Intel Unnati Industrial Training Program 2024

Project Report

On

PS 13: Vehicle Movement Analysis and Insight Generation Project in College Campus using Edge AI

By

Team Data Dynamos

Department of Computer Engineering

Marathwada Mitra Mandal's

COLLEGE OF ENGINEERING

Under the guidance of

Prof. Sarita Sapkal

INDEX

CHAPTER 1: INTRODUCTION

1.1. MOTIVATION

The "Vehicle Movement Analysis and Insight Generation Project in College Campus using Edge AI" is motivated by the need to enhance campus safety, optimize traffic management, and promote sustainable transportation practices. By leveraging Edge AI, the project aims to provide real-time monitoring and analysis of vehicle movement, allowing for immediate responses to potential security threats, traffic congestion, and accidents.

This data-driven approach not only improves operational efficiency and resource allocation but also supports academic research and demonstrates the college's commitment to adopting cutting-edge technology. Ultimately, the project seeks to create a safer, more efficient, and environmentally-friendly campus environment, enhancing the overall experience for students, staff, and visitors.

1.2. PROBLEM DEFINITION

There are always a lot of traffic movements in and around the college; parking is also another challenge and responding to emergencies. These problems are compounded by the absence of real time tracking and analytical information thereby making traffic patterns poor, chance of occurrence of accidents high and resource management inefficient. It is with such traditional technique based on the observation and control of vehicle movement in the facility through monitoring and processing of data manually and from a central point that the process is usually slow and riddled with errors.

The key challenges include:

1. **Traffic Congestion**: During peak hours, the campus faces significant traffic congestion, causing delays and frustration for students, staff, and visitors.
2. **Parking Management**: Inefficient utilization of parking spaces leads to unnecessary searching for available spots, contributing to congestion and time wastage.
3. **Safety and Security**: The absence of real-time monitoring makes it difficult to promptly detect and respond to accidents, unauthorized vehicle entries, and other security threats.

To address these issues, there is a need for an intelligent system that can continuously monitor vehicle movement, analyze data in real-time, and generate actionable insights to enhance traffic management, improve safety and security, and promote sustainable practices.

1.3. PROJECT TITLE

VEHICLE MOVEMENT ANALYSIS AND INSIGHT GENERATION PROJECT IN COLLEGE CAMPUS USING EDGE AI.

1.4. PROJECT DOMAIN

ARTIFICIAL INTELLIGENCE & MACHINE LEARNING

1.5. PROBLEM STATEMENT

- The rapid increase in vehicle traffic within college campuses presents significant challenges related to safety, congestion, and resource management. Traditional traffic monitoring systems, reliant on centralized data processing, often fail to provide the real-time insights necessary for efficient traffic management and prompt incident response.

- This project, "Vehicle Movement Analysis and Insight Generation Project in College Campus using Edge AI," aims to address these challenges by leveraging Edge AI to analyze vehicle movement in real-time.

- By deploying AI-enabled edge devices across the campus, we will collect and process data locally, reducing latency and enabling immediate action on traffic anomalies, security threats, and congestion issues.

- The goal is to enhance campus safety, optimize traffic flow, improve resource allocation, and support sustainable transportation practices, thereby creating a safer, more efficient, and environmentally friendly campus environment.

CHAPTER 2: DATASET DESCRIPTION

2.1. DATASET SOURCE

Link: https://www.kaggle.com/datasets/saisirishan/indian-vehicle-dataset

Indian vehicle number plates have a wide variety in terms of size, font, script and shape. Development of Automatic Number Plate Recognition (ANPR) solutions is therefore challenging, necessitating a diverse dataset to serve as a collection of examples.

However, a comprehensive dataset of the Indian scenario is missing, thereby hampering the progress towards publicly available and reproducible ANPR solutions.

Many countries have invested efforts to develop comprehensive ANPR datasets like Chinese City Parking Dataset (CCPD) for China and Application-oriented License Plate (AOLP) dataset for US.

In this work, we release an expanding dataset presently consisting of 1.5k images for development of ANPR solutions for Indian conditions.

2.2. DATASET DESCRIPTION

There are three directories in this dataset:

State-wise_OLX: This directory contains the sub folders corresponding to each state in India, which further have the images and their annotations. These images are obtained from web scraping of OLX website.

google_images: This directory contains the images that have been googled along with their annotation files.

video_images: The images in this directory are obtained by capturing pictures using a mobile device in the highways of Maharashtra in different daylight conditions.

2.3. DATASET FEATURES

The annotations for each image are stored in a separate .xml file.

folder: name of the folder the image is in.

filename: Name of the file along with the extension.

path: Absolute path of the image (Can be changed as per the user requirements)

width: Width of the image

height: Height of the image

depth: Depth of the image (this value is 3 as all the images are RGB)

name: License number of the vehicle

xmin: Minimum x-coordinate value of the bounding box for the license plate

ymin: Minimum y-coordinate value of the bounding box for the license plate

xmax: Maximum x-coordinate value of the bounding box for the license plate

ymax: Maximum y-coordinate value of the bounding box for the license plate

CHAPTER 3: METHODOLOGY

3.1. TOOLS USED

Languages used for development

- HTML
- CSS
- JavaScript
- Flask

Tools/Platforms used for development

- Visual Studio Code
- Kaggle Notebook

Libraries used for development

- Pandas
- Numpy
- Tdqm
- Cv2
- Torch
- Matplotlib
- Plotly
- Flask
- Ultralytics for YOLO model
- pytesseract
- datetime

3.2. TECHNIQUES USED

1. Data Preprocessing

Data preprocessing involves preparing the data for training and inference. This step typically includes:

Loading datasets: Reading images and corresponding labels.

Data augmentation: Applying transformations to the images, such as resizing, cropping, and color adjustments, to improve model generalization.

2. Model Training

Model training involves selecting and configuring a machine learning model to learn from the preprocessed data. In the context of number plate detection, the following steps are usually included:

Model selection: Choosing a suitable model architecture for object detection, such as YOLO, Faster R-CNN, or SSD.

Training configuration: Setting up parameters like learning rate, batch size, and number of epochs.

Training loop: Iteratively feeding data into the model, calculating loss, and updating model weights using backpropagation.

3. Edge AI Techniques

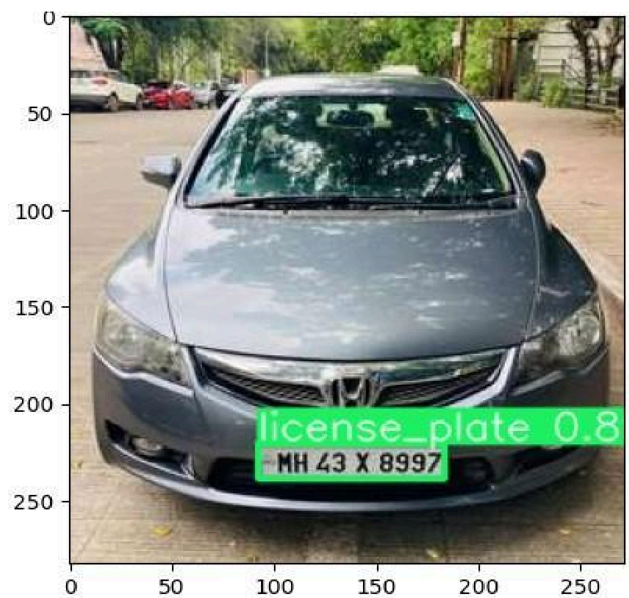
Edge AI refers to running AI models locally on edge devices (e.g., cameras, smartphones) rather than relying on cloud-based servers. Techniques used for edge AI typically involve:

Model optimization: Reducing model size and complexity using techniques like pruning, quantization, and knowledge distillation.

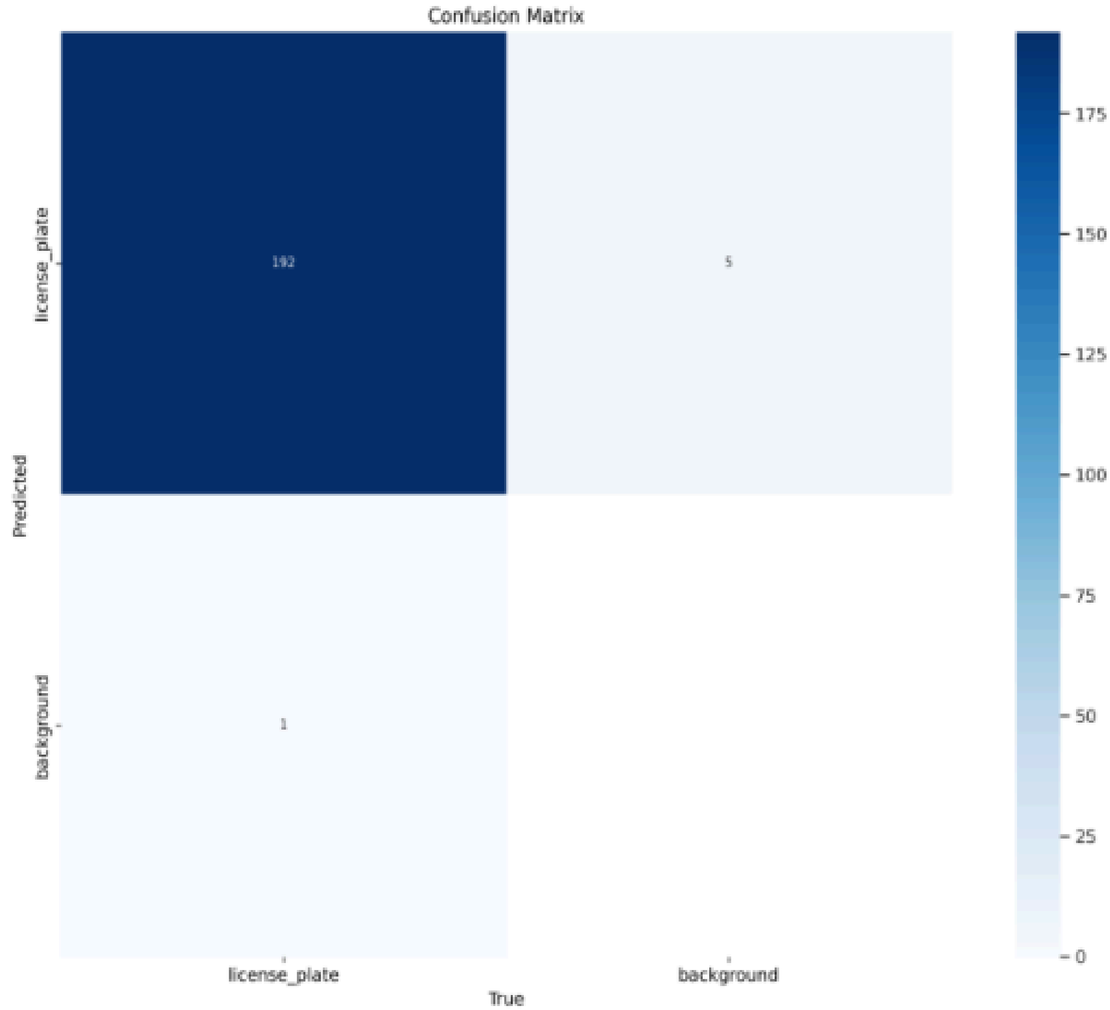
Inference on edge devices: Deploying the optimized model on edge devices to perform real-time predictions.

CHAPTER 4: RESULTS AND DISCUSSION

['JK09B7745']



['MH43X8997']

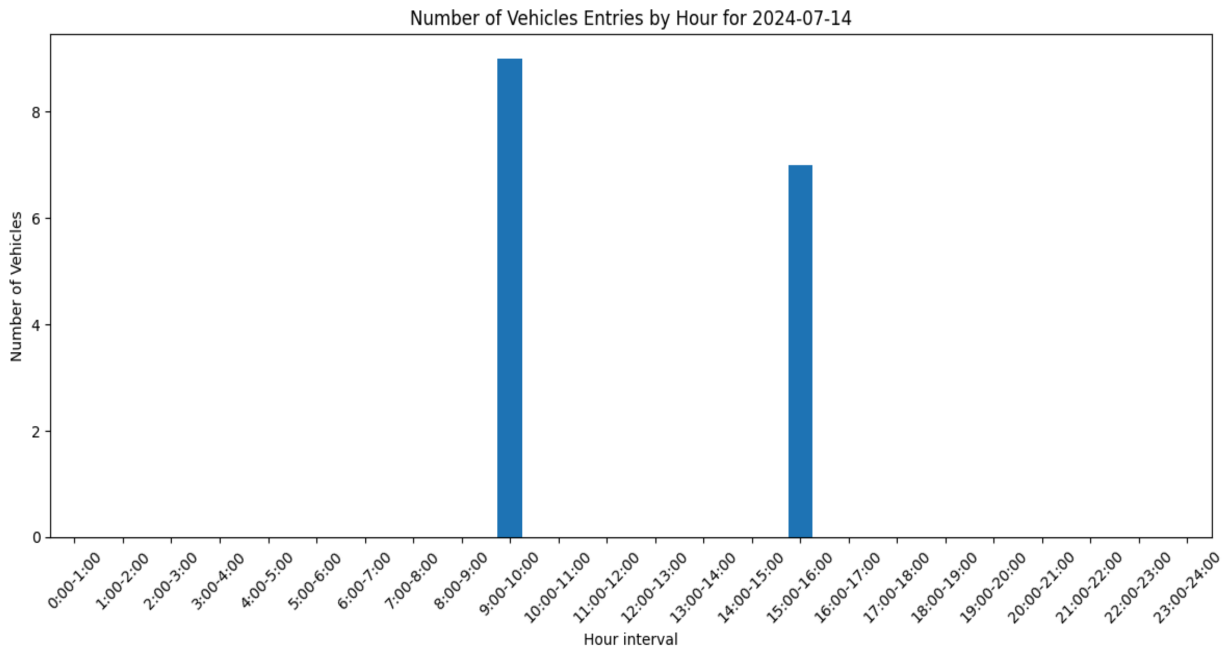


This confusion matrix evaluates the performance of a classification model, specifically distinguishing between "license_plate" and "background". Here is a detailed explanation:

1. **Axes**:
   - **X-axis (True)**: Represents the actual class labels (ground truth).
   - **Y-axis (Predicted)**: Represents the predicted class labels made by the model.
2. **Cells**:
   - The top left cell (192): True positives (correctly predicted license plates).
   - The top right cell (5): False negatives (actual license plates predicted as background).
   - The bottom left cell (1): False positives (background predicted as license plates).
   - The bottom right cell: True negatives (correctly predicted background). It seems empty or very low, indicating the model might have very few instances of background in this dataset or nearly perfect predictions for this class.

The model is highly accurate in predicting license plates (192 true positives out of a total of 193 actual license plates).

The confusion matrix indicates strong model performance, particularly in identifying license plates correctly.



This graph depicts the number of vehicle entries by hour for a specific date, July 14, 2024. Here is an explanation of the key elements:

1. **X-axis**: Represents the hour intervals of the day, ranging from "00:00-01:00" to "23:00-24:00".
2. **Y-axis**: Shows the number of vehicles that entered during each hour interval.
3. **Bars**: There are two significant bars representing the number of vehicle entries during specific hour intervals:
   - Around 09:00-10:00, there are 9 vehicle entries.
   - Around 15:00-16:00, there are 6 vehicle entries.

From the graph, we can infer that the highest number of vehicle entries occurred between 09:00 and 10:00, followed by a second peak between 15:00 and 16:00