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Pothole Detection and Reporting System

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Abstract: ***Potholes on roads are the major problem for citizens acting as pedestrians as well as drivers. Government bodies which consist of engineers and workers are responsible to detect damages on roads and fix those damages. A recent study stated that every year around 3,597 people die due to potholes. The size and depth of the pothole may vary in a different place. Potholes had to be taken seriously. This system consists of a citizen with a handheld android/ios device with internet and GPS enabled, gathering the data in form of images and reporting to the government along with Geo-location. The study focuses on collecting and analyzing the datasets of potholes that are clicked by the users and detection of a pothole in that image via the TensorFlow Lite Model. The object detection system TensorFlow Lite is used for detecting the potholes, it shows that we can identify potholes from images clicked by the citizens and uploaded by the same application on the server and if a pothole is detected it ensures the complete reporting to the municipal authority along with the location.***

Index Term: Potholes, Android, GPS, Geo-location, Tensor- Flow Lite, Datasets, Reporting.

I. INTRODUCTION

Transportation by road is fairly easy, comfortable and cost- saving although the condition of the road decides the comfort of the ride. Potholes on the road are a major issue for people who travel with vehicles or public transport as well as for pedestrians. Potholes become a menace for the drivers as they face accidents and it also leads to vehicle damage. A recent study found out that every year around 3,597 people die due to potholes. More than 30 percent of people die due to potholes. The Ministry of Road Transport and Highways provided figures that over 9300 deaths, 25000 injured in the last three years due to potholes and more than 25,000 people are getting injured due to potholes. The potholes have got to be repaired to form a ride conve- niently. Potholes are taken care of by Municipal Authorities of the city, for that, we are developing a mobile application in which user must have authorize before reporting a complaint, after successful authorization user can add a report of potholes and a marker will be added to the google maps, the image was taken by the user will be given to the TensorFlow Lite model which will detect whether pothole is detected or not after that only user can submit report. We have also implemented a dashboard for the government so that they can remove that report after taking necessary actions. Cloud Firestore is a cloud-hosted, NoSQL database that mobile and web apps can access directly via a native software development kit, so the complaint reported by the users will be stored in our database which has collected and documents, you can store data in documents that contain fields mapping to values, in our project the documents will be a FAQ, Reports, Users, etc. These reports are stored in the form of data collections, which are containers for documents that we can use to organize data and build queries. The solution for the current manual technique of reporting system consists of a deep learning model which is used for the detection of potholes on the road this model runs on mobile devices and uses the camera of this device for detection and later visualize a location of a pothole on the map using a mobile application. Dataset is used by preparing and analyzing it for the training phase. The dataset consists of data in image form generally collected from an open dataset of Kaggle and other sources also captured by us from Mumbai city. Reporting of the pothole will be done by citizens and municipal authorities can take action on this report by locating potholes with the assistance of the map.

II. RELATED WORK

A. An Intelligent Pothole Detection System by using Deep Learning

The paper aims at proposing a pothole detection system to provide a solution for both municipal authorities and citizens to reduce the number of potholes by developing an application for mobiles. The application has two major functionalities: First, for detection and gathering of data mainly for the local municipal body's usage and the other is the view of the gathered data on a map which is helpful for both citizens and municipal authorities.

B. Real Time Pothole Detection using Android Smartphones with Accelerometers

This paper describe a mobile sensing system for road irregularity detection using Android OS based smartphones. Selected data processing algorithms are discussed and their evaluation presented with a true positive rate as high as 90 percent using real-world data. The optimal parameters for the algorithms are determined and the recommendations for their application are described.

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C. The Pothole Patrol

This paper describe an application of mobile sensing: detecting and reporting the surface conditions of roads. It describes a system and associated algorithms to monitor this important civil infrastructure using a collection of sensor- equipped vehicles. This system, which is called as the Pothole Patrol (P2), uses the inherent mobility of the participating vehicles, opportunistically gathering data from vibration and GPS sensors, and processing the data to assess road surface conditions.

III. POTHOLE DETECTION AND REPORTING SYSTEM

The proposed solution aims to provide a solution for both municipal authority and the citizens to reduce the number of potholes by developing an application for mobiles and dashboard for municipal authority. The entire design of the system is based on the integration of various libraries and frameworks. A mobile application, APIs to provide insights from data gathered, an object detection model to precisely detect the potholes and a cloud storage solution to store and handle various forms of data. The application has two major functionalities. First, for detection and gathering of data mainly for the local municipal body's usage and the other is the view of the gathered data on a map which is helpful for both the authorities responsible for maintenance and also for citizens of the locality to be aware of their surrounding roads.

A. Design of the System

1) Mobile Application: In our mobile application, we have four interfaces.

a) Authentication: In our application only authorized users can fill the report for the potholes. The Application Authentication allows users to enter their credentials and store them in the application server password cache so that they are not prompted when they next run an application on that application server.

b) Report Complaint: In this interface, users can fill the form and submit the pothole report to the system. Here the user will get two options: First is the user will capture the image or upload the image of the pothole from the gallery and then the system will detect the potholes in the image. If a pothole is available in the image then that report mark as valid and able to submit and if the pothole is not detected then that report will mark as invalid and unable to submit. There are many fields available for users such as pothole type, depart- ment, address, landmark, comment, username, email, and phone number to submit the complaint or report.

c) Maps: Here Map will be shown with the pothole marker plotted. There are different colours of marker available as per the type of potholes if the pothole is more dangerous then it will be marked as red colour on maps and if the pothole size is medium then the marker colour will be yellow and if the pothole size is small than it will mark as green colour. Users can get the information and directions of the pothole by clicking on a marker on the map.

d) FAQs: In this section, users can get all frequently asked questions such as how to use the app, how to submit a report etc. All FAQs are stored in our database and fetched to the app.

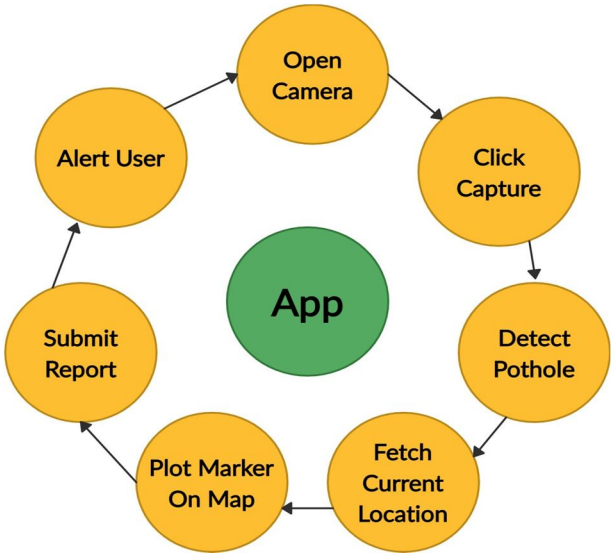

Fig. 1. Application Workflow Diagram

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2) *Web Dashboard:* The web dashboard is available only for the Government body like Municipal Corporation. So The admin from the government sector can access the web dashboard. Admin can login to enter the system. Admin will get the map view of the web dashboard in which markers are available of all nearby available potholes. Admin can get the information of potholes like name of the reporter, address of pothole, landmark, comment, location, etc. Government can take appropriate action on the pothole. And if potholes are recovered in the future then the admin can delete the report of a particular pothole from the database.

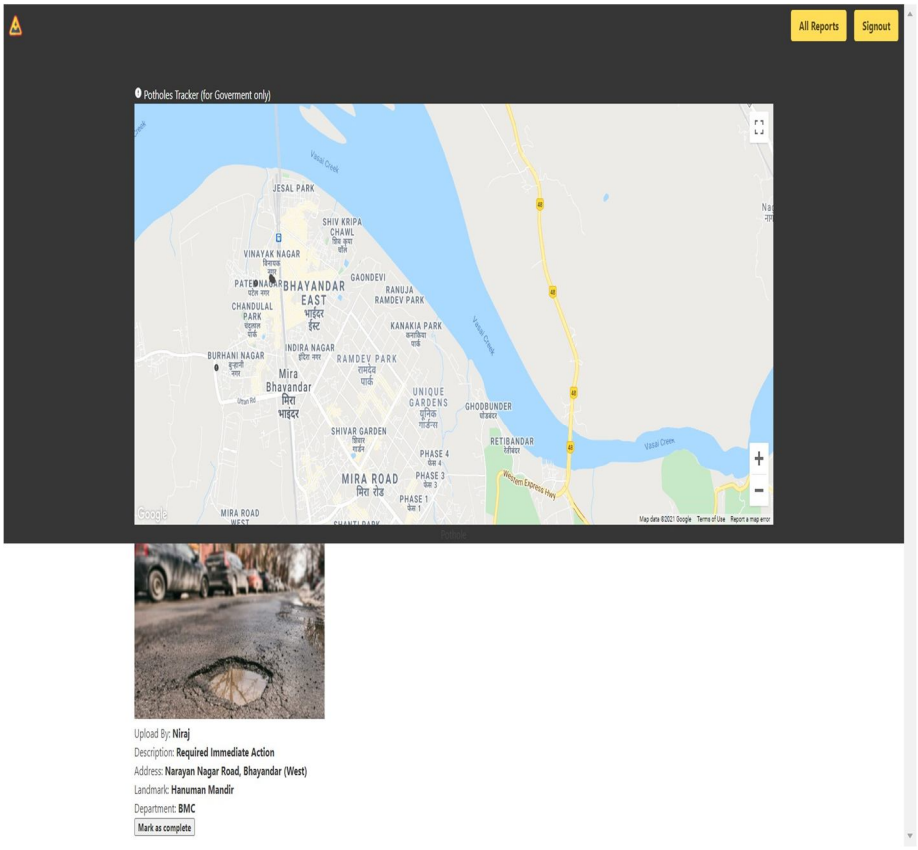

Fig. 2. Admin Web Dashboard

3) *Database:* Data gathered through all the mentioned procedures are not in a structured format, and we have to use a real-time database that can store information of potholes and also credentials of users. Therefore, we have used the Firestore NoSQL data model. NoSQL form of database that can deal with huge amounts of data faster than ordinary databases. Firebase is a cloud storage solution provided and hosted by Google which is a NoSQL form of database that stores data in a JSON file format. To have reliable synchronization within the server to feed in live data, such as the images of roads with potholes, the number of potholes, locations as latitude and longitude. So, by the real-time database, we can use the same databases to our web dashboard. APIs provided from Firebase itself allow HTTP requests to the cloud storage which helps in performing various operations on the database such as insert, update, delete. Also, integration with Firebase using Flutter or other mobile development platforms becomes effortless since both the platforms are created by the same parent organization.

B. Study of the Dataset

The main engine behind this application and database is the dataset, the dataset is trained using the YOLOv3 model. The study of the dataset is divided into four parts:

1) *About the Dataset:* The dataset for training constitutes thousands of images for training and hundreds of images for testing the model developed. Kaggle provides a public dataset of roads that contain images of potholes. This dataset consists of repetitive images which need to be filtered out. Using python and OpenCV, we also reduced the resolution of images and labeled all the images of potholes in the datasets.

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Fig. 3. Live pothole detection using App

The Fig-3 shows the self-captured image from the streets of Mumbai containing potholes which are combined with the available pothole dataset as shown in Fig-4 to give the dataset a wide spectrum of images. To make the dataset unique and versatile, web scraping is performed. Using various keywords for search, 1000 images were extracted. But, since searches using different keywords provide the same images sometimes, manual identification and removal of such images were performed. The scraped images were merged with the dataset. A label image was used to label the potholes from images according to the YOLO requirements.

Fig. 4. Image from available Dataset

2) *Description of the Dataset:* There are 2 categories in the dataset namely plain and trained. Both datasets have images that are positive and negative. Positive denotes the fact that the road contains one of the multiple potholes whereas negative will denote that the image doesn't contain any kind of potholes in it. But training a model in YOLO does not require partition of images in the dataset and hence a 60-40 ratio of images from the positive and negative images were taken from the files into the final dataset.
3) *Analyzing the Dataset:* Python is used to collect and process the final pothole dataset for our system. A common file format is used to convert all the images into the same extension. Since the dataset had taken images from the web it consisted of multiple repetitive images in a row, images in the final dataset have been taken with less redundancy of images. This ensures that the final dataset has less redundancy. The images selected have a common characteristic in them i.e. the size and the width of the pothole. So, to filter out the other unwanted parts of the image, cropping of images is done using a simple python program.

Fig. 5. Pothole labelling using OpenCV

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4) *Object Detection using TensorFlow Lite:* With multiple images being captured, it becomes essential that the object detection model detects potholes in the least amount of time. YOLOv3 (You Only Look Once ver.3) improves operation speed which meets real-time requirements for detection. In our application we have given two options: first is to capture an image through mobile and the second is to upload an image through a gallery, the model will detect whether pothole is available or not and give an accuracy of potholes if a pothole is detected then and then an only report will be submitted. TensorFlow Lite is a set of tools to help developers run TensorFlow models on mobile. It enables on-device machine learning inference with low latency and small binary size. To make the object detection model mobile-friendly, the model is converted to a TensorFlow lite model, which compresses the neurons in the neural network. This will make the model run efficiently on mobile devices. Fig-5 shows the detection of potholes that have been implemented.

IV. CONCLUSION

The paper showcases our work performed to train an object detection model capable of detecting potholes. The collection of images for the dataset to train the model consists of a mixture of Nienaber Pothole Dataset and self-captured images of potholes. TensorFlow Lite, a CNN which is capable of func- tioning on a mobile device is trained to be used as the object detection model. Furthermore, a design was introduced for the Pothole Detection System which uses a mobile application to detect potholes and represent on maps using markers with APIs from Google and other third-party resources. Using the application with the plotted information, the municipal body can see the potholes with the using marker on the map and the municipal body can repair the pothole and take necessary actions.

V. FUTURE SCOPE

We have divided our project into small modules. As the project implementation is done with respect to those modules. We further wish to test all of these modules and also integrate them into one. So as to make the final output as sound. We also wish to increase the accuracy and quality of detection. To detect the potholes the model should have enough datasets available. The research for the detection of potholes accurately is in process. We have to integrate all the modules and then add other features like Alert system, Leaderboards, In-app Map and Chatbot Assistant. We also intend to do testing in the next semester. Real-time testing with all possible inputs to make our model more accurate and more feasible with real-time users.

VI. ACKNOWLEDGMENT

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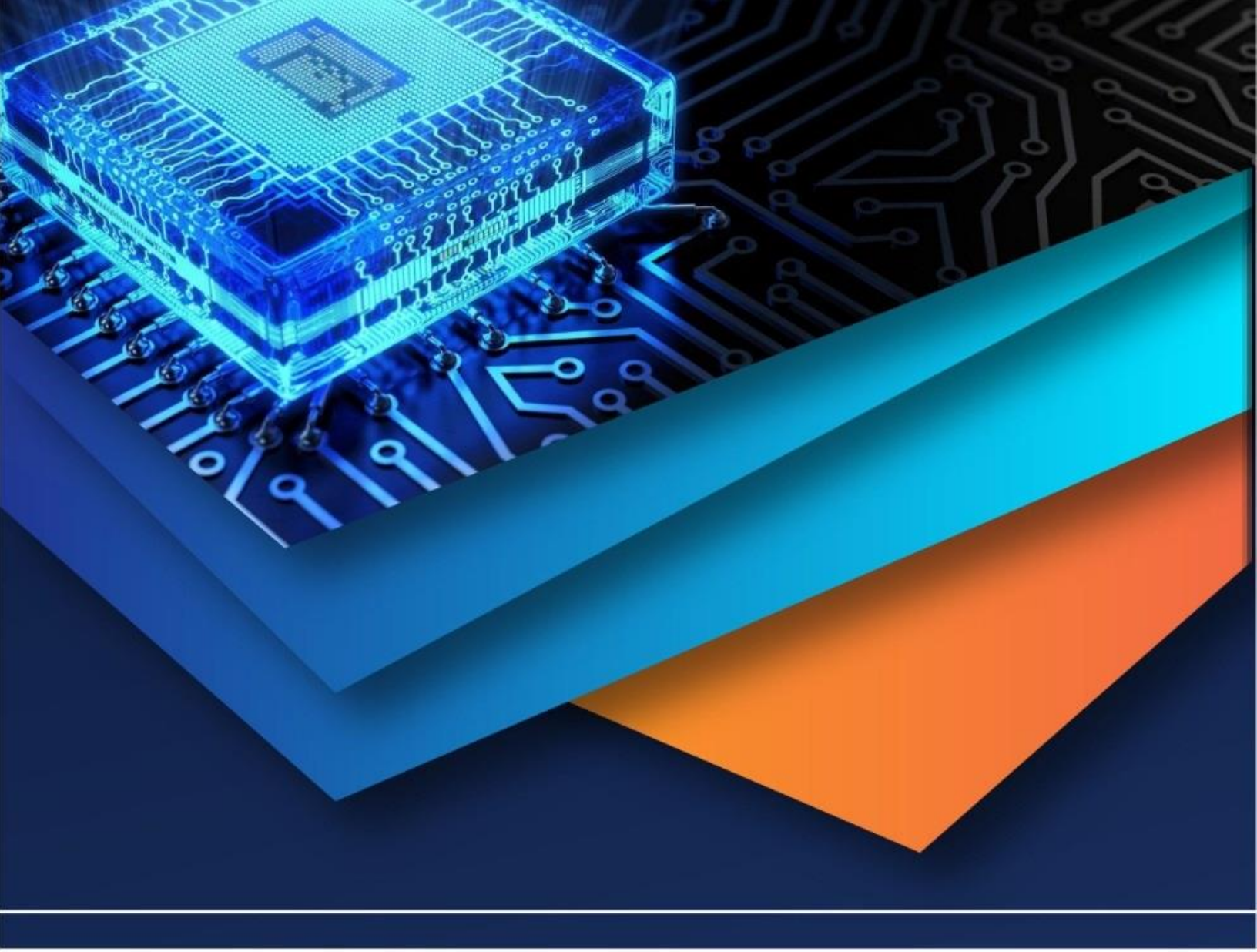

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