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Smart Pothole Detection and Mapping System

Rohan Borgalli
Assistant Professor,
Department of Electronics and Telecommunication Engineering,
Shah and Anchor Kutchhi Engineering College,
Mumbai, India.
Email: rohan.borgalli@sakec.ac.in

***Abstract*—** In any country public services and infrastructure is very crucial part of development. The qualities of these are shed light on how well the government is doing its job, the consequences of disparities in local funding. But there are few answers on these many questions. This is why this system was implemented to detect all types of potholes using different methods based on data acquired by ultrasonic sensor, gyroscope and image acquired by Pi-camera which gives the intensity and shape of the pothole in any given condition. Potholes have been a major problem in Mumbai road in recent times. Proposes system is trying to study potholes and their distribution on the roads of Mumbai with the help of hardware mentioned to acquire images and deep learning framework for potholes detection and mapping then using Android App and Google map it is generalize to the entire city.

Keywords: pothole: detection: mapping: Internet of Things(IoT): image processing: deep learning

I. Introduction

In Mumbai Damage to roads because of potholes, are increasing due to the environmental changes such as heavy rains and humidity, and thus complaints and lawsuits of accidents related to potholes are increasing. As one type of pavement distresses, a pothole is defined as a bowl-shaped depression in the pavement surface and minimum plan dimension is 150 mm [1]. Potholes can generate damages to vehicles tires and wheels also impact on the bottom part of a vehicle, Also presence of potholes leads to emergency braking and wheel steering operation leads to vehicle collision and major accidents [2]. Also, road quality measures such as detection of cracks, potholes, etc. mostly performed manually is a labor intensive and very much time consuming. To address this problem, many researches are carried out in many countries for developing a technology [3,4] that can detect and identify potholes based on sensors [5,6] and images [7,8], which may improve survey results efficiently about road quality by prior investigation and immediate action can be taken. Most recent technology to use smart-phones [3, 8, 9] to visualize pothole intensity on Google map so, it can be available to mass users [10].

In this paper, we surveyed various pothole detection and mapping methods which have developed until now and propose a system for detection and mapping of a pothole accurately and efficiently. Smart potholes detection and mapping is carried out by aggregating knowledge from multiple vehicles and users through Crowd sourcing [8] are leveraged to find environmental data with improved accuracy. We have a tendency to target victimization such knowledge to find and localize potholes on multi-lane roads. Extracting data from collective vehicle knowledge is difficult because of beneath sampling sensors, detector quality, asynchronous detector operation, detector noise, vehicle and road heterogeneousness, and GPS positioning error. GPS positioning error is especially more problematic in multi-lane environments since the positioning error is usually larger than normal lane widths. For that image processing comes into picture as we can capture multilane roads images through camera and process it to detect potholes and interface it to system.

Image processing part utilizes the python programming language and anaconda as a platform to run the program. In this program we have imported several packages like Keras, Opencv and tensorflow for the image processing. Also we have used dataset consisting of the sample of potholes with 150 images having 568 potholes labels to train our neural network. YOLOv2-CNN has been used as neural network.

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So, This Smart Pothole Detection System has Sensors and Image Processing with deep learning framework for accurately detection of pothole and Android App to Map it on Google Map.

II. Literature Review

Before start implementation of proposed system few literature survey was carried out which has different methods and systems proposed so far to give solution to pothole detection and mapping system.

A. Data acquisition and validation: the knowledge during this study was supported the routine underground mapping data collected by mine earth science personnel over a amount of over twenty years. Pothole size and frequency variability: In mining operations, potholes are also characterized into broad classes supported their size. This approach has been documented at many mining operations [1].

B. Few Pothole detection methods are discussed such as Vibration-Based pothole Detection which uses recent information acquisition hardware to develop vibration primarily based system for preliminary analysis of pavement conditions. Vibration-based technique use accelerometers so as to sight potholes which has advantages that it is needed little storage and may be utilized in real-time-processing, cost-efficient and amenable for automatic period of time processing [2].

C. Since 2007, Google has been working on regularly taking panoramic images of all the streets in the world which leads Success to Google's specially designed vehicles have traversed an overwhelming majority of the streets. It downloads the data on the kinds of roads we are interested from open Street Map(OSM). It chunks the roads into half a kilometer segments and then randomly sample from segments. The starting latitude and longitude of the sampled segments and query the Google Street view API [3].

D. Use of machine learning techniques for 2D and 3D image-segmentation techniques the pixels are semantic wise classified. Each and every pixel of the image has predefined classes. It segments an image into 12 different classes which includes roads, cars, pedestrians etc. Failure cases of this method arise when both 2D-Segmentation and 3D-segmentation information override [4].

E. The system proposed is for Validation of benchmark space spatial feature Optimization Detection after Optimizing. It collects the data with the help of acceleration sensor and gyroscope [5].

F. Systems based on land vehicles are considered as mobile crowdsensing nodes. Fuzzy logic is intended to deal with real-world applications through framework able to deal with ambiguity and inaccuracy. It follows steps as Take input. Fuzzification. Inference system. Defuzzification and generate Output. Experiments were held adopting multiple vehicles and included various motion sensors and smart devices [6].

G. Use of Image Acquisition and Segmentation, Sample Dataset Preparation and Feature Selection is based on Support Vector Machine. It also uses Artificial Neural Network [7].

H. Development of crowd sensing application to estimate road conditions (CRATER) is a smart-phone based application that measures acceleration when it finds itself on the road in order to map and measure the locations of potholes and speed bumps. It does not require any input from users, but can report detected potholes and speed-bumps to a cloud-hosted application engine, which stores partially processed data received from smart-phones of users using it and jointly processes it to obtain a better estimation of road conditions.

The information is published in map form on the web that shows that CRATER succeeds in correctly detecting roughly 90% of potholes and 95% of speed-bumps, while generating false alarms only about 10% and 5% of the time, respectively [8].

I. A simple and robust design of a portable and affordable device that is suitable for local jeepney (cab) drivers in the Philippines has distinguishing feature that it does not need a sophisticated Smartphone to automatically send the reports that was tested in an actual moving vehicle. Furthermore, the system can be installed in a moving vehicle to automatically detect and report potholes via image-processing of Raspberry-

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Pi microcontroller. The system was tested on a Hyundai Eon city car with maximum speed of 10kph - 40kph during daytime. With a rate of about 8 frames per second, images were processed per frame to detect potholes by analyzing its color, depth, and area [9].

III. System Structure

A. Hardware Implementation

The core of our hardware is the raspberry pi 3b+. We have interfaced several ultrasonic sensors to give us an accurate depth reading and positioned them accordingly to give us width of the pothole. GPS module is also used and it provides longitude and latitude in real time, accurate within 3 meters. The pi camera captures pictures of potholes to be later used for image processing. The gyroscope senses tilting of sensors and the data obtained from it is used to correct the readings of the ultrasonic sensor. Overall block diagram is given in figure 1.

Fig.1. Block Diagram

B. Software Implementation

The program first initializes all the ultrasonic sensors. This is necessary to calibrate them and avoid errors. Once the sensors are calibrated they constantly keep measuring the distance and send it to the raspberry pi. The reading is compared to predetermined threshold and if it exceeds it then it calls the gps function.

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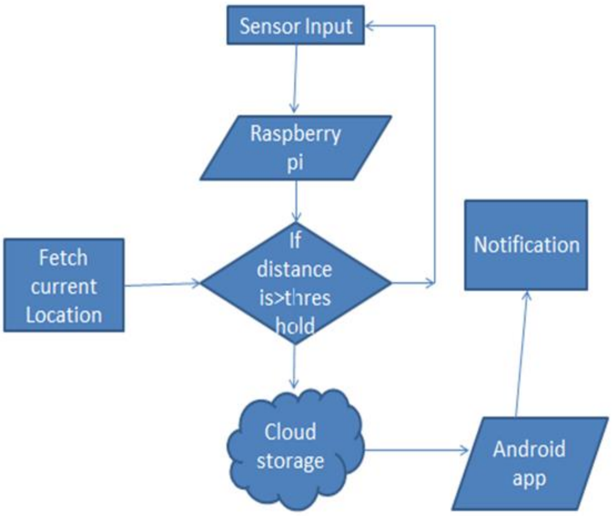

Fig.2. Flowchart of program

The gps function sends the raspberry pi longitude and latitude in degrees. The UART port is accurate upto 5 decimals. The pi then stores both the depths and co-ordinates in a file. The function then sleeps (does nothing) for 200 milliseconds to prevent measurement of the same pothole again. It then loops back to the start as shown in figure 2.

The App has been designed in android studio as shown in figure 3.

The proposed Methodology in detail is listed below which has four major steps such as pothole detection, application management, image processing and mapping.

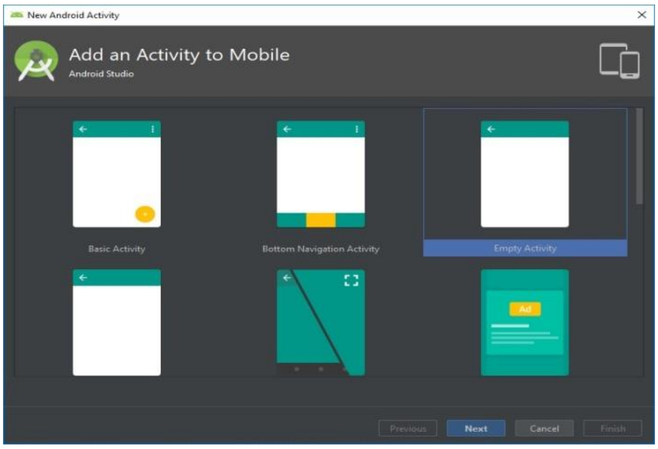

Fig.3. Android Studio

For webhosting 000webhost.comas shown in figure 4, is used with server named as 'mypotholereport'. This server consists of the database named as location and suggestions, which are than mapped along with latitude, longitude and different colors to indicate the severity of the potholes.

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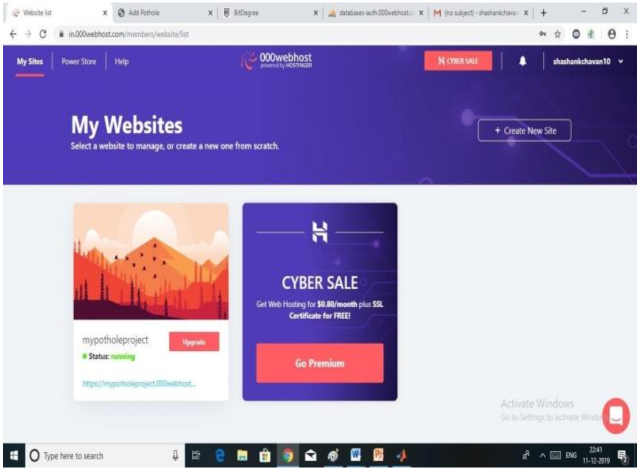

Fig.4 000Webhost

When the user selects the upload image as shown in figure 5.A, then the user is asked to turn on the GPS location of their phone. After granting the permissions required the user can capture the photo of a pothole and send it to us. The image is stored in our database along with the co-ordinates. And with the get potholes option the user can also see the severity of potholes marked with different colors as shown in figure 5.B, the red indicates deep, green indicates moderately severe and yellow indicates shallow.

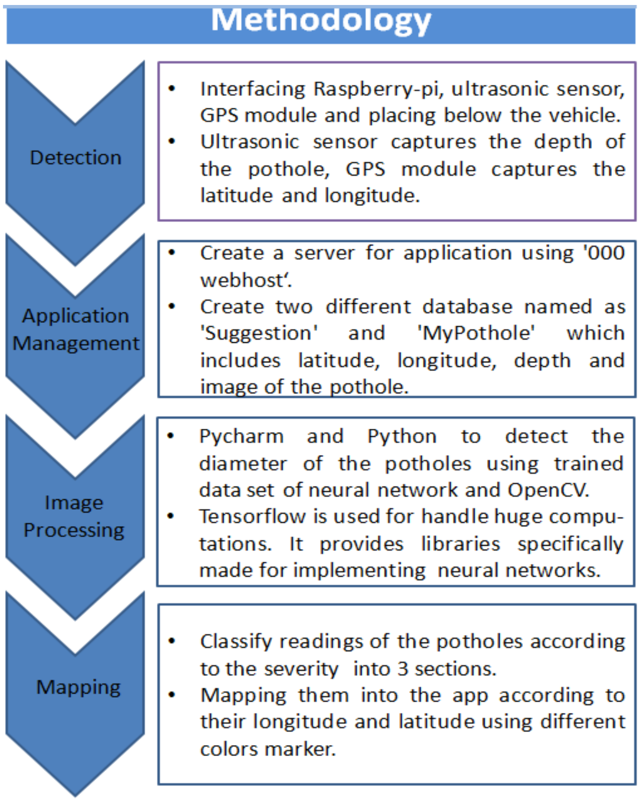

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Fig.5.A.Image Upload

Fig.5.B.Map of potholes

IV. Image Processing With Deep Learning

Here we have used YOLO(you only look once) real time object detection system to detect the edges of the pothole in the given frame and mark a rectangular box. It divides the image into different grid cells. It has 2 fully connected layers along with 24 convolutional layers. Using different inbuilt function such as conv2D, batch normalization we enhanced the image, leaky relu is the activation function is in this neural network to add the linear properties.

The steps followed for the image detection is

1. Read the image using inbuilt function in the python ‘input’
2. Create database split it into Train-Validation and Test by ratio 80-10-10
3. Train and validate the datasets using CNN using YOLOv2 real time object detection system
4. YOLOv2 Model has following layers
   a) 2D convolutional layer which is implementated as conv2D
   b) Batch normalization which includes standardization of input to layer for each mini batch
   c) Activation function ‘LeakyRelu’ for adding non-linearity into model
   d) Discretized the image using max pooling2d which is sample based discretization process
5. Test it on images acquired by pi-camera interfaced in proposed system and calculate diameter of pothole to indicate intensity of pothole as shown in figure 6 A. and 6 B which indicates Test image of pothole and detected potholes after testing it.

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Fig.6.A - Test image of potholes

Training software (CNN): The software we have used here is for image processing, A Convolutional neural network (CNN) is a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data. The model which we used has been trained with 150 images which is having 568 potholes labels. The accuracy of the model will increase by training the model with larger size dataset. A neural network is a system of hardware and/or software patterned after the operation.

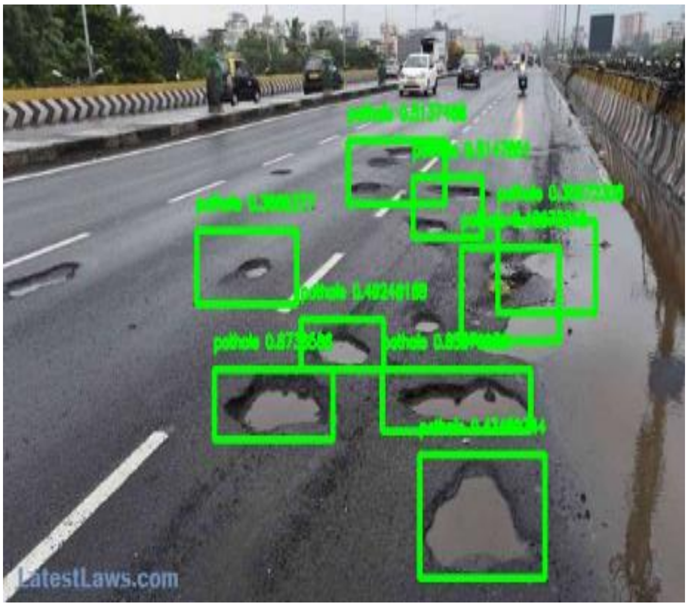

Fig.6.B - Detected Potholes by software

V. Results & Discussion

After implementing proposed Pothole Detection and Mapping System which overcomes two major problems that concerned the people the most and which leads to frequent accidents and damage of vehicles that is automatic detection of the potholes with their intensity and mapping it on map. The proposed work is more

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economical as it uses a low-cost ultrasonic sensor, Pi-Camera and a GPS module. This model also works when potholes are filled with water and corresponding information about the potholes is shown in the android app. This work provides best solution for the above problems as the location of the pothole can be seen in the app along with its intensity, it brings to the notice of the government officials as a result, and they can maintain the roads properly.

Figure 7.A displays the prototype of our prototype of hardware part of system and 7.B shows the map displayed on our app.

Fig.7.A- prototype

Fig 7.B- Mapped potholes

Fig 8.A-Input Image

Fig 8.B- Processed Image

VI. Conclusion

The model proposed overcomes two major problems that concern the people the most and which leads to frequent accidents; the automatic detection of the potholes and their depth. The proposed work is more economical as it uses a low-cost ultrasonic sensor, Pi-Camera and a GPS module. This model also works when potholes are filled with water and corresponding information about the potholes is shown in the google map API which is integrated in android app. This part is implemented as an android application that is installed on the vehicles driver's smart mobile phone to provide alerts real time about the presence of potholes also pedestrian users can use this app and upload images of potholes they encountered.
The application continuously runs in the background of phone application to provides the current geographic location of the vehicle through GPS and then accesses the locations of potholes which is stored in the server database also with the upload pothole option the user can upload a image of pothole and once its approved by

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admin then it will be processed by deep learning framework As shown in figure 8.A and 8.B and maps all the potholes records their dimensions and classifies them accordingly and update result that is pothole severity in the server database.

The **social** benefits of proposed system are as given below:

1. It helps the common people and government by localizing potholes with its severity.
2. It removes the need for citizens to submit social complaints to their government regarding road condition.
3. It also removes the need for manual collection and analysis of data.
4. It does not require any expensive dedicated hardware for data acquisition, installation and maintenance.
5. Information is continuously updating to get real information to take future decisions.
6. This may lead to further improvement in road conditions by government which allows traffic to move faster and smoother.
7. It improves health of public and vehicles.

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Author Biography:

Mr. Rohan Appasaheb Borgalli currently working as Asst. Prof. in Department of Electronics & Telecommunication Engineering, Shah and Anchor Kutchhi Engineering College, Mumbai and has 7 years of Teaching Experience.

He received his M.Tech degree in Digital Systems from Motilal Nehru National Institute of Technology (MNNIT), Allahabad, in 2013 and currently pursuing PhD in Machine Learning from Mumbai University. His research interests include Machine Learning, Emotional Intelligence, Digital Systems Design, Digital Signal and Image Processing.

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