**A**

**PROJECT REPORT**

**ON**

# "ROAD HEALTH MONITORING SYSTEM"

**SUBMITTED IN PARTIAL FULLFILLMENT OF THE**

**REQUIREMENTS OF DEGREE OF**

**BACHELOR OF ENGINEERING**

**BY**


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**UNIVERSITY OF MUMBAI**


**[2022-23]**

Mahatma Education Society's

# Pillai HOC College of Engineering and Technology, Rasayani-410207

## 2022-23

## Certificate

This is to certify that the project entitled **"Road Health Monitoring System"** is a bonafide work of **"Kaushal Bhoir (BE_B_02), Sujwal Latke (BE_B_14), Sarafaraj Shah (BE_B_47)"** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of **"Undergraduate"** in **"Computer Engineering"**.

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# Project Report Approval for B. E

This project report entitled **“Road Health Monitoring System”** by **“Kaushal Bhoir (BE_B_02), Sujwal Latke (BE_B_14), Sarafaraj Shah (BE_B_47)”** is approved for the degree of **Bachelor of Engineering in Computer Engineering**.

## Examiners

1.______________________________

2.______________________________

Date:

Place:

# Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included. We have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

____________________________

Mr. Kaushal Bhoir

____________________________

Mr. Sujwal Latke

____________________________

Mr. Sarafaraj Shah

Date:

# Abstract

*The goal of our project is to design a Pothole detection System which assists the driver in avoiding potholes on the roads, by giving him prior warnings which can be like a buzzer or series of LED, which will warn the driver in advance regarding road pothole. The scope of the project lies , where the irregularity of the road affects public people. This can be used in 4 wheeler , especially for ambulance drivers so that they could save many lives in time. The importance of road infrastructure for society could be compared with the importance of blood vessels for humans. To ensure road surface quality it should be monitored continuously and repaired as necessary. One of the major problems in developing countries is the maintenance of roads. Well maintained roads contribute a major portion to the country's economy. India is the vast country in the world that does not have proper maintenance of the road, over 95% of the people use road transportation. Due to this peak usage of road transports, there are many possibilities of potholes on roads which lead to accidents. Other major reasons for accidents are due to the head on head collisions. Potholes are an unavoidable obstacle that every motorist in India faces mainly during the rains, To solve this problem, various techniques have been implemented ranging from manual reporting to authorities to the use of vibration-based sensors. But all these techniques have some drawbacks such as the high setup cost, risk while detection, or no provision for night vision. Hence, we have come up with a project that could help people most conveniently. The main idea is to detect and notify the potholes possibly without human intervention. To achieve our goal we are using AI-enabled cameras and object detection API that help in detecting the potholes. This collected data can be used by the motorist to avoid accidents.*

**Keywords:** *Pothole, Buzzer, LED, Road, Accident, Vehicle, AI, ML, Camera.*

# Abbreviations

1. RAM – Random Access Memory
2. API – Application Programming Interface
3. AI – Artificial Intelligence
4. ML- Machine Learning
5. LED- Light Emitting Diode
6. GPS- Global Positioning System

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# Chapter 1

# Introduction

# Chapter 1
# Introduction

What do most of big cities have in common? They are all expected to spend enormous sums on various smart city initiatives. Road infrastructure has not stayed away from innovation.
About one-third of Pittsburgh's intersections will be equipped with smart traffic signals in the coming years; sensors at the intersections determine traffic volume and adjust stop-and-go times based on the number of vehicles present. Since the project's inception, wait times at intersections are down by 41% and vehicle emissions have been reduced by 21%. [2] The city of Dallas is also currently implementing an IoT-enabled traffic management system in hopes of better managing road congestion. But despite common opinion, the search for the most convenient route does not always correspond to the search for the shortest route, especially when you are planning to go on a road unknown to you.[7] It may turn out that the road you have chosen is in poor condition, so the trip will be less convenient and the time spent will increase significantly. All countries around the world suffer enormous losses due to road damage every day.
Firstly, millions are spent on repairing and "patching" damaged sections of roads. [5] Secondly, driving on uneven surfaces increases the amount of fuel consumed and more often leads to the need for maintenance.

## 1.1 Background

We believe that an automated approach for detecting potholes with little or no human interaction is more promising. This would ensure more comprehensive survey data with fewer errors caused by human factors than generated by themere enthusiasm of participants. Moreover, the productive pavement surveying process significantly leads to economic gain. It is because, if the rehabilitation process is performed timely, pavement restoration cost can be saved by up to 80%.

## 1.2 Relevance

Road health monitoring systems are highly relevant in today's context due to their potential to improve road safety, enable cost-effective maintenance, enhance transportation infrastructure, improve operational efficiency, support smart city integration, and promote environmental sustainability. These systems have the potential to significantly impact road management practices, leading to safer, more efficient, and sustainable road networks for the benefit of all road users and communities.

## 1.3 Organizations of Report

- **Chapter 1:** The following section, “Literature Survey”, explains to gain an understanding of the existing research and debates relevant to ways to implement I/ADS (Intrusion / Anomaly Detection System) for Road Health Monitoring System.
- **Chapter 2:** The section, “Requirement Gathering”, states the system hardware and software requirements needed to run the project. This is an important part of the project as if the project is run on a lesser system environment the project may not work so well.
- **Chapter 3:** The section, “Plan of Project”, gives a summary of the project architecture and also tells about the methodologies used while implementing the project idea. It also tells us about the working of the project.
- **Chapter 4:** The “Project Analysis” section talks about the assessment of every expense or problem related to a project, prior to the commencement of work on it and an early phase of the project lifecycle where ideas, processes, resources, and deliverables are planned out respectively.
- **Chapter 5:** The “Project Design” section in a report is a detailed description of the proposed project, including a management plan and methods for quantifying the proposed project and shall include all appropriate, relevant and required documentation and materials necessary for the validation of the proposed project requirements.

# Chapter 2

# Literature Survey

# Chapter 2
# Literature Survey

## Table 2.1: Summary Table

| Ref. No. | Paper Title, Publication (Year) | Authors | Merits | Demerits |
|---|---|---|---|---|
| 1. | Pothole Detection System Using Yolo V4 Algorithm (2022) | Kshitija Chavan, Chinmay Chawathe, Vatsal Dhabalia, Amruta Sankhe | Very quick to improve. Not affected by noise | May be subject to false positives and false negatives. |
| **2.** | Detection of Roads Potholes using YOLOv4 (2021) | Mohd Omar, Pradeep Kumar | Improved signal to noise ratio with a better detection with noise. Quick response time. | Sensitive to noise. May be inaccurate |
| 3. | Pothole Detection System using Artificial Intelligence (2020) | CH. Venkateswara Rao1, M Pavani2, Md Riyazuddin Ahammed3, D Sunil Varma4,P Bhami Reddy | Very quick to compute. Response time is fast. | Noise Sensitive |
| 4. | Automatic Pothole Detection System (2019) | S Gayathri, Mamatha RG, Manasa B | Quick Response Time | Cannot detect objects at distant. High Complexity |

| | | | | |
|---|---|---|---|---|
| 5. | Pothole Detection using Machine Learning (2018) | Hyunwoo Song, Kihoon Baek and Yungcheol Byun | Simple detection of edges and their orientation. Detect object at distance | May not detect all objects |
| 6. | Real-Time Pothole Detection Using Deep Learning (2017) | Anas Al-Shaghouri, Rami Alkhatib, Samir Berjaoui | Detects nearby objects. | Produce false reading. Accuracy affected by sunlight. |

## 2.1 Related Work

The YOLO (You Only Look Once) algorithm is a popular object detection algorithm that has been applied to various domains, including road health monitoring. Here are some examples of related works that utilize the YOLO algorithm for road health monitoring:

1. "Real-Time Road Damage Detection and Classification Using YOLO Neural Network" by Andrychowicz et al. (2018): This study proposes a real-time road damage detection and classification system using the YOLO neural network. The authors trained a YOLO model on road images to detect different types of road damages, including cracks, potholes, and patches. The proposed system achieved high accuracy in real-time road damage detection, demonstrating the effectiveness of the YOLO algorithm for road health monitoring.

2. "Real-Time Road Surface Defect Detection Using YOLOv2" by Das et al. (2019): This work presents a real-time road surface defect detection system using the YOLOv2 algorithm. The authors used road images and trained a YOLOv2 model to detect road defects, including cracks, potholes, and patches, in real-time. The proposed system achieved high accuracy and real-time performance, highlighting the potential of the YOLOv2 algorithm for road health monitoring.

3. "Deep Learning-Based Road Damage Detection Using YOLOv3" by Gautam et al. (2020): This study proposes a road damage detection system using the YOLOv3 algorithm. The authors trained a YOLOv3 model on road images to detect different types of road damages, including cracks, potholes, and patches. The proposed system achieved high accuracy in road damage detection, showcasing the effectiveness of the YOLOv3 algorithm for road health monitoring.

4. "Real-Time Road Crack Detection and Classification Using YOLOv3" by Xia et al. (2020): This work presents a real-time road crack detection and classification system using the YOLOv3 algorithm. The authors used road images and trained a YOLOv3 model to detect and classify road cracks into different categories, including transverse cracks, longitudinal cracks, and alligator cracks.

## 2.2 Existing System

- In developing countries, the pavement pothole is often detected manually by inspectors of the municipal corporation during periodic field surveys. Although this conventional method can help to acquire an accurate evaluation of potholes, it also features low productivity in both data collection and data processing. The reason is that one pavement inspector can only inspect less than 10 km per day.
- The simplest method might be to collect photos of road damage and hazards taken by the participants and to upload them to a central server.

## 2.3 Problem Statement

About 70% of the road accidents in India takes place due to improper construction of roads and due to unpredictable weather conditions in India. Need of such a safety providing system is becoming essential for current scenario.Every year we lose more than one lakh lives on Indian roads due to accidents and the proportion of the accidents due to potholes on the road is quite significant. Number of accidents are more when the potholes are covered by water during monsoon.

# Chapter 3

# Requirement Gathering

# Chapter 3

# Requirement Gathering

## 3.1 Software and Hardware Requirements

Here we will discuss everything we will need in order to execute. Below we list the necessary hardware and software requirements.

### 1. Software Requirements:

1. Visual Studio (v 1.73)
2. Operating System :
    - Windows
    - Linux
    - Mac OS
3. Chromium Based Browser
4. Python IDLE

### 2. Hardware Requirements:

1. Laptop or PC:

- Processor-Intel(R) Core(TM) i5-9300H CPU @ 2.40GHz 2.40 GHz
- RAM-8.00 GB
- System type-64-bit operating system, x64-based processor
- 15GB Free Storage Space
- 2GB VRAM

2. Camera:
    - 4MP-Minimum

# Chapter 4

# Plan of Project

# Chapter 4

# Plan of the Project

## 4.1 Methodology

For a pothole detection system, proposed methodology annotation for each image is performed explicitly after the collection of the dataset. The annotated data are split into training and testing data before passing it to deep learning models such as the YOLO family and SSD for custom model training. The weights obtained after training contribute to model performance evaluation on testing data. The custom weights are then converted into the OpenVino IR format to perform real-time detection on OAK-D and Raspberry pi as host computer

1 **Data Collection:** Gather a large dataset of road images or videos that represent various road conditions, such as cracks, potholes, and other damages. These images or videos should have corresponding labels or annotations indicating the presence and location of road damages.

2 **Data Preprocessing:** Prepare the collected data for training the YOLO algorithm. This may involve resizing images, normalizing pixel values, and splitting the dataset into training, validation, and testing sets. It's crucial to ensure that the dataset is representative of real-world road conditions and covers a wide range of road health scenarios.

3 **Model Training:** Train the YOLO model using the preprocessed dataset. YOLO is an object detection algorithm that can detect multiple objects in an image or video frame and provide their bounding box coordinates and class labels. The model can be trained using deep learning frameworks such as TensorFlow or PyTorch, and the training process involves optimizing the model's weights to minimize the prediction errors.

4 **Model Optimization:** Fine-tune the YOLO model based on the evaluation results to improve its performance. This may involve adjusting hyperparameters, increasing the dataset size, or using data augmentation techniques to enhance the model's ability to detect road damages accurately.

5 **Continuous Monitoring:** Monitor the performance of the deployed road health monitoring system on an ongoing basis to ensure its accuracy and effectiveness.

## 4.2 Project Plan (Gantt chart)

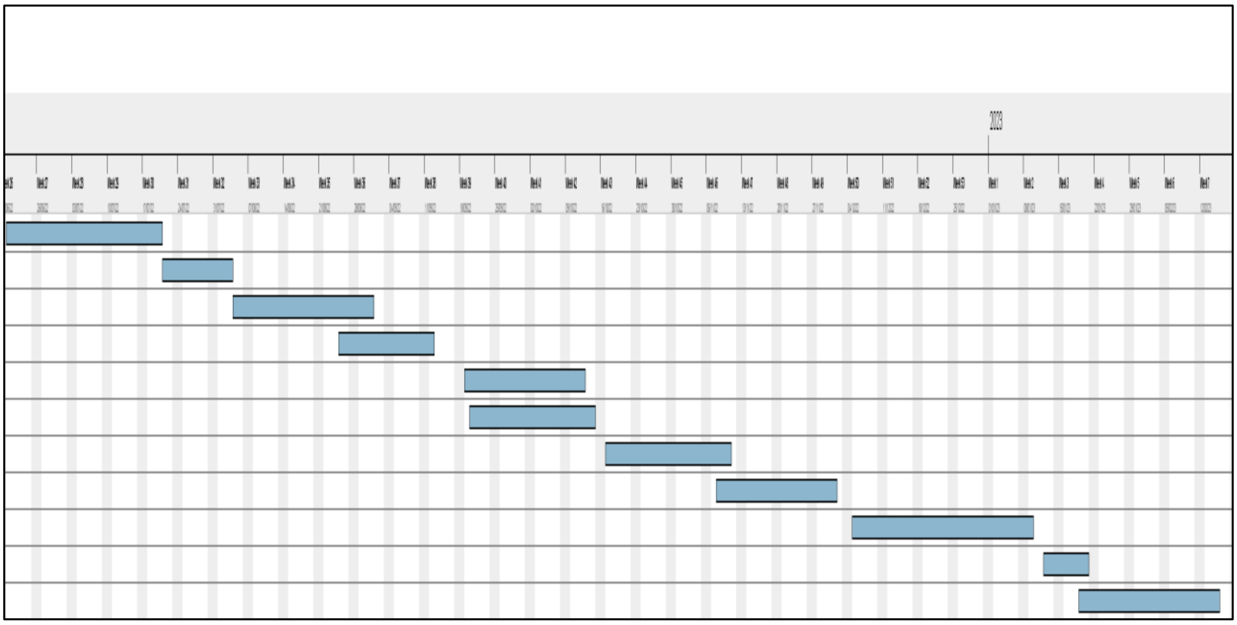

*Figure 4.2: Gantt chart*

| Task Name | Start Name | End Date |
|---|---|---|
| Topic Discussion | 20/06/22 | 20/07/22 |
| Topic Selection | 21/07/22 | 03/08/22 |
| Topic Research | 04/08/22 | 31/08/22 |
| Implementation Discussion | 25/08/22 | 12/09/22 |
| Algorithm Research | 19/09/22 | 12/10/22 |
| Neural Network Configuration | 20/09/22 | 14/10/22 |
| Model Accuracy Testing | 17/10/22 | 10/11/22 |
| Model Optimization | 08/11/22 | 01/12/22 |
| Flask App Development | 05/12/22 | 09/01/23 |
| GUI Development | 12/01/23 | 20/01/23 |
| Project Maintainace | 19/01/23 | 15/02/23 |

## 4.3 Proposed System

The potholes are considered as the objects to be detected. Deep convolutional neural networks (DCNNs) have proven their abilities for many object detection tasks. These object detectors can be one-stage object detectors or two-state object detectors. Several object detection models such as region-based convolutional neural network family (R-CNN) ,YOLO family and SSD family are available in deep learning for training. However, the R-CNN family is computationally expensive result in low latency. Conversely, YOLO and SSD are under study to supplement the responsiveness issues of the R-CNN family. Hence, we had focused on YOLO and SSD family for this problem.

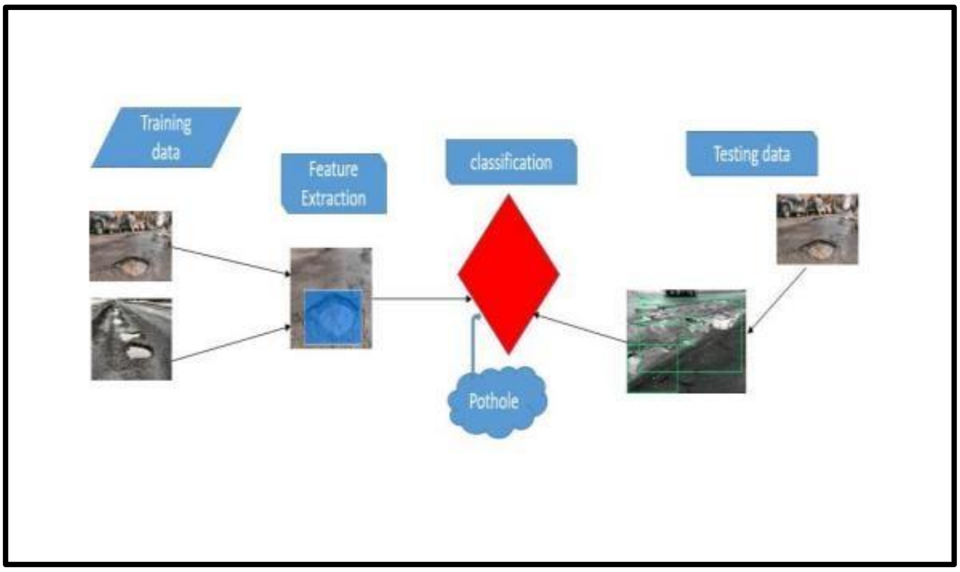


*Figure 4.3: Proposed System*

# Chapter 5

# Project Analysis

# Chapter 5 Project Analysis

## 5.1 Use case Diagram

In the use case diagram its going to identify the other types of the diagrams which are going to be accompanies by the other types of the diagrams. The use case diagram is going to give the complete details of the work. It is going to provide a higher view of the system as it is said based on the use case diagram we are going to see the real work and it provides the graphical representation and in the simplified manner it shows that how it actually works.

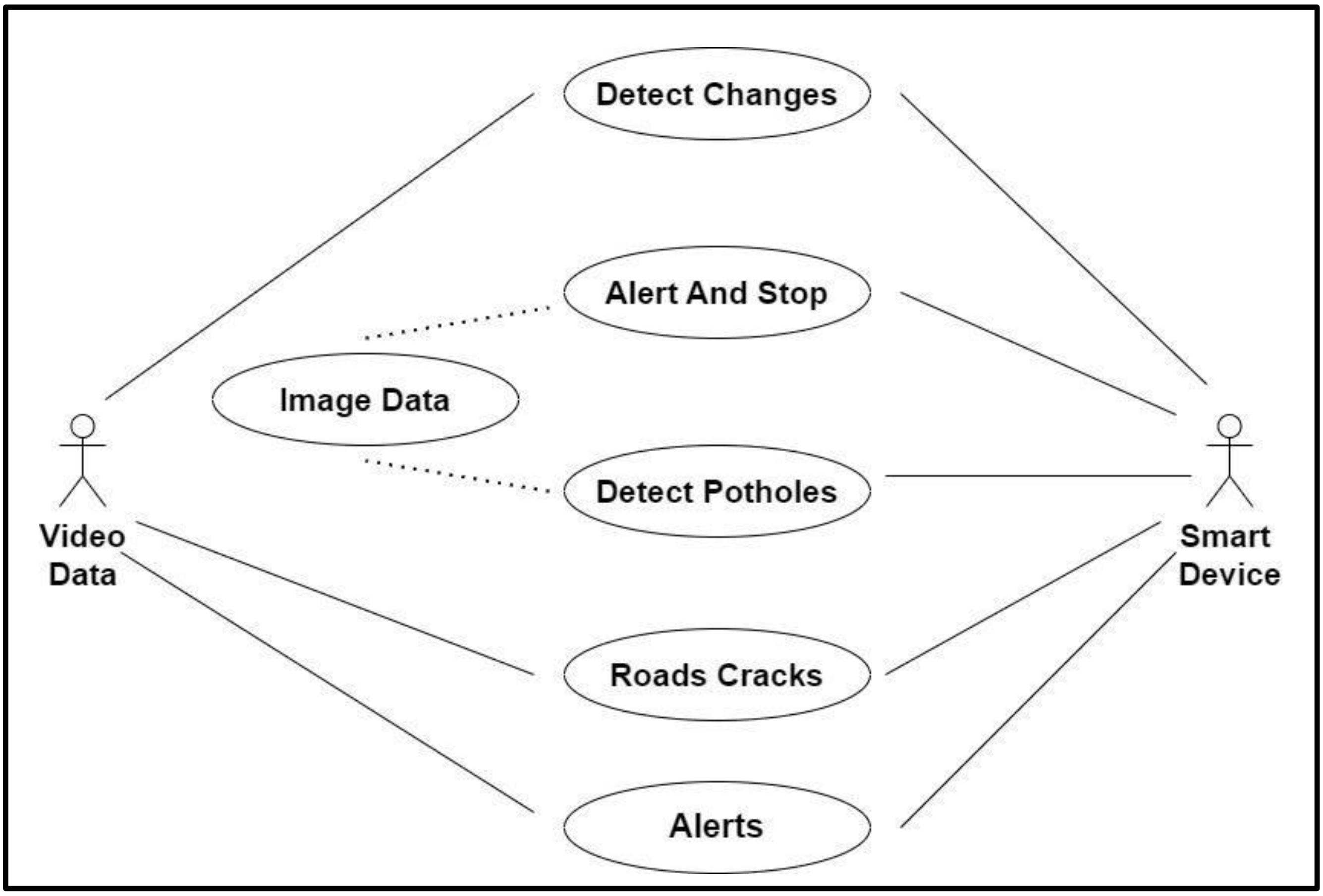


*Figure 5.1: Use case diagram*

### 5.1.1 Use Case Document

The Road Health Monitoring System encompasses the following use cases:

- **Road Condition Monitoring:**

  This use case involves collecting and analyzing data from various sources, such as sensors and cameras, to monitor the condition of roads. Data on parameters like temperature, humidity, traffic volume, and surface condition are collected in real-time and processed to determine the overall health of the road. Alerts are generated for potential issues such as potholes, cracks, or other damage that may require maintenance.

- **Predictive Maintenance:**

  This use case involves using historical data on road conditions, weather patterns, and maintenance activities to predict when roads are likely to require maintenance. Machine learning algorithms are employed to analyze the data and generate predictions, which are used to optimize maintenance activities and reduce costs. Maintenance crews receive alerts and work orders based on the predictions.

- **Reporting and Visualization:**

  This use case involves generating reports and visualizations based on the data collected and analyzed by the system. Road administrators can access dashboards that provide insights on road health, maintenance activities, and performance indicators. Reports can be generated to track road condition trends over time, evaluate the effectiveness of maintenance activities, and support decision-making processes.

- **Improved Road Safety:**

  By monitoring road conditions in real-time and identifying potential issues, the system helps road administrators take proactive measures to address hazards and improve road safety. Early detection of issues like potholes or cracks can prevent accidents and reduce the risk of damage to vehicles and injuries to road users.

- **Cost-Effective Maintenance:**

  The predictive maintenance capabilities of the system enable optimized scheduling of maintenance activities based on actual road conditions and weather patterns.

### 5.1.2 Use Case Analysis

**Road Condition Monitoring:**

Description: The system collects and analyzes data from various sources such as sensors and cameras to monitor the condition of roads in real-time. It processes data on parameters like temperature, humidity, traffic volume, and surface condition to determine the overall health of the road. Alerts are generated for potential issues such as potholes, cracks, or other damage that may require maintenance.

Actors: Sensors, Cameras, Road Administrators, Maintenance Crews

Input: Data from sensors and cameras, road condition parameters

Output: Alerts for potential road issues, real-time road health status

Benefits: Proactive identification of road hazards, early detection of issues, improved road safety, reduced maintenance costs

**Reporting and Visualization**

Description: The system generates reports and visualizations based on the data collected and analyzed. Road administrators can access dashboards that provide insights on road health, maintenance activities, and performance indicators. Reports can be generated to track road condition trends over time, evaluate the effectiveness of maintenance activities, and support decision-making processes.

Actors: Road Administrators

Input: Data on road health, maintenance activities, and performance indicators Output: Reports, visualizations, and dashboards with insights on road conditions and maintenance activities

Benefits: Data-driven decision-making, performance tracking, evaluation of maintenance effectiveness.

## 5.2 Class Diagram

A class diagram is a type of diagram used in object-oriented modeling to represent the static structure of a system or software application. It provides a visual representation of the classes, their attributes, relationships, and methods in a system. Class diagrams are part of the Unified Modeling Language (UML), which is a standard notation for modeling objectoriented systems.

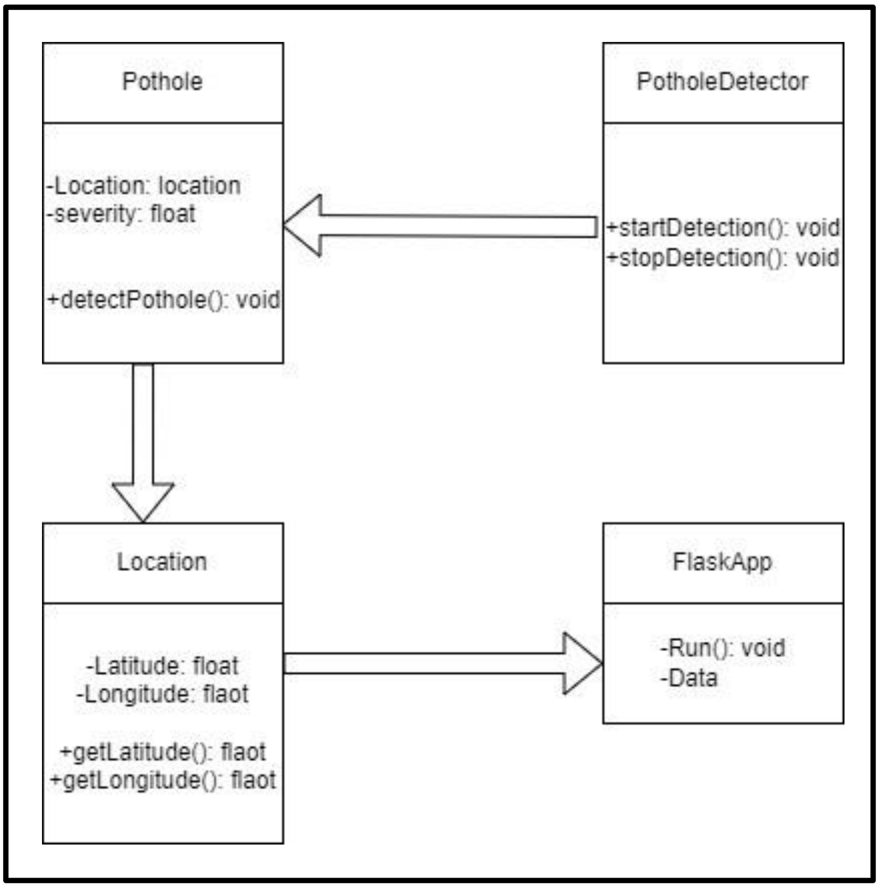


***Figure 5.2: Class Diagram***

## 5.3 Activity Diagram

An activity diagram is a type of diagram used in software engineering and business process modeling to depict the flow of activities or steps in a system or process. It is often used to model the dynamic behavior of a system or to capture the workflow of a business process. Activity diagrams are part of the Unified Modeling Language (UML), which is a standard notation for modeling software systems.

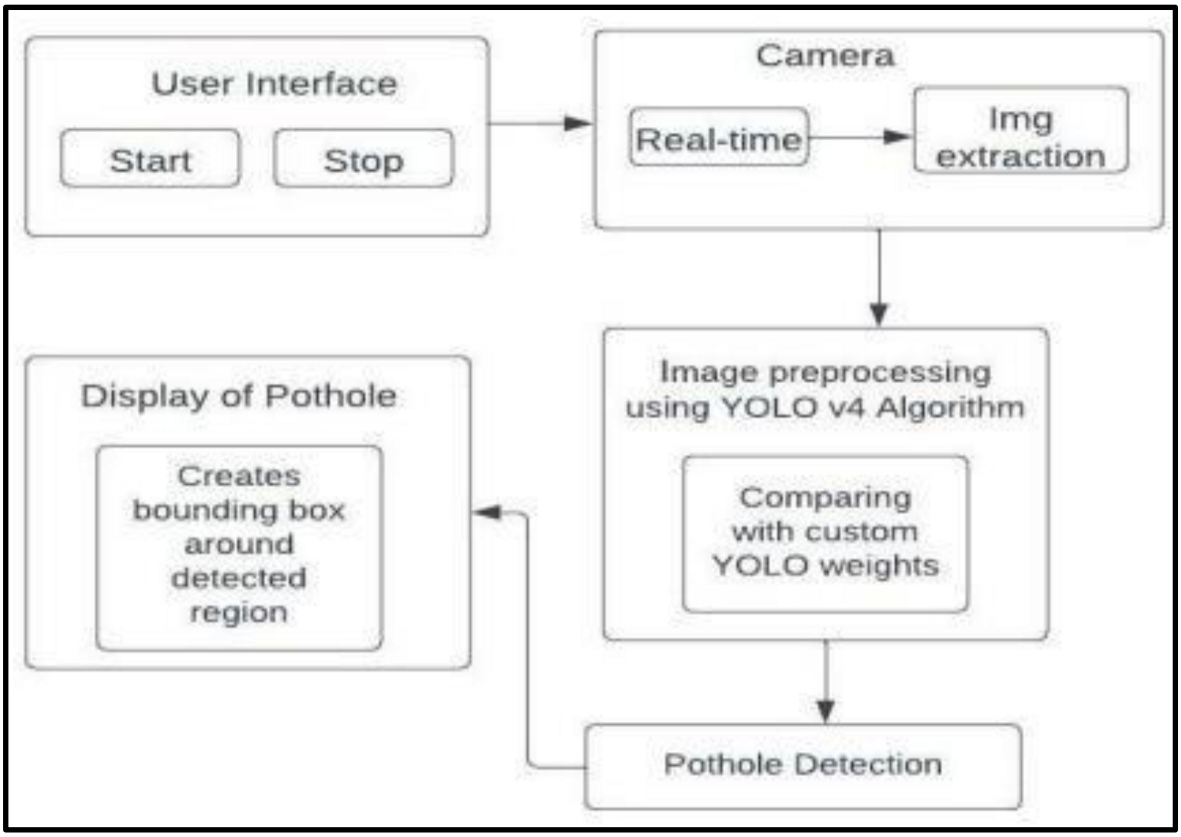


*Figure 5.3: Activity Diagram*

## 5.4 Sequence Diagram

A sequence diagram is a type of diagram used in software engineering to depict the interactions or message exchanges between objects or components in a system or software application. It represents the sequence of actions or messages exchanged between objects over time, showing the order of execution and the flow of control. Sequence diagrams are part of the Unified Modeling Language (UML), which is a standard notation for modeling software systems.

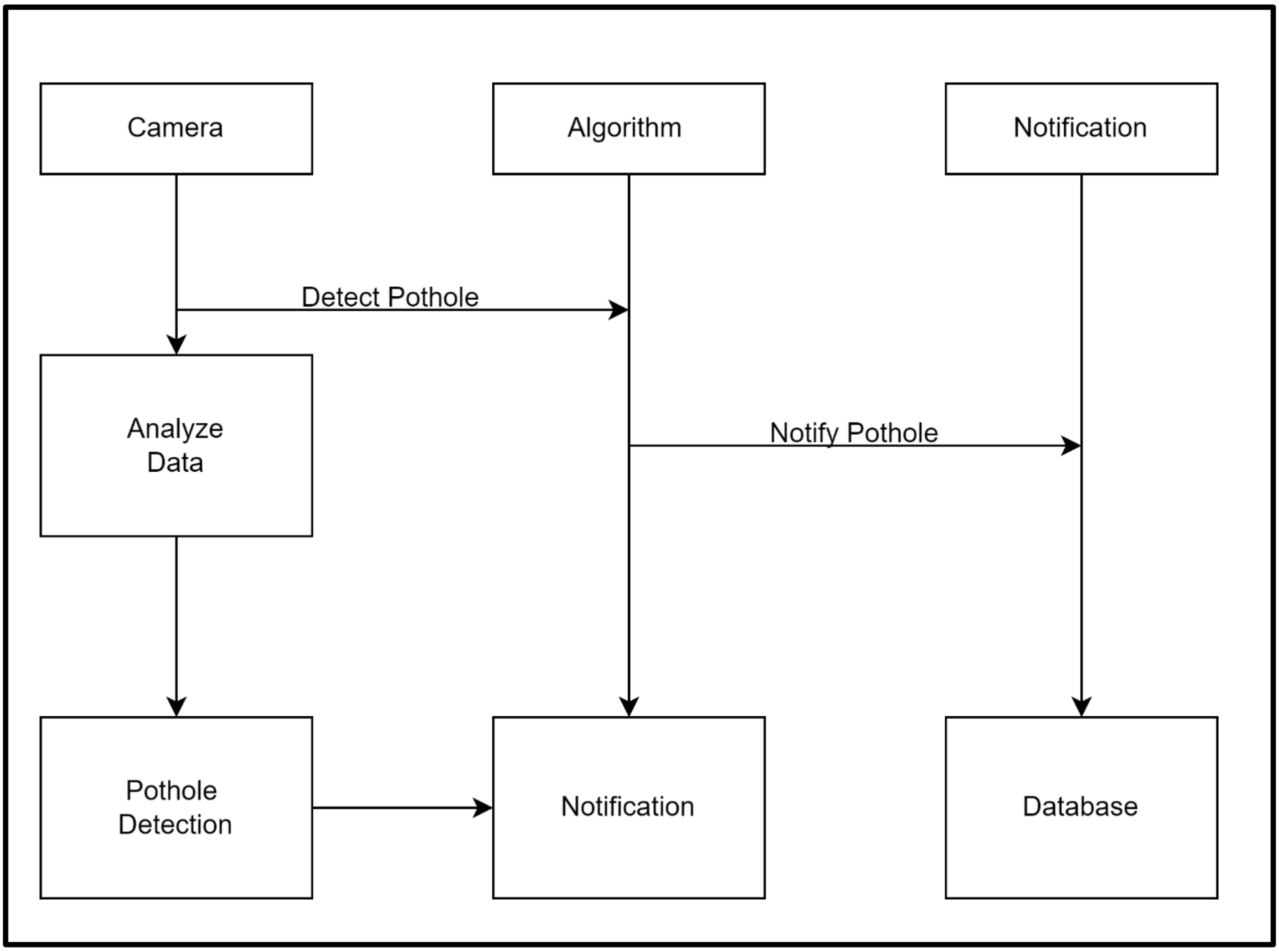


***Figure 5.4: Sequence Diagram***

# Chapter 6

# Project Design

## 6.1 Data Flow diagram

A data flow diagram (DFD) is a type of diagram used in software engineering and business process modeling to represent the flow of data within a system or process. It visually represents how data is input, processed, stored, and output within a system, showing the flow of data from one process or data store to another.

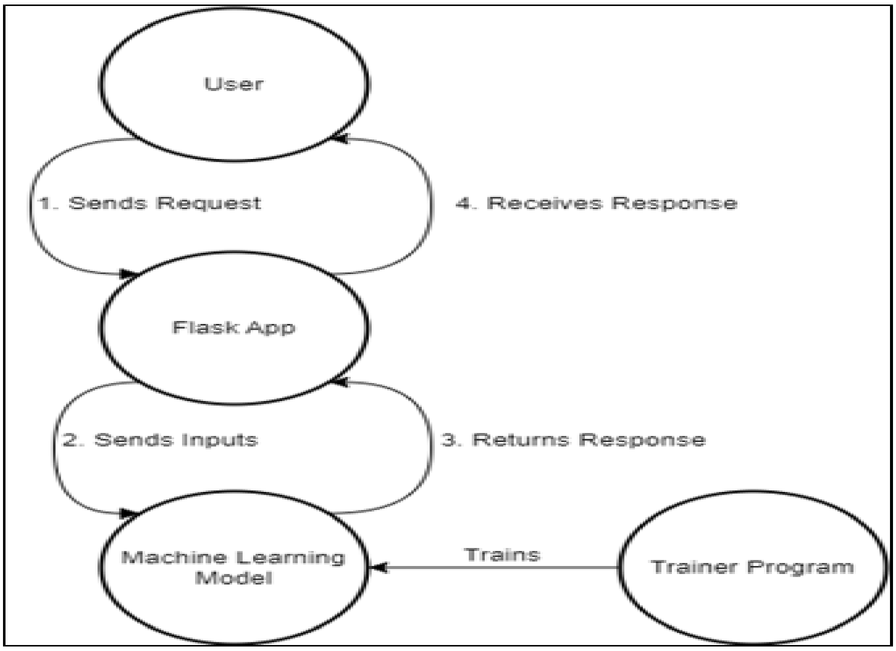


*Fig 6.1.1 DFD Level 0*

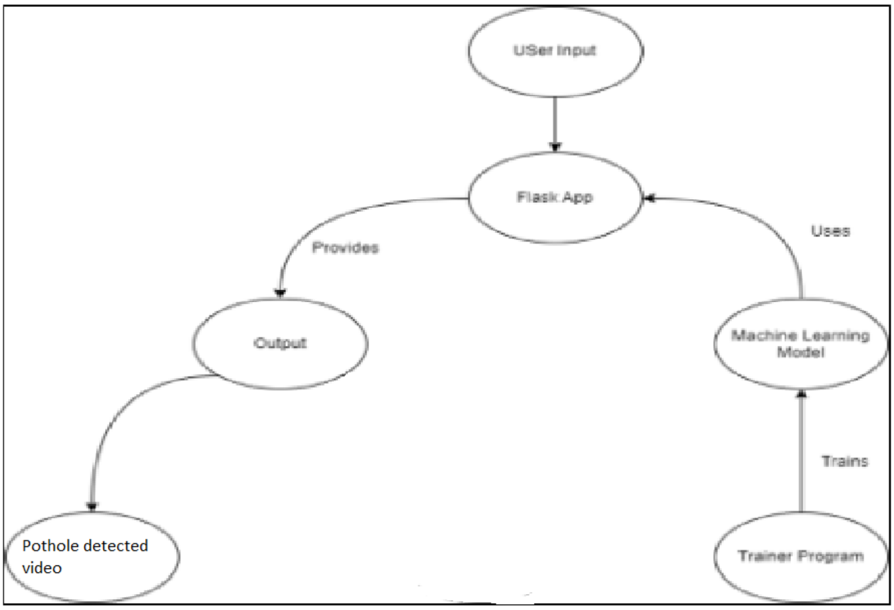


*Fig 6.1.2 DFD Level 1*

## 6.2 Flow Chart

A flowchart is a type of diagram used to visually represent the steps or processes of a system or workflow. It uses various symbols and shapes to represent different types of activities, decisions, and flows of control. Flowcharts are commonly used in software development, business process modeling, project management, and other domains to illustrate complex processes in a clear and visual manner.

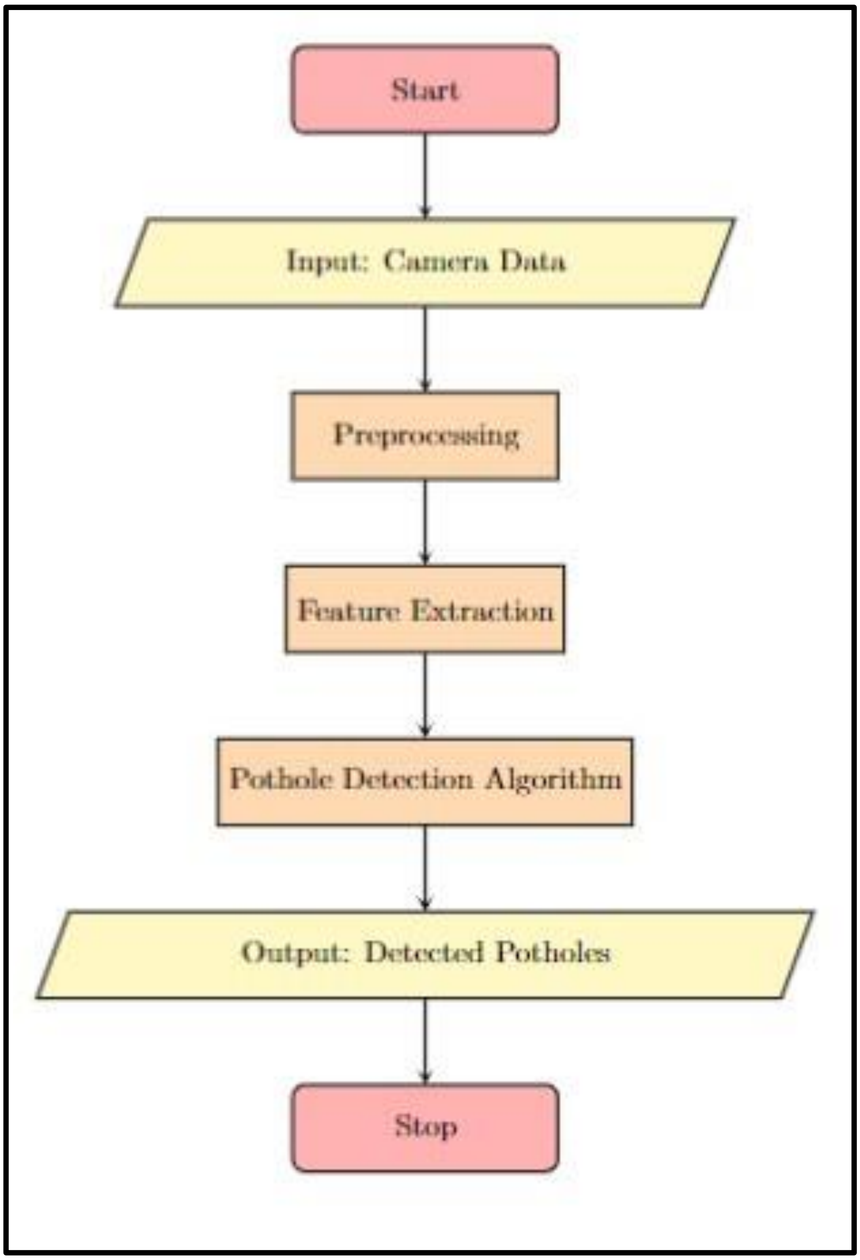


*Figure 6.2: Flow Chart*

# Chapter 7

# Implemented System

## 7.1 System Architecture

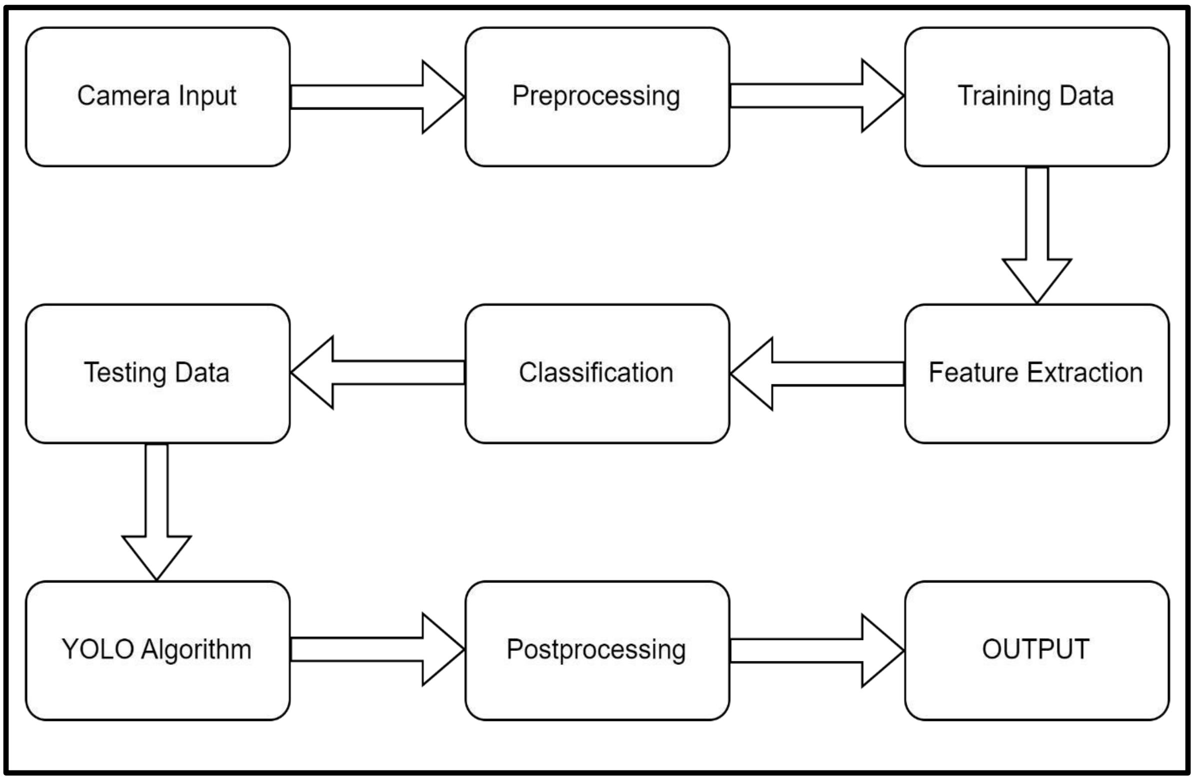


*Figure 7.1: System Architecture*

## 7.2 Sample Code

app.py > generate_frames

```python
from flask import Flask, render_template, Response
from camera import VideoCamera
import cv2

app = Flask(__name__)

camera = cv2.VideoCapture(0)

def generate_frames():
    while True:
        success, frame = camera.read()

        if not success:
            break
        else:
            ret, buffer = cv2.imencode('.jpg', frame)
            frame = buffer.tobytes()
            yield (b'--frame\r\n'
                   b'Content-Type: image/jpeg\r\n\r\n' + frame + b'\r\n')

@app.route('/video_cam')
def video_cam():
    return Response(generate_frames(), mimetype='multipart/x-mixed-replace; boundary=frame')

@app.route('/')
def index():
    return render_template('index.html')

@app.route('/base')
def base():
    return render_template('base.html')

def gen(camera):
    while True:
        frame = camera.get_frame()
        yield (b'--frame\r\n'
               b'Content-Type: image/jpeg\r\n\r\n'+frame+b'\r\n\r\n')
```

camera.py > VideoCamera > get_frame > database

```python
import cv2
import numpy as np
import winsound
import time
from location import Location, Latitude, Longitude
import mysql.connector

path = 'videos/video/pot_final0.mp4'
net = cv2.dnn.readNetFromDarknet('models/yolov4_tiny_pothole.cfg','models/yolov4_tiny_pothole_last.weights')
classes = ['pothole']

class VideoCamera(object):
    def __init__(self):
        self.video = cv2.VideoCapture(0)

    def __del__(self):
        self.video.release()

    def get_frame(self):
        ret, frame = self.video.read()
        if ret == True:
            try:
                t = time.time()
                frame = cv2.resize(frame, (800, 450), interpolation=cv2.INTER_AREA)
                ht, wt, _ = frame.shape
                blob = cv2.dnn.blobFromImage(frame, 1 / 255, (416, 416), (0, 0, 0), swapRB=True, crop=False)
                net.setInput(blob)
                last_layer = net.getUnconnectedOutLayersNames()
                layer_out = net.forward(last_layer)
                boxes = []
                confidences = []
                cls_ids = []
                for output in layer_out:
                    for detection in output:
                        score = detection[5:]
                        clsid = np.argmax(score)
                        conf = score[clsid]
```

```python
                indexes = cv2.dnn.NMSBoxes(boxes, confidences, .25, .2)
                font = cv2.FONT_HERSHEY_COMPLEX_SMALL
                for i in indexes.flatten():
                    x, y, w, h = boxes[i]
                    area = w*h//400
                    label = str(classes[cls_ids[i]])
                    t2 = time.time()
                    fps = round(1/(t2-t)) +10
                    cv2.rectangle(frame, (x-2, y-2), (x + w+2, y + h+2), (255, 0, 0), 1)
                    cv2.rectangle(frame, (x-2, y-2), (x + 60, y - 18), (255, 0, 0), cv2.FILLED)
                    cv2.putText(frame, label, (x, y - 7), font, .6, (255, 255, 255), 1)
                    cv2.putText(frame, f"area: {area} sq.ft", (x, y + 15), font, .5, (255, 255, 255), 1)
                    cv2.putText(frame, f'FPS: {fps}', (24, 30), font, 1.4, (55, 255, 255), 2)
                    ret, jpeg = cv2.imencode('.jpg', frame)

                    if label == 'pothole':
                        winsound.PlaySound('beep.wav',winsound.SND_ASYNC)


                        def database():
                              try:
                                  connection = mysql.connector.connect(host='localhost',
                                                                       database='potholedata',
                                                                       user='root',
                                                                       password='')

                                  mySql_insert_query = """INSERT INTO pothole ( Location, Lattitude, Longitude, Area)
                                                          VALUES
                                                          (%s, %s, %s, %s) """
                                  record = (Location, Latitude, Longitude, f"{area} sq.ft")

                                  cursor = connection.cursor()
                                  cursor.execute(mySql_insert_query, record)
                                  connection.commit()
                                  print(cursor.rowcount, "Record inserted successfully into pothole table")
                                  cursor.close()
```

location.py > ...

```python
import requests
from geopy.geocoders import Nominatim

def get_ip():
    response = requests.get('https://api64.ipify.org?format=json').json()
    return response["ip"]


def get_location():
    ip_address = get_ip()
    response = requests.get(f'https://ipapi.co/{ip_address}/json/').json()
    location_data = {
        "ip": ip_address,
        "city": response.get("city"),
        "region": response.get("region"),
        "country": response.get("country_name")
    }
    return response.get("city")

loc = Nominatim(user_agent="GetLoc")

getLoc = loc.geocode(get_location())

Location = getLoc.address
Latitude = getLoc.latitude
Longitude = getLoc.longitude
```

# Chapter 8

# Result Analysis

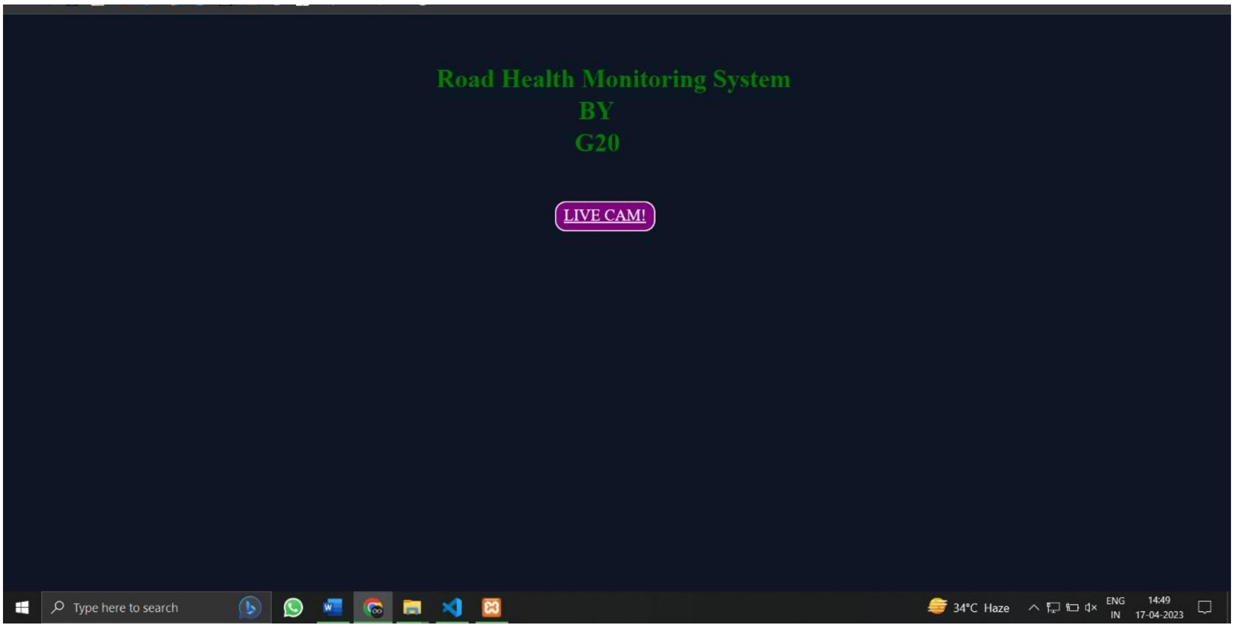


*Figure 8.1: Landing Page*

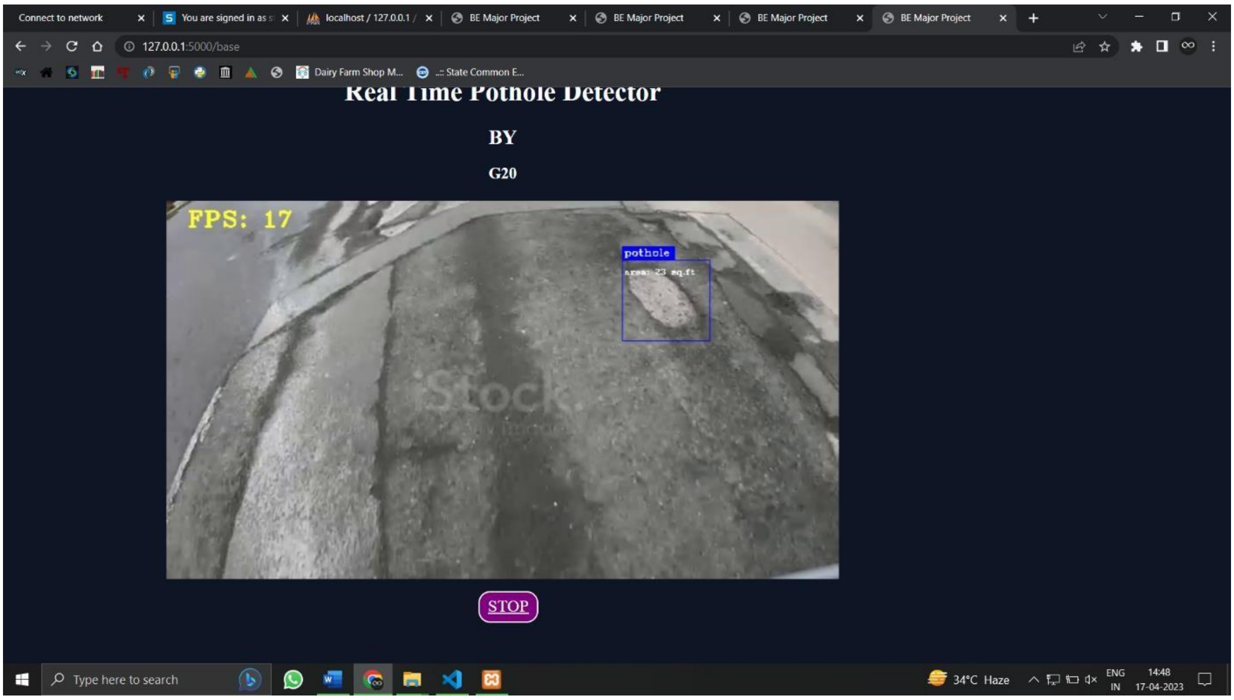


*Figure 8.2: Live camera*

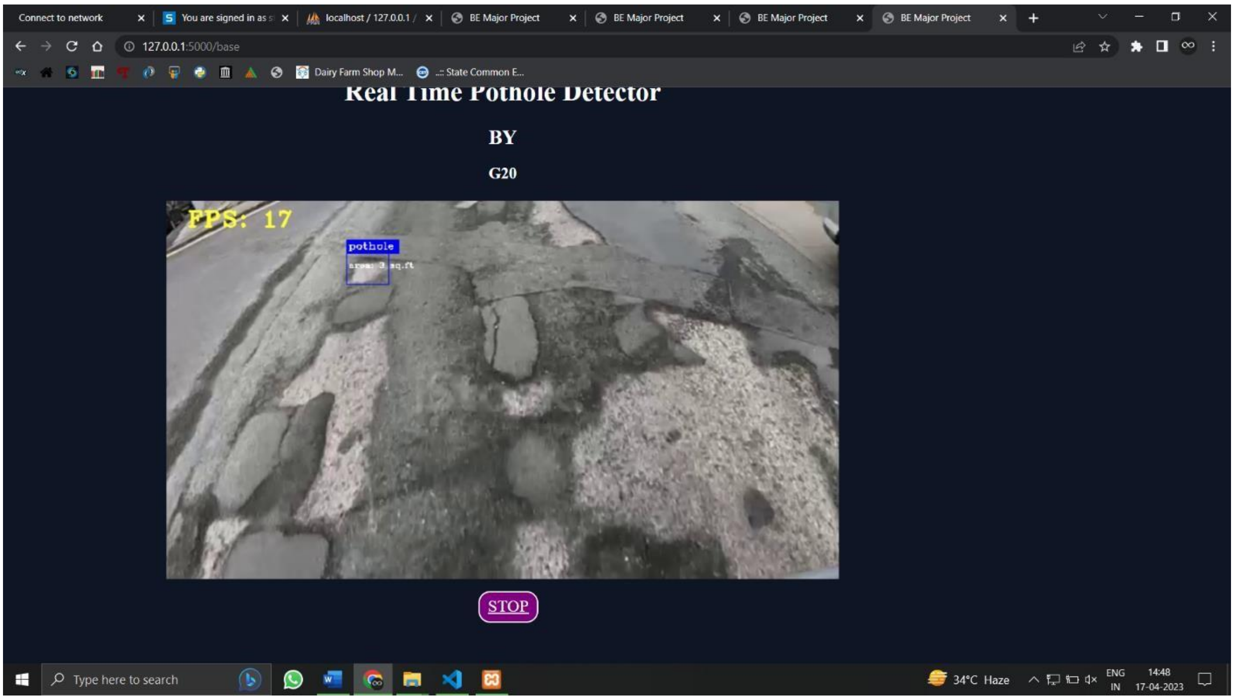


*Figure 8.3: Detecting Pothole-1*

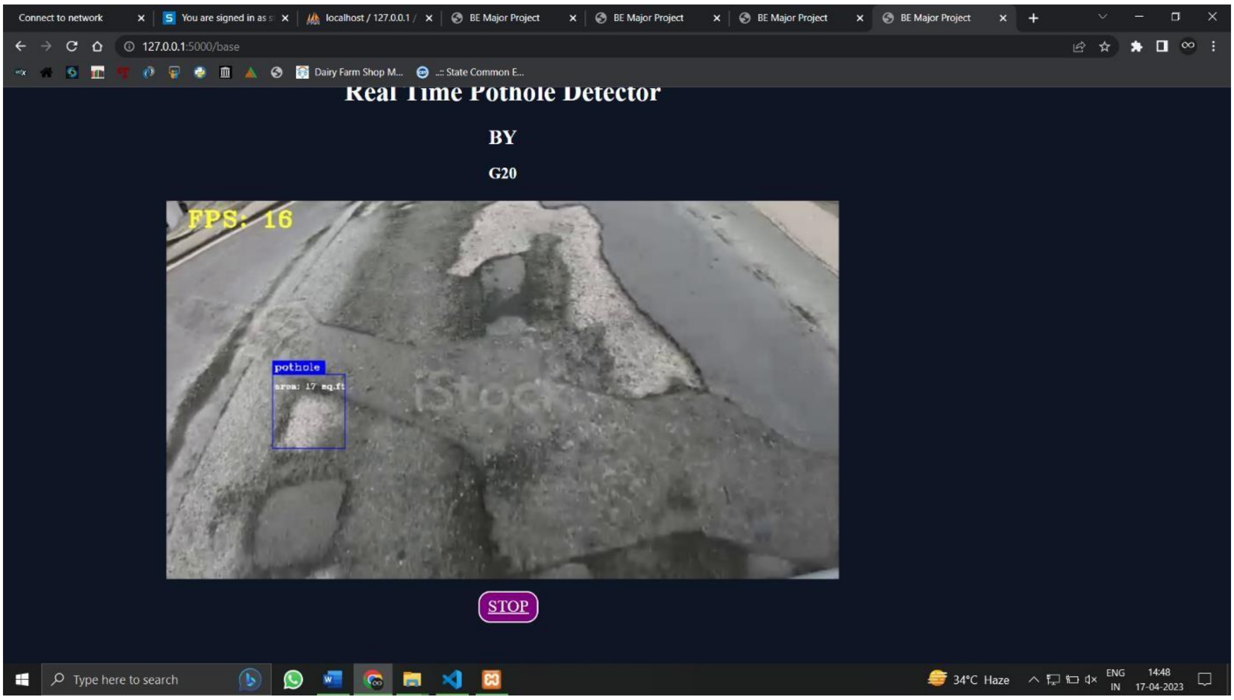


*Figure 8.4: Detecting Pothole-2*

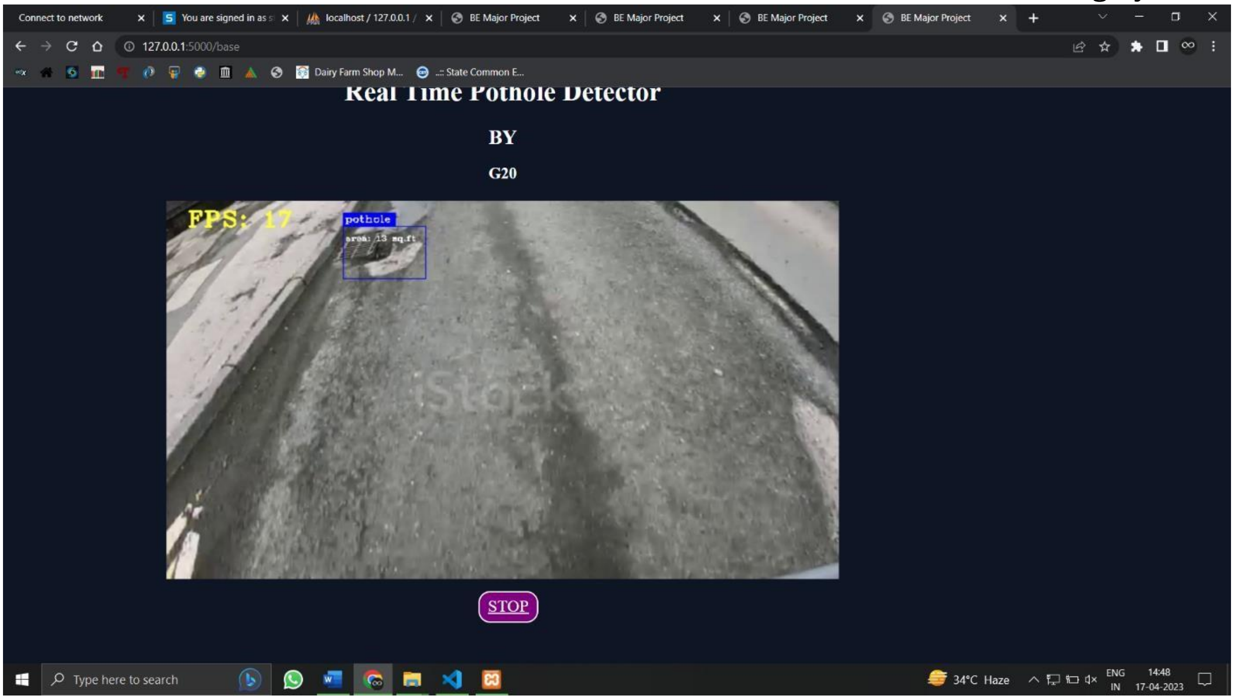


*Figure 8.5: Detecting Pothole-3*

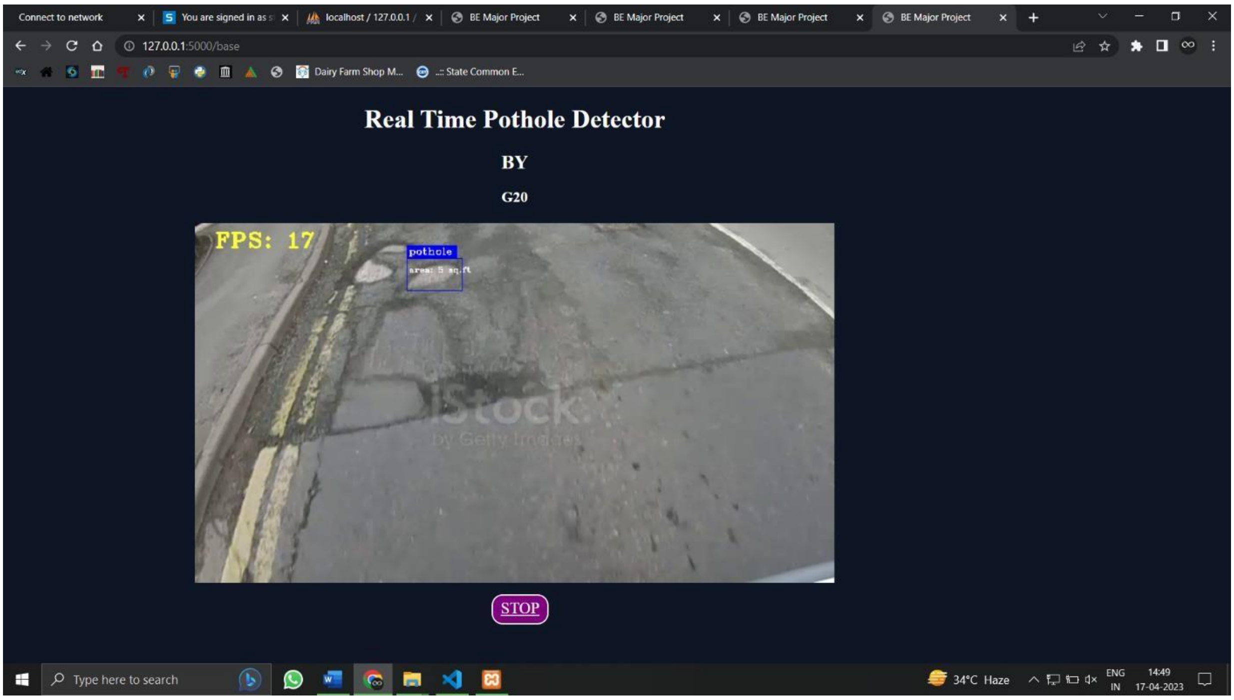


*Figure 8.6: Detecting Pothole-4*

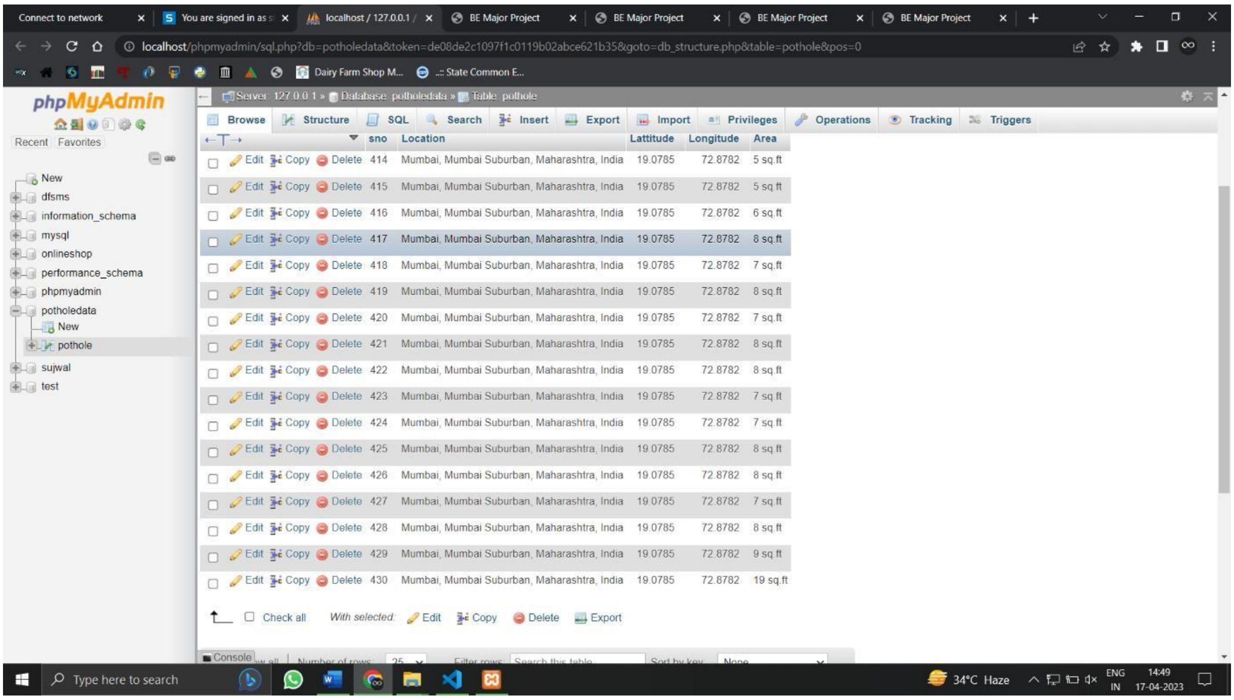

*Figure 8.8: Storing Location Co-ordinates*

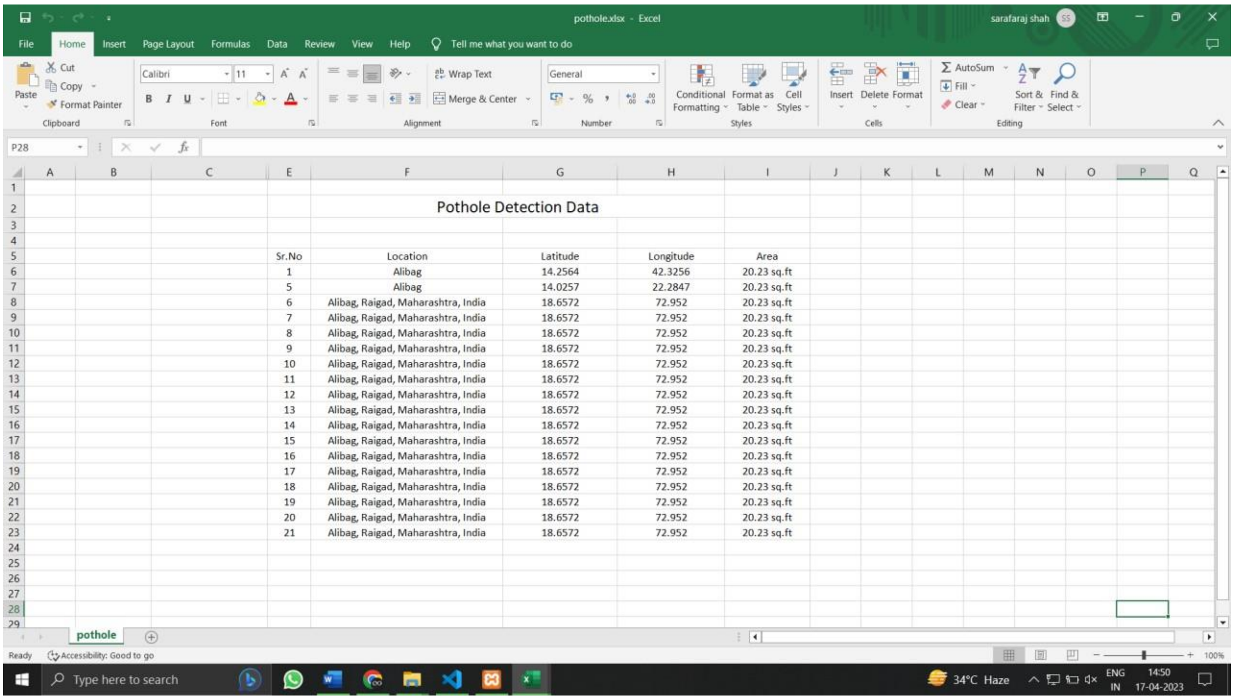


*Figure 8.9: CSV File*

# Chapter 9

# Conclusion and Future Scope

# Chapter 9

## Conclusion:

The main aim of the model is to detect potholes on the roads and notify them without any human interference.No manual intervention is required to spot and report the potholes. It can be detected automatically with the help of AI, therefore our pothole detection system helps the society in promoting road safety and reduces the difficulties in detecting the pothole and also reduces the usage of human power and hence saves time. Therefore, by filling the pothole accidents which occur on the road may be reduced. The image captured and the geographic location that is longitude and latitude of the pothole detected will be sent to the concerned government authorities mail. The authorities can see the image and if they click on the link sent through e-mail, they can check out the location of the pothole detected in the google maps.

The hardware model is cost effective which is an added advantage.

## Future Scope:

**Multi-class detection:** The current system may focus on detecting specific road damages, such as cracks or potholes. However, the system can be expanded to detect other types of road damages, such as rutting, edge wear, or other structural defects, which may require different maintenance or repair approaches.

**Advanced analytics:** The system can incorporate advanced analytics techniques to analyze the collected data and provide insights into road health trends, patterns, and correlations. This can help transportation agencies or road authorities make data-driven decisions on road maintenance strategies, budget allocation, and resource planning.

**Scalability and deployment in smart cities:** The road health monitoring system can be scaled up and deployed in smart city initiatives, where road health is an essential aspect of urban infrastructure management.

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# Acknowledgement

It is a privilege for us to have been associated with **Prof. Nikita Saindane**, our guide, during this project work. We have been greatly benefited by her valuable suggestions and ideas. It is with great pleasure that we express our deep sense of gratitude to them for their valuable guidance, constant encouragement and patience throughout this work. We are also indebted to our guide for extending the help to academic literature. We express our gratitude to **Prof. Rajashree Gadhave** (Project Coordinator), **Prof. Rohini Bhosale** (Head of Department of Computer Engineering), **Dr. J. W. Bakal** (Principal) for their constant encouragement, cooperation and support. We take this opportunity to thank all our classmates for their company during the course work and for useful discussion we had with them. We would be failing in our duties if we do not make a mention of our family members, including our parents for providing moral support, without which this work would not have been completed.

Thanking You,

Kaushal Bhoir

Sujwal Latke

Sarafaraj Shah

# Appendix I :

# List of Publications

## Journal

1. Kaushal Bhoir, Sujwal Latke, Sarafaraj Shah, Nikita Saindane, “Road Health Monitoring System”, STM Journal , April 2023 [Status : Submitted]

# Appendix II:

# Published Paper

# ROAD HEALTH MONITORING SYSTEM

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***Abstract— The purpose of our project is to create a pothole detecting system that helps drivers avoid potholes on the road by providing them with warnings in advance. These warnings can take the form of a buzzer or a series of LED lights. This can be utilised on a four-wheeler, particularly by ambulance drivers so that they can quickly save a great number of lives. Road surface quality needs to be regularly evaluated and maintained as necessary. The economy of the nation is significantly boosted by well-maintained roadways. Due to the heavy use of road transportation, there are numerous chances that potholes on the roads can cause accidents. Every driver in India must navigate potholes, which are most common during the rainy season.But each of the methods currently in use has some downsides, such as high setup costs, a risk of being discovered, or a lack of night vision capabilities. As a result, we have developed a project that might most easily assist people. The major goal is to locate and warn of potholes, ideally without human assistance. We are utilising object identification API and AI-enabled cameras to detect potholes in order to accomplish our goal. The driver can use the information gathered to prevent collisions.***

**Keywords—** ***Pothole, Buzzer, LED, Road, Accident, Vehicle, AI, ML, Camera.***

## I. INTRODUCTION

What feature do the majority of large cities share? They will all likely invest substantial sums of money in various smart city projects. Innovation has not been absent from road infrastructure. In the upcoming years, almost one-third of Pittsburgh's crossings will have smart traffic lights installed; these sensors monitor traffic volume and modify stop-and-go times according to the amount of cars present. Wait times at crossings have decreased by 41% since the project's beginning, and car emissions have decreased by 21%. Contrary to popular belief, when travelling on a road you are unfamiliar with, the search for the most convenient route may not always match to the search for the quickest route.

Initially, hundreds of thousands of dollars are spent "patching" and fixing damaged road segments. Also, driving on uneven ground uses more fuel and necessitates maintenance more frequently. We shouldn't forget that potholes on the road are frequently one of the factors contributing to collisions, which can result in injuries and occasionally fatalities. At the very least, the subpar condition of the road lane aggravates and discomforts drivers. Road maintenance is difficult because there are so many variables that can cause harm. Both organic and artificial ones are included. The cost of road repair projects strongly relates to how quickly they respond to damage. With the assistance of static sensors or human monitoring, it is nearly difficult to assure quality management of roads. Such systems need money that could be utilized for repairs because the roads are so long. The idea of the Internet of Things is becoming more and more well-known every year. The fundamental idea behind this theory is that when sensors share data, the yields of earlier fishing techniques fall..

## II. LITERATURE REVIEW

### A. Background

Both organic and artificial ones are included. The cost of road repair projects strongly relates to how quickly they respond to damage. With the assistance of static sensors or human monitoring, it is nearly difficult to assure quality management of roads. Such systems need money that could be utilized for repairs because the roads are so long. [1]The idea of the Internet of Things is becoming more and more well-known every year. The fundamental idea behind this theory is that when sensors share data, the yields of earlier fishing techniques fall.[2]

### B. Basic Terminologies

The suggested system employs the YOLO v4 algorithm to detect potholes in real-time, and it does so with the aid of a very straightforward and user-friendly GUI that gives you two options: "Start" and "Stop". When the "Start" option is chosen, the camera turns on and potholes are detected in real time. Now, while the YOLO v4 algorithm is running in the background, the camera is still recording. When a pothole is found, a bounding box is predicted to be around it. The bounding box is made up of a Box Label and a Predicted Accuracy Percentage, where Accuracy Percentage is the percentage of pothole detection accuracy. The console output reflects the number of potholes that are found in each image. The system exits the GUI as soon as you choose the "Stop" option, stopping the detection process in its tracks.

*C. Existing Systems*

When conducting routine field surveys, inspectors of the municipal corporation in developing nations frequently identify pavement potholes. This traditional approach can aid in obtaining a precise assessment of potholes, but it also has a low productivity for both data collecting and data processing. One pavement inspector can only inspect less than 10 km every day, which is the cause.[3]The automation of pothole identification becomes a critical requirement for transportation authorities due to the increasing number of road sections that must be routinely evaluated. The simplest approach might be to compile participant-taken images of road damage and hazards and upload them to a central server.[4]

## III. PLAN OF PROJECT

*A. Proposed System Architecture*

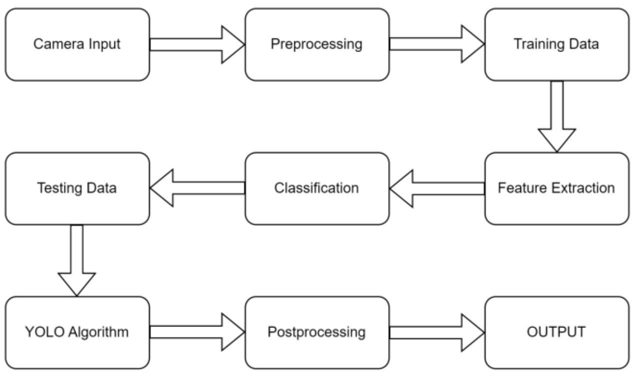



Fig 3.1 System Architecture

*1) Dataset:*

In order to develop a "Road Health Monitoring System" software project that uses only software to detect potholes, a relevant and accurate dataset is necessary. Here are some potential sources and characteristics of a dataset that could be used for this purpose:

Mobile sensors: Mobile sensors on vehicles can be used to collect data on road conditions, such as vibration and roughness, which can indicate the presence of potholes. This data can be collected from a large number of vehicles in different locations to provide a comprehensive view of road conditions.

Street view images: Potholes can be visually detected in street view photographs taken with on-board cameras or in satellite imagery. Based on color, shape, and texture, machine learning algorithms can be trained to recognise potholes in these pictures.

Crowdsourced data: Data can also be collected through crowdsourcing platforms, where drivers or other road users report the location and severity of potholes they encounter while traveling. This data can be supplemented with additional information such as weather and traffic conditions to improve the accuracy of pothole detection.

Historical data: Historical data on road conditions and maintenance can be used to predict the likelihood of potholes developing in certain areas. This data can be collected from government agencies and other organizations responsible for maintaining roads.

Simulated data: Simulated data can be used to train machine learning models to detect potholes in a controlled environment. This data can be generated using 3D modelling software or video game engines to simulate different road conditions and pothole sizes.

In order to ensure the accuracy and reliability of the dataset, it should be labelled or annotated with information such as the location and severity of potholes. It is also important to ensure that the dataset is representative of the road conditions in the target area and includes a diverse range of road types and traffic conditions.

Overall, the development of a high-quality dataset is essential for the accurate and effective detection of potholes using software in the "Road Health Monitoring System" project.

*2) Pre-processing Data:*

Cleaning and converting raw data into a format that may be used for more research is part of pre-processing, a crucial stage in data analysis.Pre-processing is a crucial step in guaranteeing the accuracy and quality of the data used for pothole identification and other road health monitoring tasks in the context of the "Road Health Monitoring System" software.Here are some of the pre-processing steps involved in the RHMS software:

Data collection: The first step in pre-processing is data collection. To provide a complete picture of the state of the roads, the RHMS software gathers information from a variety of sources, including sensors, cameras, and mobile devices.The collected data is usually in raw format and needs to be cleaned and processed before analysis.

Data cleaning: After data collection, the next step is to clean the data.Data cleaning entails deleting useless or redundant information, fixing mistakes, and adding missing data.
In the case of RHMS, this step is essential to ensure that the data used for pothole detection and other road health monitoring tasks is accurate and complete.

Data integration: RHMS software collects data from multiple sources, and the collected data needs to be integrated into a single dataset. This step involves merging data from different sources and ensuring that the data is consistent and compatible with the analysis tools.

Data transformation:The process of transforming unprocessed data into a form suitable for analysis is known as data transformation.In the case of RHMS, this step involves converting data into a format that is compatible with machine learning algorithms and other analysis tools.

Data reduction: Data reduction is the process of reducing the amount of data by eliminating redundant or unnecessary data. This stage is crucial for RHMS since it can assist decrease the amount of data that needs to be analysed, increasing the software's effectiveness and speed.

Data normalization: Data normalization is the process of scaling data to a common range to make it easier to compare and analyse. In the case of RHMS, this step can help ensure that data from different sources is consistent and compatible with the analysis tools.

*B. Methodology*

After the dataset has been obtained for a pothole detecting system, the suggested approach annotation for each image is carried out explicitly. The annotated data are split into training and testing samples before being sent to deep learning models like the YOLO family and SSD for specific model training. Utilizing testing data, the weights collected during training aid in assessing the model's effectiveness. The custom weights are then converted into real-time detection on the OAK-D and Raspberry Pi acting as the host computer using the OpenVino IR protocol.

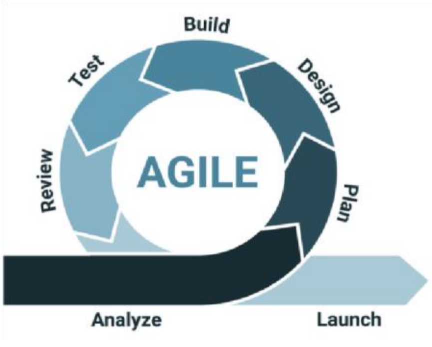



Fig. 3.2 Agile Lifecycle

Other methodologies that fall under the Agile umbrella include:

- Feature Driven Development (FDD)– One of the additional approaches that fall under the Agile umbrella is a straightforward and incremental paradigm that, as the name says, prioritises features. It goes through several checks and iterations. This system requires extensive planning and design expertise.

- Lean software development – Agile methodology is combined with the principles and practises of lean manufacturing to create lean software. Concentrate on making the most of your time while wasting as little money as possible.

- Scrum – Scrum is a methodology that focuses on managing software development in complicated knowledge work, research, and cutting-edge technology while emphasising collaboration, iteration, and responsibility.

## IV. Project Analysis

A software-based pothole detection system would typically use image processing techniques to examine photos or videos taken by cameras mounted on cars or drones. The essential steps in such a project are as follows:

Data collection: You will need to collect a large number of images or video footage of roads with potholes. You can capture these yourself or use publicly available datasets.
Image processing: Once you have the data, you will need to process it to detect potholes. This can be done using computer vision techniques such as edge detection, thresholding, and segmentation. The goal is to isolate the potholes in the image or video.

Feature extraction: After the potholes have been detected, you will need to extract relevant features from the images or video. This may include the size, shape, depth, and location of the potholes.

Classification: Once the features have been extracted, you will need to classify the potholes as either minor or major based on their severity. Machine learning algorithms like decision trees, support vector machines, or neural networks can be used for this.

Alert generation: Finally, the system should be able to generate alerts when potholes are detected. These alerts can be sent to the driver, maintenance crew, or city officials. The project will require skills in programming, image processing, machine learning, and software engineering. The software can be developed using open-source libraries such as OpenCV, TensorFlow, or PyTorch.

It's crucial to remember that while a software-only approach to spotting potholes may be successful, it may not be as accurate as a system that uses both software and hardware. For example, a system that combines camera data with sensor data from the vehicle can provide more accurate information about the location and severity of potholes.

Overall, a pothole detection system using software can be a valuable tool for improving road safety and reducing maintenance costs *A. Algorithms:*

This study suggests using the YOLOv4 algorithm for object detection and pothole detection. On a dataset of pothole photos, we assess the proposed model's performance and compare it to other well-liked object detection techniques. Our findings show that YOLOv4 performs better than other models in terms of precision and effectiveness, making it a potential method for pothole identification in practical applications. The collection of pothole photos, which consists of diverse sizes and shapes of potholes under varied lighting and weather circumstances, is used to train the proposed YOLOv4-based pothole detection model. Future study might involve putting the suggested model to the test on a bigger dataset and seeing how well it performs in practical situations.

## V. PROJECT DESIGN

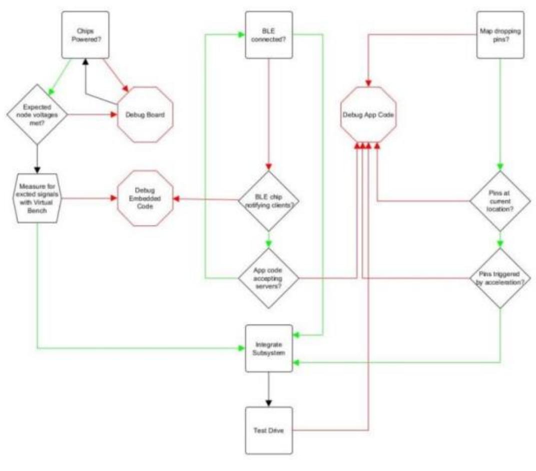


Fig 5.1 State Transition Diagram

The project is divided into two parts. These parts are considered as follows:

i. Machine Learning Model
ii. Flask Application

*Machine Learning Model:*
Similar to computer software, a machine learning model uses data or experience to identify patterns or behaviors. Machine learning is the study of various algorithms that could create a model automatically through use and past data.Similar to computer software, a machine learning model uses data or experience to identify patterns or behaviors.The learning algorithm scans the training data for patterns and then generates a machine learning (ML) model that captures those patterns. To determine if there is a pothole or not, we will utilize the YOLO v4 Algorithm for detecting the Gradient Boosting Classification.

*Flask Application:*
Flask is a straightforward WSGI web application framework. It is designed to make getting started quick and easy, with the ability to scale up to complex projects. It began as a simple Werkzeug and Jinja wrapper but has since developed into one of the most well-liked Python web application frameworks.

### A. *Activity Diagram:*

The Activity Diagram plays an essential part in our design. It shows the inflow of conditioning and the connections between different tasks in a visual manner which is essential for understanding our design methodology. In this section, we will offer a complete explanation of the exertion Diagram, including its end, symbols, and significance. By doing so, we hope to give a clear and terse understanding of our design methodology and the way involved. The illustration and explanation will help the anthology grasp our approach and results more thoroughly.

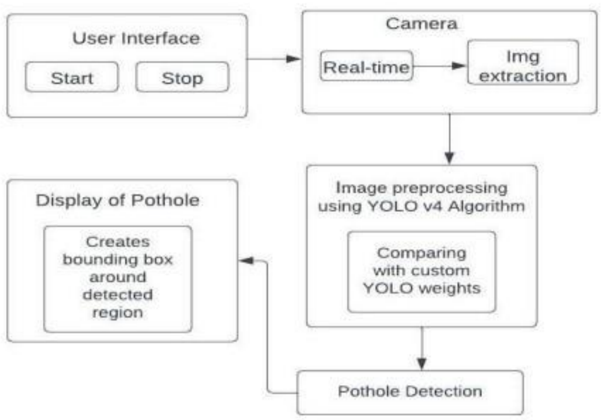


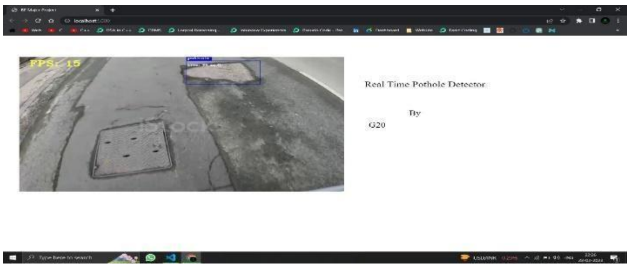
Fig 5.2 Activity Diagram

Real-time potholes detection using the YOLO v4 algorithm is made possible by a very straightforward and user-friendly GUI that gives you the choice between two options, "Start" and "Stop". When the "Start" option is chosen, the camera turns on and potholes are detected in real time. Now, while the YOLO v4 algorithm is running in the background, the camera is still recording.When a pothole is found, a bounding box is predicted to be around it. The bounding box is made up of a Box Label and a Predicted Accuracy Percentage, where Accuracy Percentage is the percentage of pothole detection accuracy.

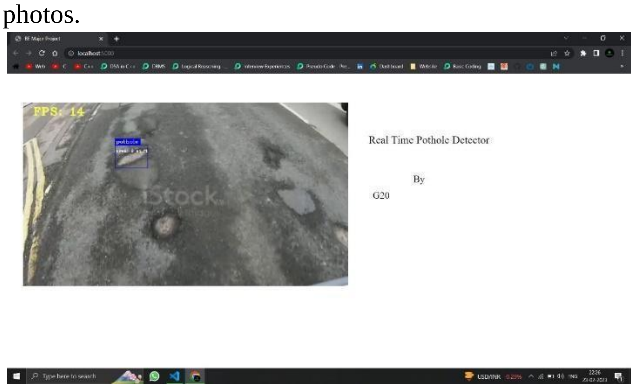
The console output reflects the number of potholes that are found in each image. The system exits the GUI as soon as you choose the "Stop" option, stopping the detection process in its tracks.

## VI. Results

A software-only pothole detection system could work by analyzing video or image data from cameras mounted on vehicles or drones. The system would need to use image processing techniques to identify potholes and distinguish them from other features such as shadows or cracks in the road.

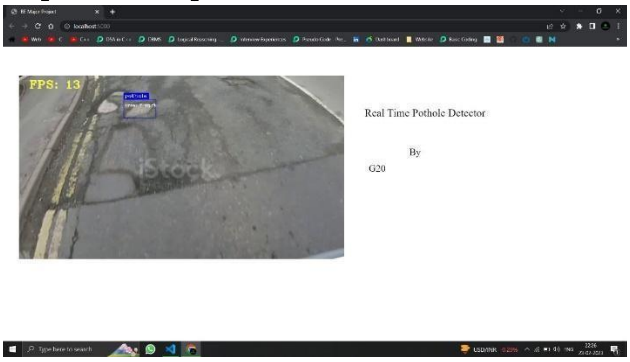



Using computer vision algorithms to spot changes in the texture or colour of the road surface, which may signify the existence of a pothole, is one method that could be used. The system might additionally classify the discovered anomalies as potholes using machine learning techniques, and it might be trained using a sizable collection of labelled pothole photos.




Once a pothole is detected, the system could alert drivers or local authorities through an app or other communication system. The system could also gather data on the location and severity of potholes, which could be used to prioritize repairs and improve road maintenance.

Overall, a software-only pothole detection system has the potential to improve road safety and reduce maintenance costs, but would require accurate and reliable image processing algorithms and a large dataset of labeled pothole images for training.




## VII. CONCLUSION

The model's primary goal is to automatically identify and report potholes on the roadways. Finding and reporting potholes doesn't take any manual work. Our pothole detection system aids society in encouraging road safety by reducing detection challenges, reducing the need for human labor, and ultimately saving time. It can be detected automatically with the aid of AI. Therefore, the number of traffic accidents may be decreased by filling potholes. The image captured along with the latitude and longitude of the pothole's position will be mailed to the appropriate government authorities. The image is visible to the authorities, who can view the position of the pothole discovered in Google Maps by clicking on the link sent via email. The suggested solution will make travelling safer and help decrease accidents. It aids municipal administration in making plans and taking action based on alerts, and the public can monitor how well municipal administration handles pothole complaints. Another benefit is the hardware model's affordability.

## ACKNOWLEDGMENT

We would like to convey our gratitude to Mrs. Nikita Saindane, who served as our project guide and gave us all the direction and support we needed. She also gave us the assistance we required and offered thorough advice on how to complete the project, for which we are grateful. We also want to sincerely thank the Project coordinators for everything that they have done. Prof. Rohini Bhosale, head of the computer department, has given her blessing to this project, and we would like to thank her for that. We would like to offer our sincere gratitude to Dr. J.W. Bakal, our esteemed principal, and the administration of The HOC College of Engineering and Technology for creating such a conducive environment for the development of this project.

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# Appendix III :

# Plagiarism Report

ORIGINALITY REPORT

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|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

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|---|---|---|
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| 2 | www.hindawi.com<br>Internet Source | 1% |
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| 4 | G Mamatha, H S Sharan, R Prathik, D S Priya, U Prajwal. "Smart Vehicular communication for Road status analysis and Vehicle trajectory prediction", 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), 2020<br>Publication | <1% |
| 5 | Submitted to Colorado Technical University<br>Student Paper | <1% |