Pothole Detection And Reporting

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Abstract- *The importance of the road infrastructure for the society could be compared with importance of blood vessels for humans. To ensure road surface quality it should be monitored continuously and repaired as necessary. The optimal distribution of resources for road repairs is possible providing the availability of comprehensive and objective real time data about the state of the roads. Participatory sensing is a promising approach for such data collection. The paper is describing a mobile sensing system for road irregularity detection using Android OS based smart-phones. 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 as well as recommendations for their application.*

Keywords- Mobile sensing, Participatory sensing, Potholes, Accelerometers, Algorithms.

I. INTRODUCTION

A pothole is a structural failure in a road surface, due to water in the underlying soil structure and traffic passing over the affected area.

Roads have been flooded with the vehicular traffic. It has become increasingly difficult to manage this traffic. One of the increasing problems the roads are facing is worsened road conditions. Because of many reasons like rains, oil spills, road accidents or inevitable wear and tear make the road difficult to drive upon. Unexpected hurdles on road may cause more accidents. Also because of the bad road conditions, fuel consumption of the vehicle increases; causing wastage of fuel. Pothole detection system aims to warn the driver about the uneven roads and potholes in its path.

The emerging concept of "Smart Cities", a place where traditional networks and services are made more flexible, efficient, and sustainable with the use of information, digital, and telecommunication technologies, encompasses different components like smart infrastructure, smart transportation, smart energy, smart health care, and smart technology. With cars rapidly getting "smarter", sophisticated sensors are installed allowing the vehicle to profile the road surface under the wheels and identify different road distresses. However, vehicles are still vulnerable to damages caused by these road distresses like bumps, patches, and especially potholes.

Figure 1- Smooth roads

Maintenance departments need to regularly assess the quality of the roads in order to properly maintain them. Currently, this is done by yearly inspections or in response to reports from the generalpublic. The inspection is sometimes done by workers walking along the streets and recording the conditions on paper which later is put into a database. In other case the agency makes use of special vehicles that measure the road surface. Those special vehicles are very costly. In either case the cost of the monitoring is high. It would also be advantageous to continuously monitor the road surface so that damages like potholes can be detected as soon as they occur. In general, such a monitoring system will allow a more efficient allocation of maintenance resources.

Figure 2- Pothole

The main challenge for a system is cost, which includes the price of sensing equipment and the cost of collecting the data. We propose a system with two key features: First, to keep the equipment cost down, we use low cost sensors and already proven equipment. Second, to minimize the cost of collecting road data, we use vehicles that already traverse the road network on a regular basis. In the following sections we will discuss these points and present our prototypesystem. We propose the design of ‘Pothole detection System’ which assists the driver in avoiding pot-holes on the roads, by giving him prior warnings. Warnings can be like buzzer if the driver is approaching a pothole, or driver may be warned in advanced regarding what road has how many potholes. This system is divided into three subsystems. First is sensing subsystem where the accelerometer readings for obtained for a trail run. Then communication subsystem which transfers the data acquired to the cloud for storage and retrieval. From the readings a threshold value is set for further computation. This application developed compares the value of the readings to the threshold set to decide if a pothole is detected for not. If a pothole is detected, then a report is sent to the government for repairs along with the location obtained from the GPS module. If the pothole is rectified, then new readings of that location will be indicated in it.

II. LITERATURE SURVEY

ArtisMednis, Girts Strazdins, ReinholdsZviedris, GeorgijsKanonirs, Leo Selavo*al et* proposedthat Preliminary data from the accelerometer sensors were collected using a modified Lynx Net collar device on an urban road with various potholes. The device uses Tmote Mini sensor node with Texas Instruments micro-controller MSP430F1611 and Analog Devices 3-axis accelerometer ADXL335. To acquire raw acceleration data and transmission through USB interface to a laptop computer MansOS based software is used. The features that classify the measurements are the values exceeding specific thresholds that identify the type of the potholes (a large pothole or a cluster of potholes). This algorithm assumes that the information about Z-axis position of accelerometer is known. The author uses a technique for implementation on a resource-constrained device was using a standard deviation of vertical axis acceleration. It was implemented in algorithm STDEV(Z). Further, the window sizes and specific threshold levels had to be determined for the tuning of the algorithm and especially for pothole event detection. To evaluate the algorithms, the author used marking of the ground truth for the selected test track using Walking GPS approach first. This was followed by test drive session on selected test track with 4 different smart-phones as data acquisition devices. Further, selected event detection algorithms were used for processing of collected data. Statistical analysis of algorithm was performed in the context of previously marked ground truth and the existing Road Mic methodology. The test drive session included 10 consecutive laps on the selected test track and was performed in the same day as the ground truth. Processing of the collected data was associated with tuning of appropriate threshold levels for all selected algorithms and appropriate sliding window size for STDEV(Z) algorithm.

AliakseiMikhailiuk, NaimDahnoun*al et* proposed Real-Time Pothole Detection on TMS320C6678 DSP this algorithm was implemented for the TMS320C6678 SoC Digital Signal Processor (DSP). Potholes can be detected by comparing the disparity values of the scene to that of the disparity of the road surface if known. Road parameters estimation for the disparity map for identification of points having a negative deviation for the model. Surface fitting was used to capture the image and sense the area of distribution. Data sampling method was used. RANSAC is an iterative surface fitting into the clouds of data randomly sampled from the initial data set until a reliable model is found. A specified number of points were required to estimate the model parameters randomly. This is solved for parameters of the model, called least squares. Further, they have to determine how many points from set of all points that fit a predefined tolerance. If the fraction of number of inliers versus all the points exceeds some predefined threshold, then it will be terminated. Otherwise, the technique is repeated up to maximum of N times (where N shall be specified). For good precision, the number of iterations, N, should be chosen high enough. Value smoothing techniques was used under the assumption that any row in a disparity map should have approximately the same depth value for points being further away from the observer, this value is smaller.

Shambhu Hegde, Harish V. Mekali, GollaVaraprasad*at el* Pothole Detection and Inter Vehicular Communication An inter-vehicular communication model is used for sharing information in this paper. Microcontroller NXP LPC 1768 with ARM Cortex-M3 core processor is used. Zigbee modules are used for communication, which can transmit and receive data within 100 m. Tarang F-20 Zigbee modules are used. These modules integrate an antenna, amplifier, transmitter or receiver LV-MaxSonar-EZ0 ultrasonic sensor to detect objects from 0 to 254 inches and provide sonar range information from 6 inches out to 254. Objects from 0 to 6 inches typically range as 6-inches and are said to be in blind range. The output is in the form of analog output voltage. A motor driver translates the input to higher voltage while maintaining the promised current output. The motor driver uses L293D to drive 3 DC motors. MBED microcontroller is used, which is based on the NXP LPC1768, with a 32-bit ARM Cortex-M3 core running at 96 MHz. Two vehicles namely transmitting vehicle and receiving vehicle should be present. Microcontroller receives the sensor output and controls the motors through motor drivers. It also transmits the information to the receiving vehicle. The receiving system receives the information, and based on this information, the microcontroller takes decision about the speed of the motors. The effect of potholes on the vehicle depends on the ground clearance of the vehicle and vehicle suspension. Ultrasonic sensors are used to detect the depth of potholes. High frequency sound waves are generated and the waves are reflected back from the object. The sensor calculates the time interval between sending the signal and receiving the echo to determine the distance to an object. Ultrasonic sensor, LVMaxSonar-EZ0 is used which provides sonar range information from 6 inches out to 254 with 1-inch resolution. A prototype model designed using Catia software. ARM CortexM3 core microcontroller is used.

Vosco Pereira, Satoshi Tamura, Satoru Hayamizu and HidekazuFukai*al et* proposed Classification of Paved and Unpaved Road Image Using Convolutional Neural Network for Road Condition Inspection System They proposed the use of CNN technique is cost efficient which automatically learn the features from input images without applying any feature extraction techniques. The data is collected using a smart phone mounted inside the vehicle, in urban and rural areas of the paved and unpaved roads and the data collected from the images was classified for training set and validation set. After the data is acquired CNN is done for classification of layers and then feature extraction is done, it distinguishes CNNs from other multi-layered neural networks which comprises of convolutional layer, pooling layer. It is then classified as several numbers of convolutional and pooling layers are usually stacked on top of each other to extract more abstract feature representations in moving through the network. Design model they have used here is based on Visual Geometry Group (VGG) architecture. And then the model is trained in various sections like framework and hardware, regularisation. The proposed model achieved 99.63% on 13.186 training images and 99.57% on 3.186 validation image. This shows how the deep learning technique can provide better solutions than conventional algorithms with limitations. They also plan to build a system for automatic unpaved, crack, and pothole detection by smartphone as future work.

Frederico Soares Cabral, Mateus Pinto, HidekazuFukai, Fernao A. L. N. Mouzinho, Satoshi Tamura *al et* proposed, An Automatic Survey System for Paved and Unpaved Road and Road Anomaly Detection using Smartphone Sensors, where the use the sensors equipped in the smartphone for road surface monitoring. They develop a mobile application on the android platform with java for data acquisition, which collects data from four sensors accelerometer, gyroscope, GPS and compass. The data is recorded in the sampling rate of 100Hz totally in eleven variables with a time stamp, and their respective sensor axes (x, y, z). Data is acquired with the smartphone kept in the vehicle cabin and the recordings are done on the national roads, paved and unpaved roads with pothole and bumps and the data collected was partitioned into two set, where 70% of the data were selected for training and the remaining 30% for testing. The pre-processing is applied for the triaxial acceleration and gyroscope at sampling rate of 100 Hz, which are further processed in four steps such as re-orientation, low-pass filter, segmentation and features extraction. An additional step for anomaly detection is also shown in a y-filter step. Classification and performance evaluation is done using various methods such as Support Vector Machine (SVM), Hidden Markov Model (HMM), Residual Network (ResNet), K-Nearest-Neighbors (KNN) and Dynamic Time Warping (DTW), Performance Evaluation. The data was recorded using various types of vehicles and smartphones All the smartphone was placed in the car cabin in various postures and simultaneously recorded the road acceleration data which were sensed from moving vehicles. The data acquisition was also included video recording. Instead of the threshold on vertical acceleration, they used machine learning techniques on multi-features of data. In the proposed model raw acceleration data was normalized tpo reduce the variability of smartphone. The Butterworth low-pass filter with a 5 Hz cut-off frequency was applied to remove engine noise and the signals were sampled with a fixed size sliding window and the result is obtained by using the performance obtained by various methods. They also plan to focus on road roughness estimation for the roads and visualize the classification on the maps as a future work.

Vigneshwar.K and Hema Kumar.B*al et* proposed the technique for detection and counting of pothole using image processing. This technique involves pre-processing of the image by Image resizing, Grayscale conversion, Median-filtering, Difference of Gaussian-Filtering. After the pre-processing the next step is image segmentation which uses different techniques for separating pothole and non-pothole region in the image. The technique in Image segmentation used are Edge detection, Thresholding technique based on Otsu’s method, K-Means based Image clustering technique, Fuzzy C-Means based Image clustering technique. After the image segmentation the performance of the different techniques were evaluated and compared and the results were obtained as for the technique used from an image sample and then latter preferred the K-Means clustering based segmentation was for its fastest computing time and edge detection based segmentation. They also plan to implement image segmentation techniques using hybrid classifiers like neural network to develop a standalone product for detecting the pothole as future work

Harikrishnan P. M, Varun P. Gopi *al et* Proposed that road surface monitoring system in uses a smartphone tri-axial accelerometer for the data collection. Operations such as segmentation and pre-processing are performed on the vibration data extracted. An algorithm is designed which performs operations to monitor road surface. The data collected is segmented into groups of n samples and all further processing operations are performed on each of these segments. This allows the system to identify the occurrence of multiple abnormal events. Max-Abs Filtering is the second stage of pre-processing. During this stage the application of a designed filtering technique is used on the segmented data. The output of this filtering removes most of the small spikes in the segmented data and maintains the larger acceleration peak. The smartphone accelerometer senses the vertical vehicle vibration by measuring the Z-axis acceleration samples. The vibrations in abnormal road sections are much greater than that on the normal road surfaces. Hence the road anomaly is detected. The next function of the system is to estimate the severity of the event. By making use of the relationship between acceleration and displacement, the severity of the event is computed.

Mae M. Garcillanosa, Jian Mikee L. Pacheco, Rowie E. Reyes, Junelle Joy P. San Juan *al et* proposed system processes between the vehicle and database. A unit was installed in the vehicle with camera module, GPS system, and three LEDs that would act as indicators if the device was turned on, if a pothole was detected, and if the report was sent. For the pothole detection, the camera module would capture eight images per second in front of the windscreen of the car. Image-processing is done by first removing other objects in the image such as the sidewalks and the pedestrian. Algorithm developed would extract images of pavement or the road itself and these would undergo the main process. Potholes then would be detected based on its colour and area using Canny edge detection, contour detection and final filtering. If a pothole was detected, the same microcomputer would connect to the Internet and send the image and the location of the pothole to the main database. An LED was placed in the system to indicate if the report was sent. A main microcomputer system connected to main server would receive and collect all data from other microcomputers.

Christoph Mertz *al et proposed* Continuous road damage detection using regular service vehicle Roads need to be monitored regularly by the maintenance departments in order to maintain their good quality. This proposed system has low equipment cost and also cost for collecting road data is minimum. A laser line striper is used for this application which works on the principle of structured light. The laser outputs a plane of light that falls on the objects and is viewed by a camera. The bandpass filter present in the camera will supress the background illumination of the result image and the laser projected will be highlighted. This laser line will be converted to world coordinates by using triangulation technique. Hence this laser liner striper is useful in obtaining high resolution three dimensional images from distance of a few meters, which is perfect for detecting potholes and other road anomalies. The system is installed on the front bumper of regular service vehicles such as buses, garbage trucks and other vehicles which travel through these roads regularly. Continuous three -dimensional images will be collected by these vehicles on its route along with its GPS location and speed. The fixed position of laser line striper will permit the sensor to scan roads in a sweeping motion. The recorded data will be updated on the map using global position. For data analysis a step operator was used on each cross section which evaluates the unevenness of the pavement at that location. The laser line striper uses a straightforward algorithm which can automatically detect the areas of road damage.

Karmel. A, Adhithiyan. M, Senthil Kumar*al et proposed* Machine learning based approach for pothole detection Government requires accurate information regularly for efficient maintenance of roads. However inspection of roads needs a large amount of man power every year. This is a slow process because of the distance that is involved with it. Hence automation techniques are employed for classification of roads and road damage detection. Additionally, machine learning algorithms are used. Pothole detection can be performed by using a combination of image processing and machine learning techniques. In this project various machine learning algorithms have been used. The resulting features have been trained into the model and analysed. Support Vector Machines(SVM) are supervised learning models with associated learning algorithms that analyse data used for classification and regression analysis. Decision tree is one of the supervised learning algorithm. It is a decision support tool usually used in classification problems. This model supports continuous as well as categorical input and output variables. Different classifiers can be selected and the data can be examined to find the accurate pothole detection using images. Pothole visualization is another important segment in this project. This consists of morphological transformation method where the image captured by the camera will be smoothened by using Gaussian blur and a prerequisite amount of threshold. For removal of noise opening and closing transformations are used. Blob detection method is used for identifying regions from the image which will have different properties like contrast, brightness. Since potholes will have different properties compared to the rest of the road, they can be distinguished.

III. SYSTEM OVERVIEW

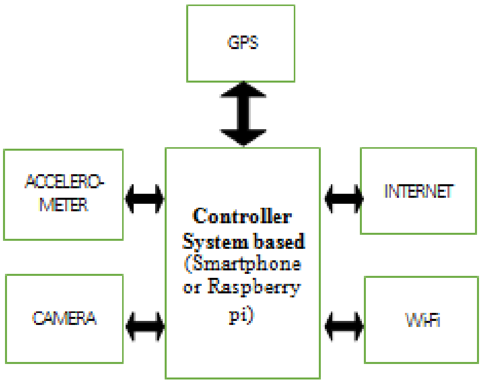

Figure 3- Proposed block diagram

A. *IP Camera* - An IP camera is a video camera that is networked over a Fast Ethernet connection. The IP camera sends its signals to the main server or computer screen via an Internet or network link. It is mostly used in IP surveillance, closed-circuit television (CCTV) and digital videography. Benefits of IP camera over analog technology include: Remote administration from any location,the ability to easily send images and video anywhere with an Internet connection. Disadvantages of IP surveillance include greater complexity and bandwidth demands.

B. *Accelerometer* - An accelerometer is an electromechanical device used to measure acceleration forces. Such forces may be static, like the continuous force of gravity or, as is the case with many mobile devices, dynamic to sense movement or vibrations. Acceleration is the measurement of the change in velocity, or speed divided by time. At rest, an accelerometer measures 1g: the earth's gravitational pull, which registers 9.81 meters per second or 32.185 feet per second. Accelerometers that use the piezoelectriceffect measure a small voltage change. Others measure capacitance between two components. Applications for accelerometers include: Monitoring devices in biology, engineering cars, industry, volcanology and more, Input in smartphones, tablets and game controllers. A typical mobile device has an accelerometer that can detect acceleration on two or three axes, allowing it to sense motion and orientation.

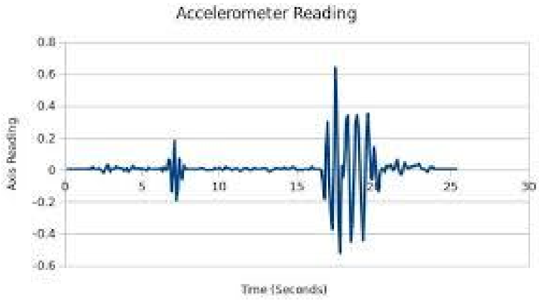

Figure 4- Accelerometer readings

C. *Raspberry pi* - A Raspberry Pi is a credit card-sized computer originally designed for education, A Raspberry Pi is a credit card-sized computer originally designed for education, The Raspberry Pi is open hardware, with the exception of the primary chip on the Raspberry Pi, the Broadcomm SoC (System on a Chip), which runs many of the main components of the board–CPU, graphics, memory, the USB controller, etc. There are a two Raspberry Pi models, the A and the B, A comes with 256MB of RAM and one USB port. It is cheaper and uses less power than the B. The current model B comes with a second USB port, an ethernet port for connection to a network, and 512MB of RAM. The Raspberry Pi A and B boards been upgraded to the A+ and B+ respectively. The Raspberry Pi was designed for the Linux operating system, Two of the most popular options are Raspbian, which is based on the Debian operating system, and Pidora, which is based on the Fedora operating system.

D. *GPS* - Stands for "Global Positioning System." GPS is a satellite navigation system used to determine the ground position of an object. Today, GPS receivers are include in many commercial products such as automobiles, smart phones.The GPS system includes 24 satellites deployed in space about 12,000 miles (19,300 kilometers) above the earth's surface. They orbit the earth once every 12 hours at an extremely fast pace of roughly 7,000 miles per hour (11,200 kilometers per hour). The satellites are evenly spread out so that four satellites are accessible via direct line-of-sight from anywhere on the globe. Each GPS satellite broadcasts a message that includes the satellite's current position, orbit, and exact time. A GPS receiver combines the broadcasts from multiple satellites to calculate its exact position using a process called triangulation. Three satellites are required in order to determine a receiver's location, though a connection to four satellites is ideal since it provides greater accuracy.

IV. WORKING OF THE SYSTEM

Preliminarily the data is collected from the accelerometer using either a smart phone or Raspberry Pi module. Trial runs are conducted to obtain the accelerometer values for further computation. The data is collected and stored on cloud. A suitable threshold value is selected for accelerometer readings to detect potholes.

Figure 5- Pothole detection

An application is developed using Android OS which will show the location of potholes to the user. Similarly, a Raspberry Pi module is also programmed to locate potholes. The data is collected is uploaded to cloud and retrieved from the cloud. The application compares the threshold value and the data. This gives the location of potholes. Based on this the quality of the road is decided.

Figure 6- Pothole repairs

The app will also report the location off potholes to the concerned authorities. Based on the data collected from commuters on road, the pothole condition is determined. If the pothole is rectified then the data collected from the app will indicate. Hence, this will help government keep a check on the road maintenance.

Figure 7- Smooth road

V. CONCLUSIONS

This paper describes accelerometer data evaluation for pothole detection using Smart phones and Raspberry Pi. The evaluation tests resulted in optimal setup for each selected algorithm and the performance analysis in context of different road irregularity classes show true positive rates as high as 90%. The future work includes experiments with combinations of algorithms and development of self-calibration functionality.

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