AN INTELLIGENT SYSTEM TO DETECT POTHOLES, HUMPS AND AVOIDS COLLISION OF VEHICLES ON ROADS

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ABSTRACT

One of the major issues faced by developing countries is the maintenance of roads. Well maintained roads contribute a major portion to the country's development. Identification of potholes and humps on roads not only helps the drivers to avoid accidents or vehicle damages, but also helps the respective authorities to look after the quality of roads. This paper deliberate foregoing pothole detection techniques that are being used and proposes an economic solution to identify the potholes and humps and its corresponding height and depth measures. The proposed system uses Global Positioning System (GPS) which captures the geographical coordinates of the potholes and hump. The sensed data includes pothole depth, height of the hump and geographic location, which is sent through Global System for Mobile Communication (GSM) transmitter. The values are received by GSM receiver and it is stored in a computer which acts as a database. This serves as a valuable source of information to the vehicle drivers and government authorities so that precautionary measures can be taken to evade accidents. Signal warning of danger is given in the form of flash messages with an audio beep to the vehicle drivers to avoid the accidents or vehicular damages.

Keywords: Ultrasonic Sensor, GSM Transmitter, GSM Receiver, PIC 16F887

1. INTRODUCTION

With the increase in world's population, there has been increasing load on the infrastructure. Roads have been flooded with the vehicular traffic. Accident is an event, occurring suddenly, unexpectedly and inadvertently under unforeseen circumstances. Road accidents appear to occur regularly at some flash points such as sharp bends, potholes and poor condition of the highways. At such points over speeding drivers usually find it difficult to control their vehicles, which then result to fatal traffic accidents, especially at night. Cases of fatal Road Traffic Accidents (RTA) are reported almost daily on the major highways. Motor vehicle crashes are the leading cause of death in adolescents and young adults.

India accounts for about 10 percent of road accident fatalities worldwide, 85% of all road accident fatalities occurring in developing countries [2]. Injuries due to RTA depend upon number of factors such as human, vehicle and environment which plays a vital role before, during, and after a serious RTA. The important factors are human errors such as human's mental weakness, less traffic knowledge, mechanical issues of vehicle, over speeding, traffic rules violation, bad road conditions etc. Hence it has become increasingly difficult to manage this. This is the primary motivation of creating an intelligent vehicle to help drivers in various situations.

The major problem faced by the drivers is the worsened conditions of roads because of many reasons like rains, oil spills, road accidents or inevitable wear and tear make the road difficult to drive on it. Unexpected obstacles on road may lead to accidents. Also because of the bad road conditions, the vehicle consumes more fuel which leads to its wastage.

Because of this it is very important to get the data of such road conditions, collect this information about the presence of potholes and humps in a database and alert the driver before reaching them. But there are various challenges involved in this. First of all, there are various methods to get details about the road conditions. These details must be collected and maintained in a respective module and must be conveyed to the driver in a manner so that he can be alerted of the presence of humps and potholes.

Our proposed system aims at providing cost effective solution to avoid the accidents due to worsened road conditions and the collision of the road traffic by warning driver about the presence of potholes, humps and controlling the speed of the vehicle automatically by maintaining a certain distance between the vehicles.

2. Literature Review

The latest survey done in this field is described here. Rajeshwari Madli et al., [1] describes about detecting Potholes and humps on roads by using ultrasonic sensors and an android application is developed to notify the drivers about the presence of Potholes with its corresponding geographic location.

Eriksson et al., [3] describe an application of mobile sensing: detecting and reporting the surface conditions of roads. It explains a system and with its associated algorithms to monitor this

important civil infrastructure using a collection of sensor equipped vehicles. This system is called as the Pothole Patrol (P2), uses the inherent mobility of the participating vehicles that gathers data from vibration and GPS sensors, and processing the data to assess road surface conditions.

Rode et al., [4] proposed a pothole detection and warning system which is divided into three subsystems. First is, sensing subsystem that senses the potholes encountered by it, about which it did not have the prior knowledge. Second is communication subsystem that handles the information transfer between Wi-Fi and Mobile Node. Third is the localization subsystem which sort out the data received from Access Points and warns the driver regarding the occurrence of potholes.

Mertz et. al., [5] uses service vehicles to detect road damages. The system consists of light sensor and a camera mounted on vehicles which travel the roads. It makes use of sensors and equipment present on the vehicle, like GPS on transit buses. The data collected from many vehicles is aggregated and analyzed at a main location and the assessment results are displayed interactively for road maintenance.

De Zoysa et al., [6] proposed a method of detecting potholes where pothole data and its GPS coordinates are saved in the sensor. The stored data is uploaded to the base station when the bus reaches the station. The station acts as a server which is given to the buses that travel in that route.

Ajit et al., [7] proposed an image processing approach where the potholes are first photographed or recorded using camera which is placed on a car. This image scans the road such that the pothole appears as a distinct black color. The image captured is filtered to remove unnecessary objects like other cars using proper pattern matching. This efficiently detects the presence of potholes on the roads.

Murthy and Varaprasad et al., [8] have proposed a system that detects potholes based on a vision based approach. The images of the road surface are captured using a camera. The images are then processed using MATLAB to detect the presence of potholes. It is a 2D vision based solution and works only under uniform lighting conditions and also the system does not include 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.

Jengo et. al., in [9] uses hyperspectral imagery to characterize the quality of roads, the approach is of semi-automated in nature. Smartphones are used for detection and avoiding mechanisms. Mednis et al., [10] describe a mobile sensing system for road irregularity detection using Andr-oid OS based smartphones. Selected data processing algorithms are discussed and their evaluation presented with true positive rate as high as 90% using real world data. The optimal parameters for the algorithms are determined and the recommenddations for their application are described.

Strazdins et al., [11] tests the feasibility of such Android Smartphones for pothole detection. The problem is well studied for autonomous robots too. A detection-avoidance mechanism was introduced for the navigational aid of autonomous vehicles [12]. In this paper, they discuss a solution to detection and avoidance of simulated potholes in the path of an autonomous vehicle operating in an unstructured environment. An obstacle avoidance system was developed for a custom-made autonomous navigational robotic vehicle (ANR-OV), based on an intelligent sensor network and fuzzy logic control [13].

More et al., [14] proposed a system where sensors are mounted on public vehicles. These sensors record vertical and horizontal accelerations experienced by vehicles on their route. The installed GPS device logs its corresponding coordinates to locate potholes and the collected data is processed to locate potholes along the path traversed earlier by the vehicle. A Fire Bird V robot is used for experimenting with constant speed. The moving robot is mounted with a servo motor which rotates 0-180 degrees along with IR Sharp sensors. IR Sharp sensors check for variance in constant speed. If variance is detected, it is an indication of a pothole; robot stops and camera moves to take pictures of the pothole while GPS device locates its coordinates. Altho-ugh this is a cost-effective solution, it is restricted to collecting information about potholes.

Yu and Salari [15] implemented a system that uses laser imaging for detecting potholes. Pavement distress such as pothole is detected when the laser source deformation is observed in the captured images. Different techniques such as multi-window median filtering and tile partitioning are applied to detect the presence of potholes. These potholes are further classified based on their shapes and severity. Although this is an accurate and efficient method for detecting potholes, the cameras capture shaky images due to uneven road

surface, which reduces the efficiency of pothole detection.

Chen et al., [16] proposed a system for detecting potholes using GPS sensor and three-axis accelerometer. The outputs are taken from the GPS sensor and three-axis accelerometer and fed into data cleaning algorithm. In the second part of the implementation the inputs to the algorithm are processed for power spectra density (PSD) to calculate the roughness of potholes. After analyzing, roughness is classified into different levels.

3. Methodology

This research paper uses ultrasonic sensors to detect Potholes and humps on roads to aid the drivers and also controls the speed of the vehicle. Data from the ultrasonic sensors are processed and its corresponding geographical co-ordinates are sent through GSM modem. GSM receiver receives the values and it is stored in PC through RS-232 cable for further usage.

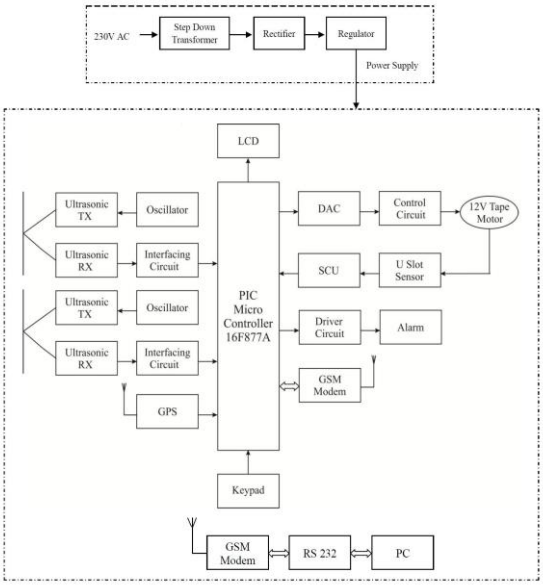

Figure 1: Block Diagram

4. Components Used

Components used in the proposed system are as follows:

Ultrasonic Sensors: The Parallax ultrasonic sensor provides error-free, non-contact distance measurements from about 2 cm (0.8 inches) to 3 meters (3.3 yards). It is easy to hook up with microcontrollers requiring one I/O pin. The sensor works by transmitting an ultrasonic (above the range of human hearing capabilities) burst which provides an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the distance to target can easily be calculated.

GPS Receiver: GPS receiver provides accurate positions with high sensitivity, high speed and tracing capabilities & provides standard NMEA-0183 strings in “raw” mode for any microcontroller. This receiver section provides present time, date, latitude, longitude, speed, altitude and travel direction/heading among other data which can be used in applications such as navigation, tracking systems, fleet management, mapping and robotics.

This GPS Module requires no external components except power supply decoupling capacitors. It has inbuilt internal RTC Backup battery which makes the module to connect to Microcontroller's USART directly. This module also has an option for connecting external antenna (active) if necessary.

PIC Microcontroller: Peripheral Interface Control (PIC 16F887) is a 40pin microcontroller with 8k program memory. Its features are low cost, high application support and wide availability. Microcontroller is the heart of the proposed system and is responsible for executing various tasks, processing from all the sensor inputs to alerting the driver.

GSM Modem: GSM Modem uses AT commands to make and receive calls, send SMS and do other GSM operations. It uses the highly popular SIM300 module for all its operations. It can be directly connected to micro controllers and computers through its inbuilt RS232 interface.

The modem consists of external circuitry which is required to start experimenting with SIM300 module like power regulation, SIM Holder, external antenna, etc.

12V DC Motor: Speed control of the vehicle is shown through 12V DC motor. The holes type pulley is hooked up in the motor shaft. The pulley is rotated between the USLOT which has IR transmitter and receiver. IR transmitter is one type of LED which emits infrared rays and IR receiver is used to receive the IR rays transmitted by it. Both IR transmitter and receiver must be placed in a straight line to each other.

When the power is ON, the IR transmitter conducts and it passes IR rays to the receiver. The IR receiver is connected to base of BC 547 (switching transistor) through resistors. When motor is idle, the IR transmitter transmits the rays to the receiver. The IR receiver conducts once the IR rays received. Now the VCC +5V is given to the input of the NOT gate (IC7404) and zero

taken as output. When motor rotates, the pulley attached to the shaft also rotates, which leads to interruption of IR rays between transmitter and receiver, which makes IR receiver to go idle. So more than 0.7V is goes to the base of the transistor. Now the transistor conducts which shorts the collector and emitter terminal. The 0V is provided at the inverter input and +5v is taken at the output. Hence depends on the motor speed the zero to 5v square pulse is generated at the output. In order to count the pulse this output is given to the microcontroller. This pulse rate converted into speed by calculating with respect to Time. If it is calculated with respect to minute or second then it is a RPM/RPS respectively. We can use any kind of Non-Transparent material instead of holes type pulley. The speed calculation will be varied depend upon the number of holes in pulley.

Alarm: An alarm or buzzer or beeper is a signaling device, usually electronic, used in house -hold appliances such as a microwave oven, auto-mobiles or game shows. It consists of number of switches/sensors interfaced to a microcontroller that determines which button was pushed or a pre-set time has lapsed, a warning signal is given in the form of continuous or beeping sound.

5. **System Description:** The system is consisted of following modules:

- Pothole and Hump Detection
- Controller Module
- Speed Control and Collision Avoidance
- Personal Computer

5.1. **Pothole and Hump Detection:** This module consists of ultrasonic sensor which is used to detect Potholes and humps on roads. This ultrasonic sensor is placed at the bot-tom of vehicle and it is used to measure the distance between vehicle body and the road surface. Distance between vehicle body and the smooth road surface is taken as threshold value. Pothole is detected, if the distance measured by ultrasonic sensor exceeds the threshold value and if the distance is smaller, it is considered as hump, else it is a normal smooth road.

5.2. **Controller Module:** The data from the ultrasonic sensor is received by the microcontroller. The GPS receiver which is connected to the microcontroller captures the geographical coordinates of the detected Poth-ole or hump and sends message to the registered mobile number through GSM modem.

5.3. Speed Control and Collision Avoidance

This module consists of ultrasonic sensor which is placed at front of the vehicle body. The sensor measures the distance between the vehicle body and the vehicles which is travelling at front of it. If the distance between vehicles reduces (say less than 5m) then the speed of the vehicle will be reduced automatically, even if the driver tries to accelerate.

5.4. **Personal Computer:** This module consists of GSM modem which is connected to PC through RS-232 cable. The messages sent are received by the GSM modem and it is stored in PC.

6. Experimental Results

The proposed model is analyzed in a simulated environment with artificial potholes and humps. This is also tested in real time by placing it on a motor bike (Honda Activa).

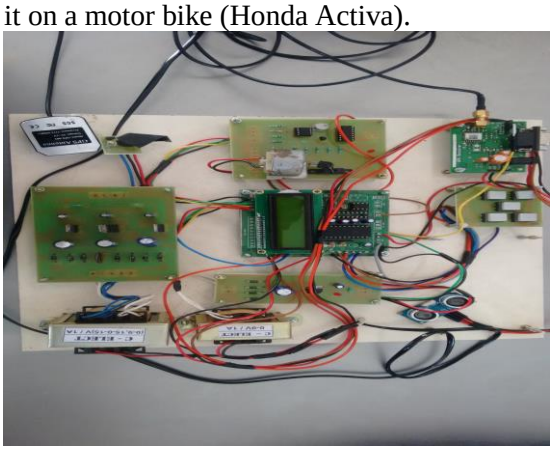

Figure 2. System Model

Tests carried out in two phases. In the first phase, the speed of the vehicle is controlled to avoid the collision between the vehicles and the presence of potholes and humps on roads were detected. In the second phase, the information about the potholes and humps are stored in a database. Warning signal is generated based on the information stored in the database. The signal may be in the form of beep sound and flash message displayed in the LCD.

Table 1: Information about Potholes and Humps Collected in Simulated Test Environment

Obstacle Type	Height/Depth (cm)	Latitude	Longitude
Pothole	25.3	10.898056	77.004722
Pothole	19.8	10.898073	77.004747
Hump	10.1	10.898116	77.004632
Pothole	22.4	10.898028	77.004596
Hump	14.3	10.898043	77.004781

Figure 2 shows the kit used in the real time testing of the proposed model. This module is placed on a vehicle (Activa) and the threshold distance value was configured to be 15cm, which is the ground clearance for Honda Activa. The vehicle is moved on a road to

record the presence of potholes and humps. Table 1 shows the potholes and humps detected during the real time tests. Figure 3 shows the simulation result of the proposed model.

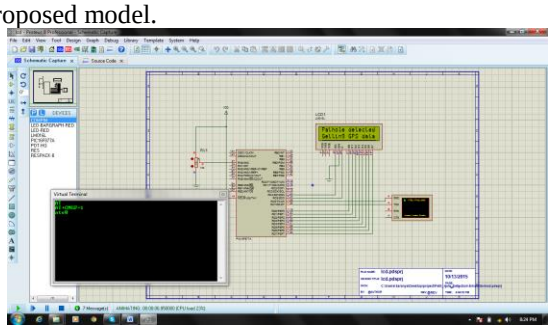

Figure 3. Proteus Simulation output for Potholes and hump Detection

7. Conclusion

The proposed methodology serves three important purposes, detection of potholes and humps on roads, speed control and alerting vehicle drivers to avoid major accidents. The proposed approach is an economic solution for detection of dreadful potholes and uneven humps, since it uses ultrasonic sensors of low cost and high quality. Once the potholes and humps are detected the controller provides timely alerts to the drivers. Also, to avoid the collision between the vehicles, its speed is reduced by the controller automatically. This result works in all situations even when potholes are filled with water as warning signals are generated using the information stored in the database. The source from the database provides useful information about potholes and humps and its respective geographical coordinates which can be used by both drivers and respective authorities to avoid accidents and maintenance of roads. We feel that the solution provided in this paper can save many lives who suffer from tragic accidents.

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