ROLE OF ULTRASONIC SENSOR IN AUTOMATIC POTHOLE AND HUMP DETECTION SYSTEM

Stepheena Joseph,PG-Embedded System Technologies, Department of Electrical and Electronics Engineering
Nehru Institute of Engineering and Technology,TM Palayam,Coimbatore,TN
Stephij10@gmail.com
Mr.K.Edison Prabhu,Assistant Professor, Department of Electrical and Electronics Engineering
Nehru Institute of Engineering and Technology,TM Palayam,Coimbatore,TN
edisonprabhu@gmail.com

***Abstract*--Dangerous road conditions may be the result of natural events, such as tropical rains and flooding, that make driving unsafe. Dangerous conditions can also arise from the poor physical condition of a road and its surroundings. It may cause road accidents. Also while driving in the night just the headlights might not be a sufficient assistance for driver. Unexpected hurdles on road may cause more accidents. Also because of bad road conditions, fuel consumption of the vehicle increases; causing wastage of precious fuel. We proposed this system 'Pothole and hump Detection and vehicle speed control System' to inform the driver about the pothole or hump and controlling the speed of the vehicle. This system uses ultrasonic sensor to sense the potholes and humps and which measure the height and depth of the potholes.**

Keywords : ultrasonic sensor, ARM7, GPS,GSM, IR speed sensor

INTRODUCTION

India is the world's largest democratic republic. With the advancement of Transport Systems, countries are identified on the basis of their "Roads". Now a days road accidents are major issue in most of the counties, one of the reason of road accident is due to irregularities of the road surface and high speed of driving. India has difficult road and traffic conditions. Traffic jam, safety issues, rash driving, lawlessness and increasing load of vehicular traffic are decreasing the quality of road. Roads normally have humps so that the vehicle speed can be controlled to avoid accidents. In order to eliminate the potholes on the road , several researches have been done.

Fig.1: road condition with potholes.

RELATED WORK

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. 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. Youquan et al. 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. However, results get affected by LED light intensity and environmental factors. Lin and Liu have proposed a method for pothole detection

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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. Orhan and Eren , 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.

Fig2:potholes in roads

Medniset al. 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. Zhang et al. [9] have made use of stereo camera images coupled with a disparity calculation algorithm to identify potholes. The location coordinates of the potholes are also captured and stored in the database. Strutu et al. 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. Murthy and Varaprasad et al. , 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. Rode et al. 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 set up.

Fig3:humps on roads

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Venkatesh et al. have proposed an intelligent system that has made use of laser line striper 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. Hegdeet al.,have proposed an intelligent transport system to detect potholes. It makes use of ultrasonic sensors to detect the presence of potholes. This system also sends warning messages to all the vehicles in the range of 100 meters using Zigbee module. However, the system provides warnings after detecting the potholes which does not effectively help drivers to avoid potential accidents. More et al. , 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. Although this is a cost effective solution, it is restricted to collecting information about potholes. Yu and Salari, 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. 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 analysing, roughness is classified into different levels.

Fig.4:Block diagram of the system

The system which offers the cost effective for the detection of the potholes and humps which notifying drivers about their presence, the components used in the system are :

ULTRASONIC SENSORS: The HC-SR04 ultrasonic sensor is used in this system. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit. There are only four pins on the HC-SR04: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground). It generates high frequency sound and calculate the time interval between the sending of signal and the receiving of echo. Therefore, ultrasonic sensor can be used to measure distance.

Fig.5: ultrasonic sensor HC-SR04

The basic principle of work using IO trigger for at least 10us high level signal. The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back. If the signal back, through high level,time of high output IO duration is the time from sending ultrasonic to returning. Test distance=(high level timexvelocity of sound (340M/S) /2.

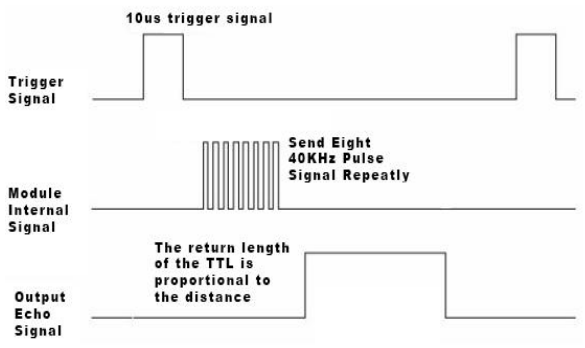
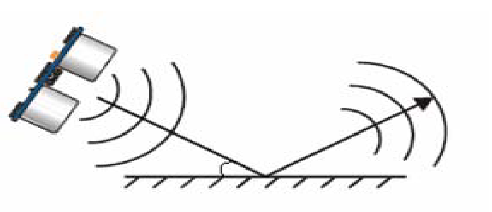


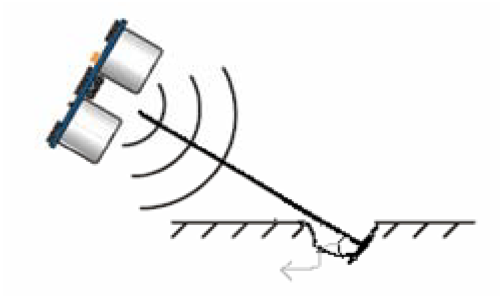
Fig.5:Timing diagram of ultrasonic sensor

ARM7 PROCESSOR: The ARM7TDMI-S provides high-performance and very low power consumption. It is a general purpose 32-bit microprocessor. RISC principle is used in ARM architecture and the instruction set and related decode mechanism are much simple. This simplicity results in a high instruction throughput and powerful real-time interrupt response from a small and cost-effective processor core.

GPS RECEIVER: The Global Positioning System (GPS) is a satellite-based navigation system made up of at least 24 satellites. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges. A GPS tracking unit is a device that uses the Global Positioning System to determine the location of a vehicle, person, or other asset to which it is attached. This position will be recorded at regular intervals. The recorded location data can be stored within the tracking unit, or it may be transmitted to a data base (Central Location), or internet connected computer, using a cellular (GPRS or SMS), radio, or satellite modem embedded in the unit.



(a) plain ground



(b) pothole

Fig.6: *Ultrasonic burst hitting ground at (a) critical angle* θ_c *(b)* $\theta > \theta c$

GSM SIM900: This is Quad-band GMS/GPRS modem, it mainly used for communication purpose. It is suitable for SMS, voice as well as data transfer application in M2M interface. The modem has RS232 interface, which allows connecting microcontroller with modem. It can communicate with controllers via AT commands. It allows for seamless and secure connectivity between networks on a global scale. Digital encoding is used for voice communication, and time division multiple access (TDMA) transmission methods provide a very efficient data rate/information content ratio.

ARCHITECTURE& IMPLEMENTATION

The block diagram of the proposed system is shown in fig.4.The controller module is used to gather information about potholes and humps and their geographical locations and this information is sent to the server. Ultrasonic sensors are used to measure the distance between the car body and the road surface and this data is received by the ARM processor. The distance between car body and the ground, on a smooth road surface, is the threshold distance. Threshold value depends on the ground clearance of vehicles and can be configured accordingly. If the distance measured by ultrasonic sensor is greater than the threshold, it is a pothole, if it is smaller, it is a hump otherwise it is a smooth road. The GPS receiver captures the location coordinates of the detected pothole or the hump. The information about pothole collected by the proposed system is displayed on the LCD and also send to the driver's mobilephone. The information includes depth of the pothole or height of the hump and its location coordinates.. The distance between the vehicle location and the pothole location stored in database is computed. If the distance between

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the two is within 100 meters, an alert message pops up on the screen. This message is accompanied with an audio beep. Drive shaft is the rotating part which drives the vehicles wheel via a gearbox. So drive shaft determines the vehicles speed. To control the speed of this shaft we need to control the engines combustion. Basically fuel is sprayed to the engine by means of fuel injectors. So by controlling the rate of fuel injection we can control the rotation of the drive shaft. Also we need to check for the drive shafts speed by means of an IR Non-contact tachometer. Here we are monitoring the drive shaft from the feedback receiving from the speed sensor and we can simply vary its speed by co-relating the values from ultrasonic sensor and effectively control the fuel injector.

Table 1:Information about the pothole and hump detected.

SL.NO.	OBSTACLE TYPE	DEPTH/HEIGHT IN cms	LATTITDE	LONGITDE
1	P	19.35	12.9567	77.5789
2	H	3.1	12.9126	77.5671
3	H	3.8	12.9423	77.5143
4	P	13.2	12.9765	77.5981
5	P	8.7	12.9289	77.5398
6	P	6.3	12.9543	77.5125
7	H	2.3	12.9532	77.5762
8	P	15.8	12.9538	77.5092
9	H	3.1	12.9765	77.5380
10	P	18.2	12.9568	77.5865

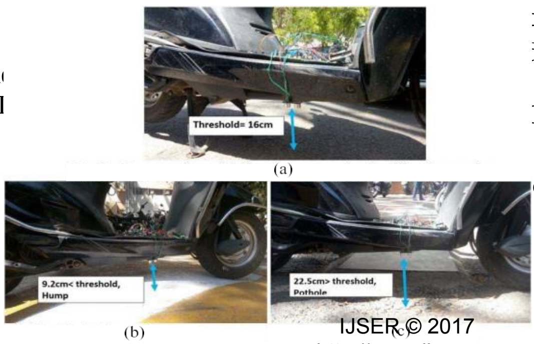

Fig. 6. (a) mod
for testing. (b) I
of pothole.

CONCLUSION

In this paper, we have proposed a system which will detect the potholes on the road and save the information in the server and reduce the vehicle speed if needed. Due to the rains and oil spills potholes are generated which will cause the accidents. The potholes are detected and its height, depth and size are measured using ultrasonic sensor. The GPS is used to find the location of pothole. All the information is saved in the database. This timely information can help to recover the road as fast as possible. By controlling the rate of fuel injection we can control the rotation of the drive shaft by means of an IR Non-contact tachometer. This helps to reduce the vehicle speed when pothole or hump is detected. Hence the system will help to avoid road accidents.

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