International Journal Of Electronics Engineering (Issn: 0973-7383)
Volume 10 • Issue 2 pp. 272-278 June 2018-Dec 2018 www.csjournals.com

Identification of Poth Holes, Humps On Roads and Alert System to Drivers

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Abstract: One of the major problems in developing countries is maintenance of roads. Well maintained roadscontribute a major portion to the country's economy. Identification of pavement distress such as potholes notonly helps drivers to avoid accidents or vehicle damages, but also helps authorities to maintain roads. This paperdiscusses previous pothole detection methods that have been developed and proposes a costeffective solution toidentify the potholes on roads and provide timely alerts to drivers to avoid accidents or vehicle damages.ARM7 is used to identify the potholes on the road, thegeographical location coordinates of the potholes are identified using a global positioning system receiverrespectively. The sensed data includes pothole width and geographic location, which is stored in the database(cloud). This serves as a valuable source of information to the society and vehicle drivers. An androidapplication is used to alert drivers so that precautionary measures can be taken to evade accidents. Alerts aregiven in the form of an App notification and vibration.

Index Terms: Web application, GSM SIM900, GPS,ARM7, ultrasonic sensors.

I. INTRODUCTION

INDIA, the second most populous Country in theWorld and a fast growing economy, is known to havea gigantic network of roads. Roads are the dominantmeans of transportation in India today. They carryalmost 90 percent of country's passenger traffic and65 percent of its freight. However, most of theroads in India are narrow and congested with poorsurface quality and road maintenance needs are notsatisfactorily met. No matter where you are in India,driving is a breath-holding, multi-mirror involving,potentially life threatening affair. Over the last twodecades, there has been a tremendous increase in thevehicle population. This proliferation of vehicles hasled to problems such as traffic congestion andincrease in the number of road accidents. Patheticcondition of roads is a boosting factor for trafficcongestion and accidents. Researchers are working inthe area of traffic congestion control, an integralpart of vehicular area networks, which is the need ofthe hour today. Roads in India normally have speed

Fig.1. Condition of road with potholes

Fig.2. Killer potholes

Breakers so that the vehicle's speed can be controlledto avoid accidents. However, these speed breakers areunevenly distributed with uneven and unscientificheights. Potholes, formed due to heavy rains andmovement of heavy vehicles, also become a majorreason for traumatic accidents and loss of humanlives. According to the survey report "RoadAccidents in India, 2011", by the ministry of roadtransport and highways, a total of 1,42,485 peoplehad lost their lives due to fatal road accidents. Ofthese, nearly 1.5 per cent or nearly 2,200 fatalitieswere due to poor condition of roads. Fig.1 portraysthe condition of roads with normal potholes. AndFig. 2 portrays the condition of roads with killerpothole which damaged the lorry. To address theabove mentioned problems, a cost effective solutionis needed that collects the information about theseverity of potholes and also helps drivers to drivesafely. With the proposed system an attempt has beenmade to endorse drivers to ward off the accidentscaused due to potholes.

II. RELATED WORK

Pavement distress detection is an intriguing topic ofresearch and researchers have been working onpothole detection techniques. This section gives abrief description about the existing solutions fordetecting potholes and humps on roads. Moazzam et al, have proposed a low cost model for analyzing3D pavement distress images. It makes use of a lowcost Kinect sensor, which gives the direct depthmeasurements, thereby reducingcomputing costs. The Kinect sensor consists of aRGB camera and an IR camera, and these camerascapture RGB images and depth images. These imagesare analysed using MATLAB environment, byextracting metrological and characteristic features, todetermine the depth of potholes. Rode et al, have proposed a system in which, Wi-Fi equipped vehicles collect information about theroad surface and pass it to the Wi-Fi access point.The access point then broadcasts this information toother vehicles in the vicinity in the form of warnings.

However, the system turns out to be an expensive oneas all vehicles should be installed with Wi-Fi stationsand more number of access points have to be set up.Youquan et al, developed a model to detect thethree-dimensional cross section of pavement pothole.The method makes use of LEDlinear light and twoCCD (Charge Coupled Device) cameras to capturepavement image. It then employs various digitalimage processing technologies including image preprocessing,binarization, thinning, three dimensionalreconstruction, error analysis and compensation to getthe depth of potholes. However, results get affectedby LED light intensity and environmental factors. Linand Liu, have proposed a method for potholedetection based on SVM (Support Vector Machine).This method distinguishes potholes from otherdefects such as cracks. The images are segmented byusing partial differential equations. In order to detectpotholes, the method trains the SVM with a set ofpavement images. However, the training model failsto detect the pavement defects if the images are notproperly illuminated.

Orhan and Eren, have proposed a work developedon android platform to detect road hazards. There arethree components in this proposed work viz, Sensingcomponent, Analysis component and Sharingcomponent. The sensing component basically worksby collecting raw data from accelerometer andsynchronizes with interface, hence leading to ease ofaccess. In analysis component, the values obtainedfrom the sensors are used for developing analysismodules. The sharing component works as follows:the developed framework is connected with thecentral application, where it can directlycommunicate with the social network. All thecollected data is stored at central repository forfurther processing. Although this methodcommunicates traffic events with other drivers, itincreases the cost and complexity of implementation. Mednis et al, have proposed a real time potholedetection model using Android smartphones withaccelerometers. Modern smart phones with androidOS, have inbuilt accelerometers, which sense themovement and vibrations. The accelerometer data isused to detect potholes. Different algorithms suchasZ-thresh, which measure the acceleration amplitudeat Z-axis, Z-diff to measure the difference betweenthe two amplitude values, STDEV (Z) to find thestandard deviation of vertical axis acceleration and GZeroare used to identify potholes.

Zhang et al, have made use of stereo cameraimages coupled with a disparity calculation algorithmto identify potholes. The location coordinates of thepotholes are also captured and stored in the database.Strutu et al, have proposed a method fordetecting defects on the road surface usingaccelerometers. It also makes use of GPS system toidentify the exact location of the defects. Potholedetection algorithm runs on a mobile platform(moving vehicles), which is installed withaccelerometer, GPS, local computer and a wirelessrouter. The sensed data is communicated to thecentral database using primary access points andsecondary access points which can be used for futureprocessing. However, installing wireless router andlocal computer on all mobile platforms and setting upaccess points turns out to be quite expensive. Murthy and Varaprasad et al, have proposed a systemthat detects potholes based on a vision basedapproach. The pictures of the road surface arecaptured using a properly mounted camera. Theimages are then processed using MATLAB to detectthe occurrence of potholes. It is a 2D vision basedsolution and works only under uniform lightingconditions and also the system does not involve anykind of warning system. The above solutions arelimited only to the identification of a pothole. Thesesolutions do not provide any aid to the driver to avoidaccidents due to potholes. Venkatesh et al, haveproposed an intelligent system that has made use oflaser line striper and a camera to detect and avoidpotholes. This system maintains a centralizeddatabase of the location of potholes. It also sendswarning messages to the nearby vehicles about theoccurrence of potholes using Dedicated Short RangeCommunication protocol. Hegde et al., haveproposed an intelligent transport system to detectpotholes. It makes use of ultrasonic sensors to detectthe presence of potholes. This system also sends warning messages to all the vehicles in the range of100 meters using Zigbee module. However, thesystem provides warnings after detecting the potholeswhich does not effectively help drivers to avoidpotential accidents. More et al., proposed asystem where sensors are mounted on public vehicles.

These sensors record vertical and horizontalaccelerations experienced by vehicles on their route.The installed GPS device logs its correspondingcoordinates to locate potholes and the collected datais processed to locate potholes along the pathtraversed earlier by the vehicle.A Fire Bird V robot isused for experimenting with constant speed. Themoving robot is mounted with a servo motor whichrotates 0-180 degrees along with IR Sharp sensors. IRSharp sensors check for variance in constant speed. Ifvariance is detected, it is an indication of a pothole;robot stops and camera moves to take pictures of thepothole while GPSdevice locates its coordinates.Although this is a cost effective solution, it isrestricted to collecting information about potholes.Yu and Salari, implemented a system that useslaser imaging for detecting potholes. Pavementdistress such as pothole is detected when the lasersource deformation is observed in the capturedimages. Different techniques such as multi-windowmedian filtering and tile partitioning are applied todetect the presence of potholes. These potholes arefurther classified based on their shapes and severity.

Although this is an accurate and efficient method fordetecting potholes, the cameras capture shaky imagesdue to uneven road surface, which reduces theefficiency of pothole detection. Chen et al,proposed a system for detecting potholes using GPSsensor and three-axis accelerometer. The outputs aretaken from the GPS sensor and three-axisaccelerometer and fed into data cleaning algorithm. Inthe second part of the implementation the inputs tothe algorithm are processed for power spectra density(PSD) to calculate the roughness of potholes. Afteranalyzing, roughness is classified into different levels.

III.COMPONENTS OF PROPOSED SYSTEM

The proposed system offers a cost effective solutionfor detecting potholes on roads and notifying driversabout their presence. Components used in theproposed work are as follows:

ADVANCED RISC MACHINE 7(ARM7)

The LPC2148 is based on a 16/32 bit ARM7TDMI-S"CPU with real-time emulation and embedded trace support, together with 128/256 kilobytes (kb) of embedded high speed flash memory. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at maximum clock rate. For critical code size applications, the alternative 16-bit Thumb Mode reduces code by more than 30 % with minimal performance penalty. With their compact 64 pin package, low power consumption, various 32-bit timers, 4-channel 10-bit ADC, 2 advanced CAN channels, PWM channels and 46 GPIO lines with up to 9 external interrupt pins these microcontrollers are particularly suitable for automotive and industrial control applications as well as medical systems and fault-tolerant maintenance buses. With a wide range of additional serial communications interfaces, they are also suited for communication gateways and protocol converters as well as many other general-purpose applications.

Key Features

- 16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 16 kb on-chip Static RAM.
- 128/256 kb on-chip Flash Program Memory. 128-bit wide interface/accelerator enables high speed 60 MHz operation.
- In-System Programming (ISP) and In-Application Programming (IAP) via on-chip boot-loader software. Flash programming

takes 1 ms per 512 byte line. Single sector or full chip erase takes 400 ms.

- Embedded ICE-RT interface enables breakpoints and watch points. Interrupt service routines can continue to execute while the foreground task is debugged with the on-chip RealMonitor“ software.
- Embedded Trace Macrocell enables non-intrusive high speed real-time tracing of instruction execution.
- Two interconnected CAN interfaces with advanced acceptance Filters.
- Four channel 10-bit A/D converter with conversion time as low as 2.44 ms.
- Multiple serial interfaces including two UARTs (16C550), Fast I2C (400 kbits/s)and two SPIs
- 60 MHz maximum CPU clock available from programmable on-chip Phase-Locked Loop with settling time of 100 □ s.
- Vectored Interrupt Controller with configurable priorities and vector addresses.
- Two 32-bit timers (with four capture and four compare channels), PWM unit (six outputs), Real Time Clock and Watchdog.
- Up to forty-five 5 V tolerant general purpose I/O pins. Up to nine edge or level sensitive external interrupt pins available.
- On-chip crystal oscillator with an operating range of 1 MHz to 30 MHz.
- Two low power modes Idle and Power-down.
- Processor wake-up from Power-down mode via external interrupt.
- Individual enable/disable of peripheral functions for power optimization.
- Dual power supply:
    - CPU operating voltage range of 1.65 V to 1.95 V (1.8 V ±0.15 V).
    - I/O power supply range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads.

Fig.3. ARM7 Board

The PCB layout was done by Circuitco and Circuitcois the sole funder of its development and transition toproduction. The Software is written and supported bythe thousands of community members, includingJason Kridner, employees of TexasInstruments,DigiKey, and Circuitco. Fig.3. Shows theBeaglebone Black Board Camera: Normal webcamera is used to capture the images. For furthermore clarity still advanced digital cameras can beincluded. GPS: Global Positioning System (GPS) is asatellite navigation system and is used to capturegeographic location and time, irrespective of theweather conditions. It is maintained by the U.S.Government and is freely available to anyone whohas a GPS receiver. It obtains the GPS informationfrom satellites in National Marine ElectronicsAssociation (NMEA) format. The NMEA has defineda standard format for the GPS information. This isfollowed by all the satellites. The standard definesvarious codes such as GLL-Latitude/Longitude data,GSV–Detailed satellite data and RMC-MinimumRecommended Data.

IV. EXPERIMENTAL RESULTS

The working model of the proposed system is shownin Fig.4. It was tested in a simulated environment withartificial potholes and humps. The model was also testedin real time by fixing it on a motor bike (Honda Activa).

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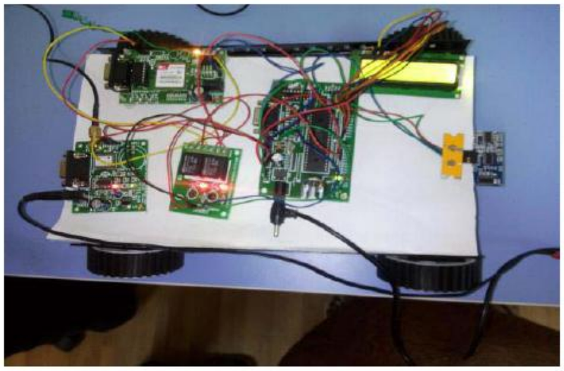


Fig.4. Working model of the proposed system

TABLE I
INFORMATION ABOUT POTHOLES AND HUMPS COLLECTEDIN 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

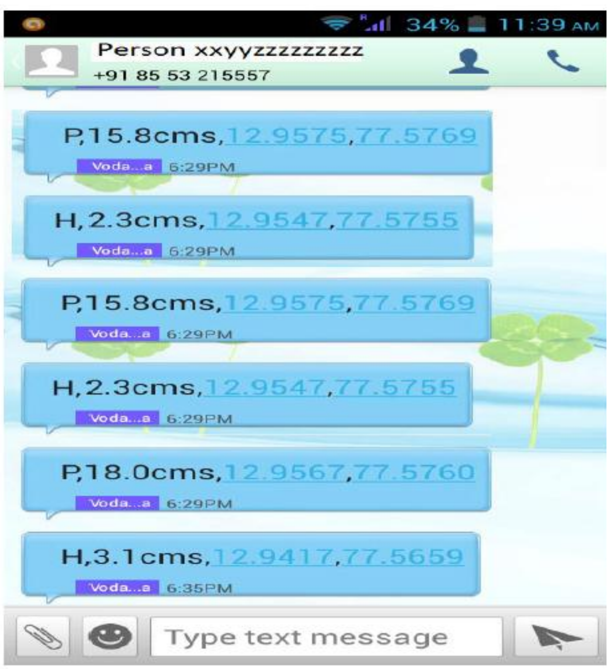
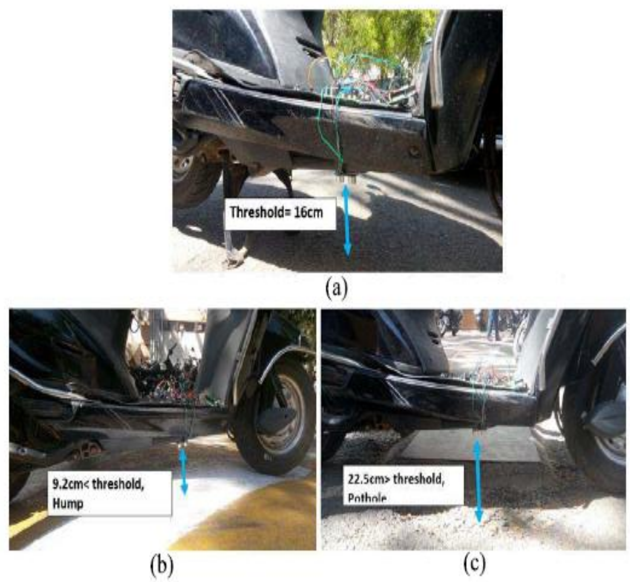


Fig.5. Message sent to android device about the pothole and hump locations.

Tests were carried out in two phases. In the first phase,information about potholes and humps was recorded andstored in the server database. In second phase, alerts weregenerated based on pothole and hump information storedin database. While testing in the simulated environment,

Fig.6. Pothole alert displayed on the mobile phone.



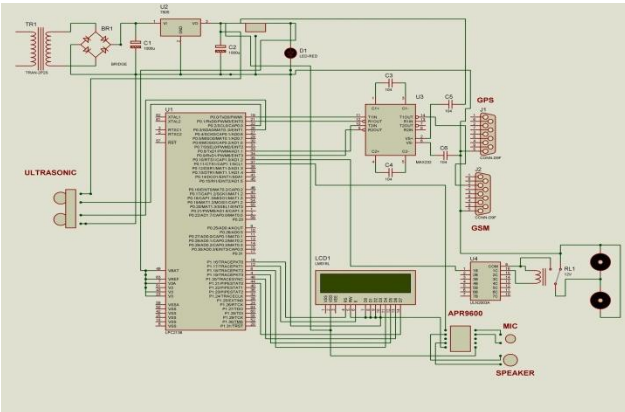


Fig.7. (a) Proposed model fixed on two wheeler bike for testing.(b) Detection of lump. (c) Detection of pothole.

the microcontroller module was fixed on a toy-car and thethreshold value was configured to 5 cm. During the testsit was found that the microcontroller module worked asexpected to identify potholes and humps. Table I shows aset of potholes and humps identified by the system in thesimulated environment. Information about potholes and humpswas successfully sent to the android device (server). Thesnapshot of these messages can be seen in Fig.5. The serverprocessed the messages received and stored in the database.

In the above table, obstacle type ‘P’ indicates a potholeand ‘H’ indicates a hump.

In the second phase of testing, the mobile application thatgenerates alerts was successfully tested by moving the toy-caron routes containing potholes and humps and alerts weregenerated for potholes and humps recorded in the first phase.Fig.6 shows an alert generated by this application.Fig.7 shows the real time testing of the proposed model.The microcontroller module was fixed on Honda Activa andthe threshold distance value was configured to 16 cm, whichis the ground clearance for Honda Activa. The vehicle wasmoved on Bangalore roads for the purpose of recordinginformation about potholes and humps, and the test resultswere as expected. Table II shows a set of potholes and humpsdetected during real-time tests.

TABLE II
INFORMATION ABOUT POTHOLES AND HUMPS COLLECTEDDURING REAL-TIME TESTING

Sl No	Obstacle Type	Height/Depth in cms	Latitude	Longitude
1	P	22.5	12.94048	77.56598
2	H	9.2	12.94062	77.56583
3	H	7.5	12.94039	77.56569
4	P	24.3	12.94047	77.56692
5	P	23.7	12.94073	77.56480

V. CONCLUSION

The model proposed in this paper serves 2 importantpurposes; automatic detection of potholes and alertingvehicle drivers to evade potential accidents. Theproposed approach is an economic solution fordetection of dreadful potholes, as it uses low costcontroller. The mobile application used in this systemis an additional advantage as it provides timely alertsabout potholes. The solution also works in rainyseason when potholes are filled with muddy water asalerts are generated using the information stored inthe database. We feel that the solution provided inthis paper can save many lives and ailing patientswho suffer from tragic accidents. The proposedsystem considers the presence of potholes. However,it does consider the fact that potholes get repaired byconcerned authorities periodically because it updatesthe server with altered information every particular interval specified. This system can be furtherimproved to consider the above fact and update serverdatabase accordingly. Also, Google maps andSATNAV can be integrated in the proposed system toimprove user experience.

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