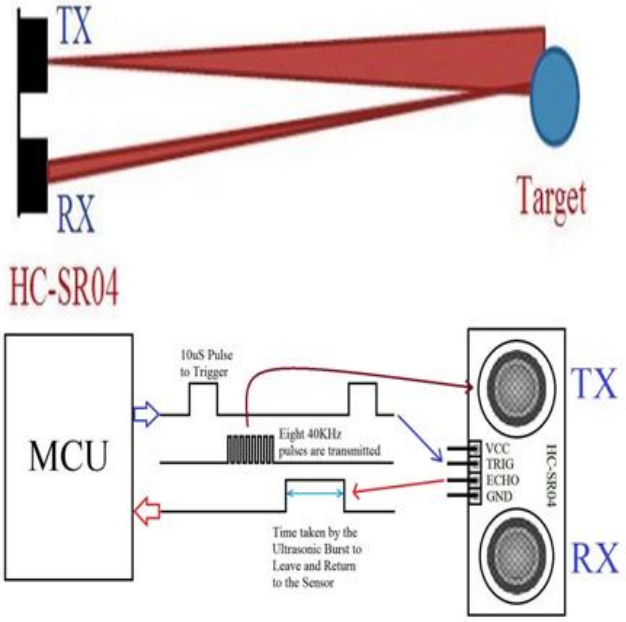

Figure 4: Working of ultrasonic sensor

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. The standard defines various codes such as GLL-Latitude/Longitude data, GSV–Detailed satellite data and RMC-Minimum Recommended Data. it contain various Features like High sensitivity SiRF Star chipset, High performance receiver tracks up to 20 satellites, TTL output for GPS command interface, Low power consumption, Average Cold Start time under 42 seconds, On-chip 1Mb SRAM, Reacquisition time 0.1 second. Support accurate 1PPS output signal aligned with GPS timing, Support Standard NMEA-0183 and SiRF Binary protocol. Multi-path mitigation hardware. In this paper a GPS MODEM of analog devices is used. Whichever the modem is used, it works based upon the NMEA 0183 protocol. This device has to be powered. It will give continuous data as output. The data can be taken in to the controller by using UART protocol. Then this data can be analyzed and we can find out the longitude and latitude of the current location. The NMEA means The National Marine Electronics Association (NMEA) is a non-profit association of manufacturers, dealers, distributors, educational institutions, and others interested in different peripheral marine electronics occupations and so on. The NMEA 0183 standard defines an electrical interface and data protocol for communications between marine instrumentation.

NMEA Message Prefix Format	NMEA Message Prefix Format
$GPGGA Time	Position and fix type data.
$GPGLL Latitude	longitude
$GPGSA GNSS DOP and active satellites	$GPGSA GNSS DOP and active satellites
$GPGSV Satellites in view.	$GPGSV Satellites in view.
$GPMSS	Radio beacon signal-to-noise ratio, signal strength,
$GPRMC Recommended minimum specific GNSS data.	$GPRMC Recommended minimum specific GNSS data.
$GPVTG Speed and course over ground.	$GPVTG Speed and course over ground.
$GPZDA Date and time.	$GPZDA Date and time.

Server Module:

This module consists of two parts; the android device and the database. It acts as a negotiator layer between the microcontroller module and the mobile application. The server module is implemented as an android application that runs on a device and is suitable for reading messages sent by the given mobile SIM present in the microcontroller module. It processes the contents of this message and accumulates it in the database (cloud).

GSM SIM 900:

SIM900A module that connects to the specific application and the air interface. As SIM900A can be integrated with a wide range of applications, all functional components of SIM900A Standards for Mobile Communication (GSM) is a set of standards for Second generation (2G) cellular networks. The GSM SIM 900 module uses any network provider's SIM to communicate over the telecommunication network. This modem can be used to send and receive text messages SIM900A is a dual-band GSM/GPRS engine that works on frequencies EGSM 900MHz and DCS 1800MHz. SIM900A features GPRS multi-slot class 10/ class 8 (optional) and supports theGPRS coding schemes CS-1, CS-2, CS-3 and CS-4. SIM900 can meet almost many of the space requirements in many of applications, such as smart phone, M2M, PDA and other mobile devices

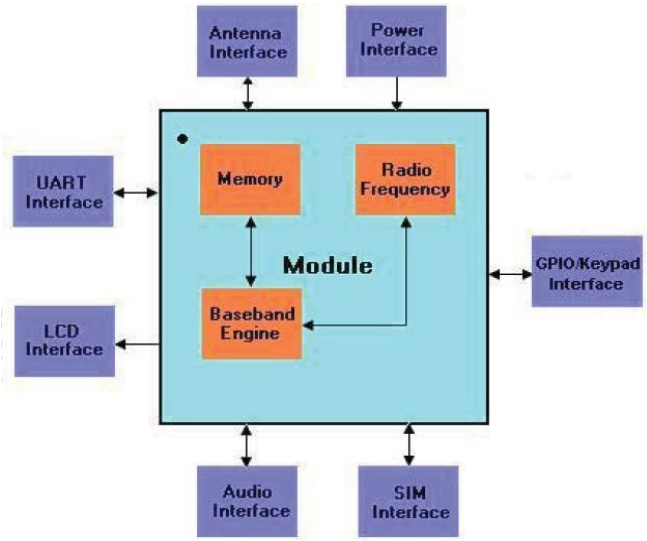

Figure 5: SIM900A functional diagram

SIM900 can be seen as a quad-band GSM/GPRS engine that works on many frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM900 has features of GPRS multi-slot class 10/ class 8 (optional). It will also support the GPRS coding schemes such as CS-1, CS-2, CS-3 and CS-4. With a tiny configuration of 24mm x 24mm x 3mm, SIM900 can meet almost many of the space requirements in many of applications, such as smart phone, M2M, PDA and other mobile devices

The physical interface to the mobile application is done as a 68-pin SMT pad, which can provide all hardware interfaces between the modules to customers' boards. Serial port and Debug port easily develop various applications. One audio channel includes a microphone as input and a speaker as output. The SIM900 equipped with power saving feature so that the current consumption is low as 1.5mA in SLEEP mode. The SIM900 is usually integrated with the TCP/IP protocol or extended TCP/IP. AT commands helps customers to use the TCP/IP protocol easily, and is very useful for those data transfer applications. Single supply voltage is in the range of 3.4V to 4.5V. Typical power consumption in SLEEP mode is seen as 1.5 mA. The frequency bands are set by AT command.

EXPECTED RESULTS

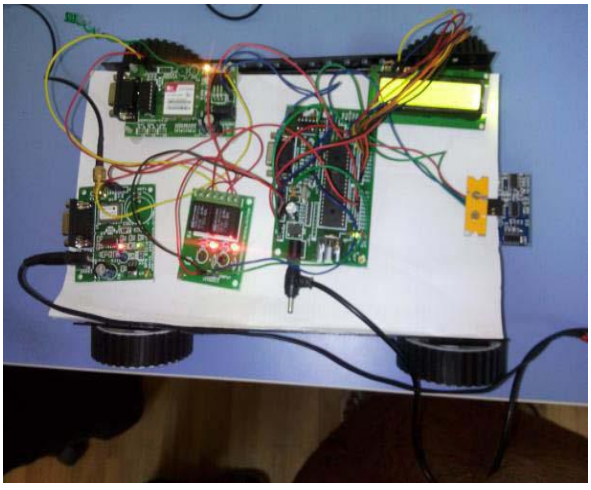

Figure 6: Working model of the proposed system

TABLE I
INFORMATION ABOUT POTHOLES AND HUMPS COLLECTED IN SIMULATED TEST ENVIRONMENT

Sl No	Obstacle Type	Height/Depth in cms	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	12.9434	77.5669
5	P	8.7	12.9411	77.5654
6	P	6.3	12.9423	77.5658
7	H	2.3	12.9547	77.5755
8	P	15.8	12.9575	77.5769
9	H	3.1	12.9417	77.5659
10	P	18.2	12.9567	77.5760

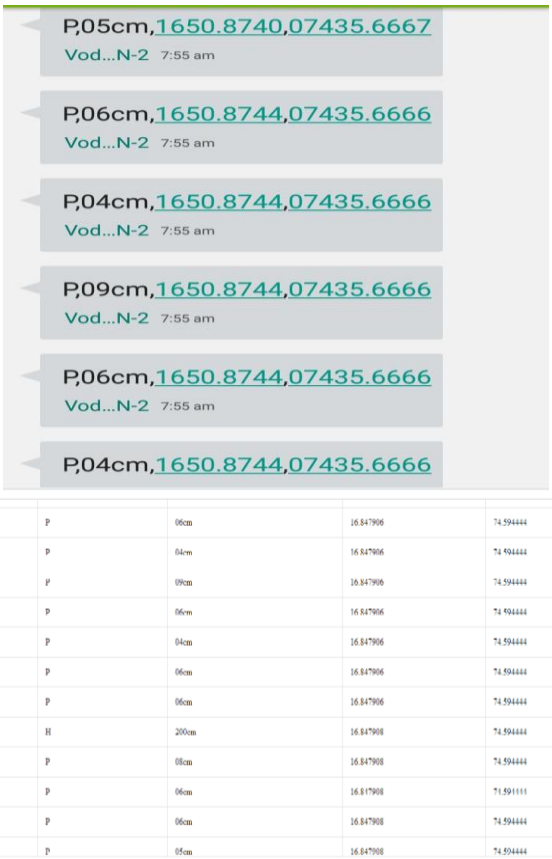

Figure 7: Simulated and expected result on server database

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

FUTURE WORK

The given system considers the presence of potholes and humps. However, it does not consider the fact that potholes or humps get maintain by concerned authorities constantly. In given system can be also improved to consider the given fact and update server database accordingly. Also, SATNAV and Google maps can be integrated in the proposed system to improve user experience.

CONCLUSION

Automatic detection of potholes and humps and alerting vehicle drivers to avoid potential accidents. The given system approach is an economic solution for detection of dreadful potholes and uneven humps, as it uses ultrasonic sensors which is low cost. The mobile application used in this system as it provides timely alerts about potholes and humps. This system mostly works in rainy season when potholes are filled with muddy water as alerts are generated using the information collect in the database. We feel that the solution provided in this system can save many people and ailing patients who suffer from accidents.

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