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# Automatic Detection of Potholes on Roads to AID Drivers

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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 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 on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. Camera captures the image of the road, Beagle bone is used to identify the potholes on the road, the geographical location coordinates of the potholes are identified using a global positioning system receiver respectively. 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 soceity and vehicle drivers. An android application is used to alert drivers so that precautionary measures can be taken to evade accidents. Alerts are given in the form of a App notification and vibration.**

***Key words-*** **Beagle bone black, Android application, GPS, Database.**

## I. INTRODUCTION

India, the second most populous Country in the World and a fast growing economy, is known to have agigantic 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 [1]. 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 [2], 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 vehicle's speed can be controlled to avoid accidents.

*Figure 1. Condition of road with potholes*

*Figure 2. Killer potholes*

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. Figure 1 portrays the condition of roads with normal potholes. And Figure 2. portrays the condition of roads with killer pothole which damaged the lorry.

To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and also helps drivers to drive safely. With the proposed system an attempt has been made to endorse drivers to ward off the accidents caused due to potholes. The remaining sections of the paper are as follows: section II emphasises on the related work that has been done and is going on in the field of detection of potholes Section III discusses the various components used in the proposed system. Section IV describes the architecture and implementation of the proposed system. Experimental results of the proposed work are presented in Section V. Section VI talks about conclusion and future scope.

## II. 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.* [3] 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. Rode *et al.* [4], 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.

Youquan *et al.* [5] 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 [6], 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. Inorder 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 [7], 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.

Mednis *et al.* [8] 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.* [10] 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.* [11], 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.

Venkatesh *et al.* [12] 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. Hegde *et al.* [13], 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. [15], 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 [16], 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. [17] 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.

*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. The distance is calculated based on the time taken by the ultrasonic pulse to travel a particular distance [19]. Using this the depth of the pothole is identified.

## III.COMPONENTS OF PROPOSED SYSTEM

The proposed system offers a cost effective solution for detecting potholes on roads and notifying drivers about their presence. Components used in the proposed work are as follows:

***Beagle bone black*:** The Beagle Bone Black is the latest addition to the Beagle Board family and like its predecessors, is designed to address the Open Source

Community, early adopters, and anyone interested in a low cost ARM Cortex-A8 based processor. It has been equipped with a minimum set of features to allow the user to experience the power of the processor and is not intended as a full development platform as many of the features and interfaces supplied by the processor are not accessible from the Beagle Bone Black via onboard support of some interfaces.

It is not a complete product designed to do any particular function. It is a foundation for experimentation and learning how to program the processor and to access the peripherals by the creation of your own software and hardware. It also offers access to many of the interfaces and allows for the use of add-on boards called capes, to add many different combinations of features. A user may also develop their own board or add their own circuitry. Beagle Bone Black is manufactured and warranted by Circuit co LLC in Richardson Texas for the benefit of the community and its supporters. In addition, Circuit co provides the RMA support for the Beagle Bone Black.

Jason Kridner of Texas Instruments handles the community promotions and is the spokesmen for Beagle Board. The board is designed by Gerald Coley, an employee of Texas Instruments and a charter member of the Beagle Board. Or community. The PCB layout was done by Circuit co and Circuitco is the sole funder of its development and transition to production. Figure 3 shows the Beagle bone Black Board. The Software is written and supported by the thousands of community members, including Jason Kridner, employees of Texas Instruments, Digi Key, and Circuit co

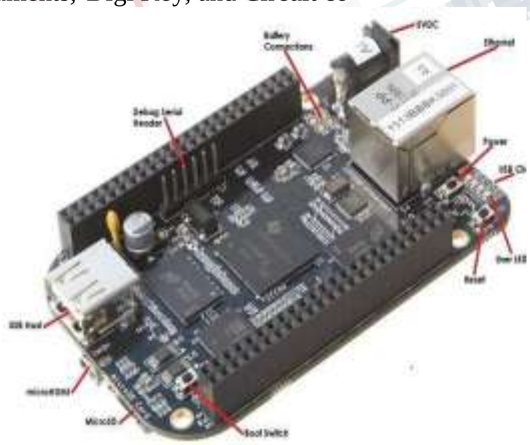

*Figure 3. Beagle bone Black Board*

***Camera:*** Normal USB camera or webcam is used to capture the images. For furthur more clarity still advanced digital cameras can be included. Figure 4.(a) shows the USB camera used. A webcam is a video camera that feeds or streams its image in real time to or through a computer to computer network. When "captured" by the computer, the video stream may be saved, viewed or sent on to other networks via systems such as the internet, and email as an attachment. When sent to a remote location, the video stream may be saved, viewed or on sent there. Unlike an IP camera (which connects using Ethernet or Wi-Fi), a webcam is generally connected by a USB cable, or similar cable, or built into computer hardware, such as laptops.

The term "webcam" (a clipped compound) may also be used in its original sense of a video camera connected to the Web continuously for an indefinite time, rather than for a particular session, generally supplying a view for anyone who visits its web page over the Internet. Some of them, for example, those used as online traffic cameras, are expensive, rugged professional video cameras.

***GPS:*** 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 U.S. 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 NMEA 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

[14]. Data. Figure 4.(b) shows the GPS receiver

Figure 4.(a)USB Camera

Figure 4.(b)GPS Receiver

## IV. ARCHITECTURE AND IMPLEMENTATION

The architecture of the proposed system consists of 3 parts; beagle bone black module, server module and the mobile application module. Figure 5. Shows the architecture of the proposed system.

Beagle bone black module is used to gather information about potholes and their geographical locations and this information is sent to the server. Server module receives information from the beagle bone black module, processes and stores in the database. Mobile application module uses information stored in the server database and provides timely alerts to the driver.

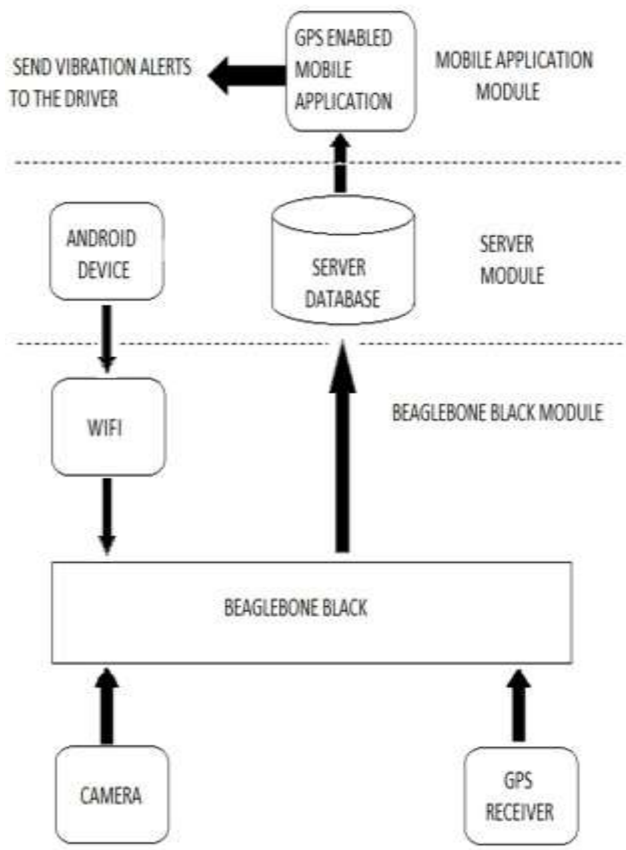


*Figure 5. Architecture of the proposed system*

***Beagle bone Black Module*:** This module consists of 3 components, namely, camera, beagle bone black, GPS. Camera are used to see the road surface from the car body and this data is received by the beagle bone black. The road surface is captured by camera and undergone through Image processing procedure to identify that the captured image contains the pothole along with its width. Figure 6.(a) shows interface between beagle bone and camera. Then currently capturing image of the road is compared with the previous image. Threshold value depends on the ground clearance of vehicles and can be configured accordingly.

The GPS receiver captures the location coordinates of the detected pothole and sends notification to the Android device which acts as the server. Figure 6.(b) shows interface between beagle bone and GPS. The notification sent include information about width of the pothole and its location coordinates. Figure 7.(a) shows the flow chart of this module.

**Server Module:** This module consists of two parts; the android device and the database. It acts as an intermediary layer between the Beagle bone module and the mobile application module. The android device creates a hotspot for the need by Beagle bone (i.e.Beagle bone requires network connection. This is accomplished by wifi from the android device.) The server module deals with the cloud computing technology. The database is required for the storage of information's regarding potholes.

Server module processes the contents of the comand and stores it in the database (cloud). Integrating sensor networks with cloud and Internet of Things[18], it is possible to allow broader access to sensor data. Figure 7.(b) show flow chart for server module.

Figure 6.(a) Interface between Beaglebone and Camera.

Figure 6.(b) Interface between Beaglebone and GPS.

***Mobile Application Module*:** This module is implemented as an android application that is installed on the vehicle driver's mobile phone to provide timely alerts about the presence of potholes

The application continuously runs in the phone background. It first captures the current geographic location of the vehicle and then accesses the locations of potholes stored in the server database. The distance between the vehicle location and the pothole location stored in database is computed. If the distance between the two is within 100 meters, an alert vibration is provide by the moblie as alert messages may not be able to read or heard by the driver due to travelling and traffic congestion. This vibration is made in different type so that the driver can differentiate it from other vibrations.

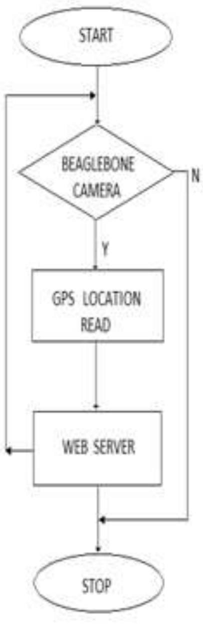


Figure 7.(a) Flow chart of Beaglebone Module.

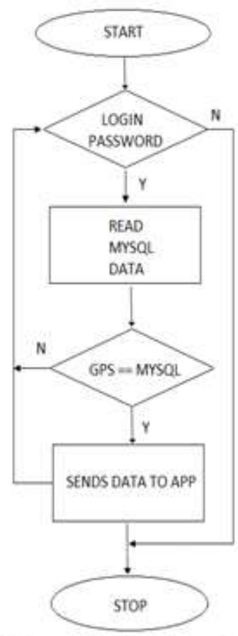


Figure 7.(b) Flow chart of Server Module.

## V. EXPERIMENTAL RESULTS

The working model of the proposed system is fixed to any car or bike. It was tested in a simulated environment with artificial potholes. The model was also tested in real time by fixing it on a motor bike.Tests were carried out in two phases. In the first phase, information about potholes was recorded and stored in the server database. In second phase, alerts were generated based on pothole information stored in database. While testing in the simulated environment, the beagle bone module was fixed on a toy-car and the threshold value was configured to 5 cm. During the tests it was found that the beagle bone module worked as expected to identify potholes. Table I shows a set of potholes identified by the system in the simulated environment, this is stored in database and maintained regularly.

| S.No | Date and Time | GPS data | Pothole |
|---|---|---|---|
| 1 | 01.03.2016,12:07pm | 12.83N, 77.67E | 15.2cm |
| 2 | 01.03.2016,12:09pm | 12.84N, 77.67E | 100.34cm |
| 3 | 01.03.2016,12:11pm | 12.85N, 77.67E | 30.09cm |
| 4 | 01.03.2016,12:15pm | 12.86N, 77.67E | 28.4cm |
| 5 | 01.03.2016,12:22pm | 12.87N, 77.67E | 155.8cm |

***Table 1. showing the information about the pothole location***

Information about potholes was successfully sent to the android device (server). The server processed the messages received and stored in the database. In the second phase of testing, the mobile application that generates alerts was successfully tested by moving the toy-car on routes containing potholes and alerts were generated for potholes recorded in the first phase. The beagle bone module was fixed on bike and the threshold distance value was configured to 16 cm, which is the ground clearance for bike. The vehicle was moved on Bangalore roads for the purpose of recording information about potholes, and the test results were as expected.

## VI. CONCLUSION AND FUTURE RESEARCH WORK

The model proposed in this paper serves 2 important purposes; automatic detection of potholes and alerting vehicle drivers to evade potential accidents. The proposed approach is an economic solution for detection of dreadful potholes , as it uses low cost controller. The mobile application used in this system is an additional advantage as it provides timely alerts about potholes. 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. The proposed system considers the presence of potholes. However, it does consider the fact that potholes get repaired by concerned authorities periodically because it updates the server with altered information every particular interval specified. This system can be further improved to consider the above fact and update server database accordingly. Also, Google maps and SATNAV can be integrated in the proposed system to improve user experience.

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