

Sustainable Approach for Pothole Detection – A Machine Learning Implementation

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Abstract

Low-traffic roadways connecting communities are known as rural roads, and most of them are owned by local governments. A good rural road network is necessary for the village's economic and social development because the growth of country roads has an impact on the economy of the community. Logistics may be challenging, transportation may be challenging, and local contracting capacity may be constrained. This project aims to detect potholes and notify authorities with minimal human involvement. The suggested module consists of an ESP32 module that collects GPS coordinates and communicates them along with a photo captured by a camera module to a location identifier through Telegram and a MEMS accelerometer that detects pits and holes. Machine learning (ML) techniques are used to identify abnormalities in the data sets in order to evaluate the hole, its location, and its severity. The Kodular Smartphone application shows a notification when a pit appears.

Keywords: MEMS accelerometer, ESP32 module, GPS, potholes, Kodular mobile application, Machine Learning

Introduction

Roads are a significant form of transportation in India, which has resulted in the country having the world's second-largest road network. A total of 4,03,116 road accident cases were registered in 2021, up from

3,54,796 in 2020, according data from the National Crime Records Bureau (NCRB). In the meantime, the number of people killed in traffic accidents rose by 16.8%, from 1,33,201 in 2020 to 1,55,622 in 2021. 3,71,884 individuals were hurt in traffic accidents last year. Additionally, the number of fatalities per 1,000 cars rose from 0.45 in 2020 to 0.53 in 2021.

Deaths from potholes are quite frequent and have been on the rise. The lack of road maintenance would be the main cause of this. Potholes are a natural occurrence that cannot be avoided, but pothole deaths can be avoided by taking the necessary precautions. The Ministry of Road Transport and Highways reports that between 2013 and 2017, 14, 936 people died as a result of potholes. Similarly there have been 4800 pothole accidents in 2019, of which 2000 fatalities have been reported. Over the past year, accidents caused by potholes claimed the lives of more than 2000 people, and poor road maintenance was to blame for about 4800 other accidents.

The World Health Organization defines road safety as "measures taken to reduce the uncertainty of traffic congestion injuries and deaths." Due to material deterioration brought on by heavy traffic, severe weather, ageing, poor constructability, and inadequate maintenance, roadway infrastructure is vulnerable to structural degradation. The accomplishment of a road transportation system is inextricably linked to the commuters' level of comfort and riding quality, making prompt fault finding and remedial maintenance of the utmost importance. A major cause of pavement damage and a widespread problem in many nations, the absence of quick and integrated road monitoring methods calls for significant efforts in this direction.

As India has nearly 6,215,797 km of roadways as of April 2020, there is a huge scope of making them well maintained for the economical growth of India in turn save fuel and passengers time. As traditionally, human workers personally check for road condition can be avoided and make it easier and automatic while a vehicle passes through a pit. Identifying the pits with the help of sensors would be useful enough for road management to operate and implement at low cost. Once transport authority receives the data prioritization is done and the most affected area is recovered first and also notifies the location of the roads which are in verge of severe damage. Ultimately to recover bad road condition as soon as possible. People will be more comfortable if the road conditions are addressed. The proposed solution is unique in such a way that the information tracked will be sent to the road transport authority at the same instant along with the picture of that pit; which makes the work easier for the authority to start their work. Even this can be done manually but it takes a lot of time for the information to be reached and some might be lost which in turn is not helpful for the development of the nation.

Literature Review

Numerous studies have demonstrated pothole extraction methods that effectively segment and detect potholes by utilising either the texture or the grey information from the pit, or both. This paper allows citizens to report potholes by attaching an image and Location information. Markov random fields and wavelet energy fields were proposed by Manjunatha et al. [1] as a method for segmenting and classifying pothole photos. The proposed method is divided into three stages. (A) To identify the image, a wavelet energy file is built using geometrical features and morphological analysis. (B) The region of intersection is extracted using an edge-based segmentation approach. (C) Classifying the potholes is done using a neural network. 93% of the time, the suggested solution is successful. The segmentation process will take a long time if a Markov random field is used. According to Taehee Lee et al. [2], this work developed a Smartphone-based dual-acquisition technique system that could capture pictures of road-surface anomalies and analysing the vehicle's acceleration when they are detected in order to investigate the

complementary advantages of the two different approaches. 1896 images of the road surface were used for a road evaluation, and three-axis acceleration data was recorded. Each shot's anomaly type and presence were categorised, and the histograms of the largest variations in gravity acceleration were contrasted. This study created a system that analyses three-axis accelerations and uses an FCN model to detect flaws in the road surface in collected images. However, the current study was unable to evaluate the impact of vehicle type and speed on the accuracy of the information gathered, which should be the focus of multiple studies to increase the suggested system's accuracy. In their study of Indian roads, Pranjali Ulhe et al. [3] suggested a method for identifying lanes, potholes, and road signs as well as classifying them. They also suggested an automated driving guiding system. They concentrate on systems, such as traffic/driveway surveillance systems, where the camera is mounted both on the vehicle and in a fixed location. The Hough Transformation method is used for lane detection, and Color Segmentation and Shape Modeling with Thin Spline Transformation (TPS) with a nearest neighbour classifier is used for road sign recognition and classification. The next step is to assess the image with the intention of quickly speculating where an obstruction might be located and then verifying those locations. The results of using novel image processing methods to assign a qualitative descriptor to a road scene are described in this study. The qualitative analysis of a road scene can be used to control traffic lights and place warning signs alongside the road to warn drivers to slow down or point them in the direction of an alternate route. For on-line real-time operations, a low-cost frame recorder and a Pentium-based computer system are required for this full frame image analysis solution.

Study Objectives and Methodology

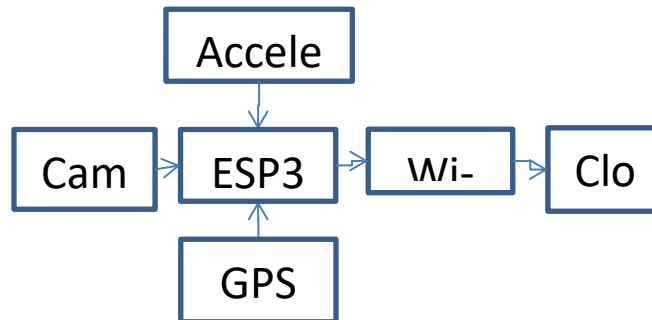


Fig1. Block diagram of pit detection module

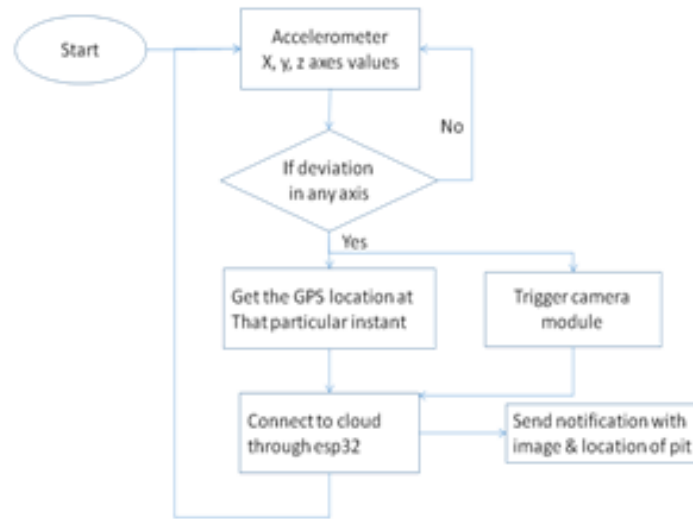


Fig2. Flowchart of the pothole detection and alert system

Utilizing sensor data is crucial for developing a system for additional data categories that already exist. As real-time and natural data are being used, the solution would be to use unsupervised learning approaches. In addition, the data that is provided is not labelled. Creating a method to demonstrate any abnormalities in the results is the objective. If a difference is found, the study identifies the pit situation and the place whose data is being examined. A machine learning approach may then be used to evaluate the data and look for odd patterns.

With regard to the target data, the project employs the One-Class SVM technique. When compared to unlabeled data, the algorithm that is employed performs better. Finding the judgement surface across the data is done using the one-class method. Support vector machines (SVMs) are powerful yet flexible supervised machine learning algorithms which are used both for classification and regression. They are extremely popular because of their ability to handle multiple continuous and categorical variables. The main goal of SVM is to divide the datasets into classes to find a maximum marginal hyperplane (MMH). In simple words, kernel converts non-separable problems into separable problems by adding more dimensions to it. It makes SVM more powerful, flexible and accurate.

Kodular is a free online development platform for mobile applications. It primarily offers an online drag-and-drop Android app developer that allows anybody to create any type of app without having to write a single line of code. Many sensor and label blocks are used to display the sensor values. The Kodular interface and the blocks arranged are shown in Fig3.

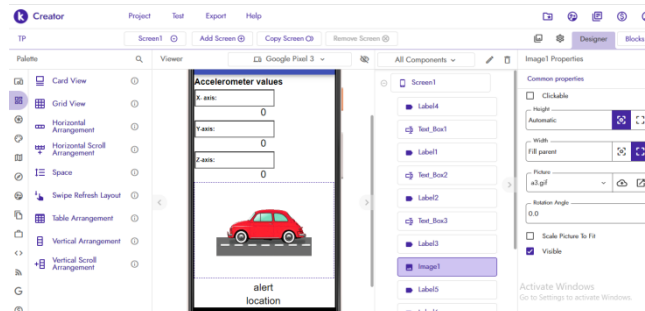


Fig3. Kodular Interface

When an accelerometer detects a pit, a notice is sent to the user's telegram account with the GPS position as well as a photo of the pit. The notifications sent to the given telegram account and Kodular mobile application.

Analysis & Discussion:

The suggested model collects 3-axis accelerometer data for roughly 445.375 seconds, and the data obtained consists of 5595 samples with x, y, and z axes values and the time duration. Given that the data were gathered in.csv format, the 3-axes data were then used to plot against time as shown in Fig4, to determine the mean and standard values of the data as shown in Fig5.

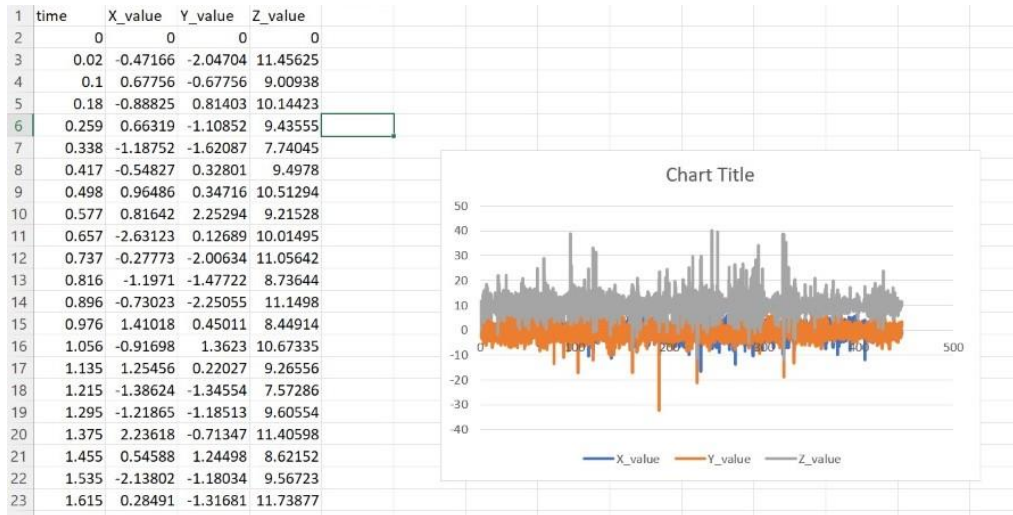


Fig4. 3 axes data plotted from the csv file

| | time | X_value | Y_value | Z_value |
|-------|-------------|-------------|-------------|-------------|
| count | 5595.000000 | 5595.000000 | 5595.000000 | 5595.000000 |
| mean | 222.651268 | 0.212467 | -0.360978 | 9.665951 |
| std | 128.593922 | 2.228826 | 3.006775 | 3.455312 |
| min | 0.000000 | -16.558300 | -32.352850 | -12.057200 |
| 25% | 111.336000 | -1.028310 | -2.337940 | 7.778760 |
| 50% | 222.645000 | 0.296880 | -0.555450 | 9.473860 |
| 75% | 333.937000 | 1.575380 | 1.413775 | 11.206060 |
| max | 445.375000 | 17.161640 | 17.379510 | 39.873040 |

Fig5. Data description obtained through python programming

Conclusion

This paper proposes a solution to help the Government authorities, as with traditionally where human workers personally check for road condition can be avoided and make it easier and automatic when a vehicle passes through a pit. Once the road maintenance authority receives the data, prioritization is done and the most affected area is recovered first and also notifies the location of the roads which are in verge of severe damage. Identifying the pits with the help of sensors would be useful enough for road management to operate and implement at low cost. As part of a smart city initiative, the system might be

valuable. In further studies, the IoT-based data classification algorithms can also assist the system adapt to changing elements like road conditions and vehicle types.

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