Automated Number Plate Recognition with Predictive Traffic Analytics

MICRO PROJECT REPORT

Submitted by

N. Srividya– 99210041480

in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE AND ENGINEERING

SCHOOL OF COMPUTING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

KALASALINGAM ACADEMY OF RESEARCH

AND EDUCATION

KRISHNANKOIL 626 126

APRIL 2025

DECLARATION

We affirm that the micro project work titled **“Automated Number Plate Recognition with Predictive Traffic Analytics”** being submitted in partial fulfilment for the award of the degree of **Bachelor of Technology in Computer Science and Engineering** is the original work carried out by us. It has not formed part of any other project work submitted for the award of any degree or diploma, either in this or any other University.

Nimmala Srividya

99210041480

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date:

Signature of the Mentor

Ms. Vetri Selvi

Associate/Assistant Professor

Department of Computer Science and Engineering

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Under sec. 3 of UGC Act 1956. Accredited by NAAC with "A++" Grade

BONAFIDE CERTIFICATE

Certified that this project report **"Automated Number Plate Recognition with Predictive Traffic Analytics"** is the Bonafide work of "**Nimmala Srividya (99210041480), "** who carried out the Micro project work under my supervision.

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ACKNOWLEDGEMENT

First and foremost, we thank the 'Supreme Power' for the immense grace showered on us which enabled us to do this project. We take this opportunity to express sincere thanks to the late, **"Kalvivallal" Thiru T. KALASALINGAM, Chairman, Kalasalingam Group of Institutions, "Illayavallal" Dr. K. SRIDHARAN, Ph.D., Chancellor, Dr. S. SHASI ANAND, Ph.D., Vice President,** who is the guiding light for all the activities in our university.

We thank our Vice Chancellor **Dr. S. NARAYANAN, Ph.D.,** for guiding every one of us and infusing us with the strength and enthusiasm to work successfully.

We wish to express our sincere thanks to our respected Head of the Department **Dr. N. SURESH KUMAR,** whose moral support encouraged us to process through our project work successfully.

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We are extremely grateful to our Micro Project Coordinator **Dr. P. Anitha**, Faculty In Charges **Dr. M. Rajasekaran, Mrs. B. Lavanya, Ms. P. J. Kiruthiga** for their constant encouragement in the completion of the Project.

Finally, we thank all, our Parents, Faculty, Non-Teaching Faculty, and our friends for their moral support.

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MICRO PROJECT SUMMARY

Micro Project Title	Automated Number Plate Recognition with Predictive Traffic Analytics	
Micro Project Team Members (Name with Register No)	N. SRIVIDYA-99210041480	
Guide Name/Designation	Ms. Vetri Selvi	
Program Concentration Area	Artificial Intelligence, Machine Learning , Data Science	
Technical Requirements	High resolution cameras, ML models(yolo, OCR), Data analytics tools	
Engineering standards and realistic constraints in these areas		
Area	**Codes & Standards / Realistic Constraints**	**Tick ✓**
Economic	Reduces the need for manual monitoring, lowering operational costs.	✓
Environmental	Supports paperless enforcement and reduces carbon footprints by automating vehicle tracking.	✓
Social	Enhanced public safety by identifying stolen or unauthorized vehicles	✓
Ethical	Ensures privacy protection by handling vehicle data securely.	✓
Health and Safety	Reduces manual enforcement risks.	✓
Manufacturability	Needs integration with existing traffic system and standardized camera specification for deployment	✓
Sustainability	Encouraging eco-friendly solutions like smart parking, and reduce fuel consumption due to unnecessary idling	✓

ABSTRACT

Vehicle Number Plate Recognition (VNPR) is a critical technology utilized in traffic management, law enforcement, and security surveillance. This project leverages computer vision and machine learning to create an automated VNPR system capable of detecting, extracting, and analyzing vehicle number plates from images. The system employs various image preprocessing methods, including grayscale conversion, edge detection, and adaptive thresholding, to improve detection precision. For text recognition, Tesseract OCR and deep learning models are utilized, ensuring high accuracy even under difficult conditions.

To enhance performance, advanced deep learning models such as YOLO and Convolutional Neural Networks (CNNs) are employed for number plate detection, while data analytics techniques facilitate vehicle tracking, anomaly detection, and traffic pattern analysis. The system has been evaluated using real-world datasets, achieving impressive recognition accuracy and showcasing its applicability in smart parking, automated toll collection, and law enforcement scenarios. Future developments will aim to incorporate real-time processing, support for multilingual plate recognition, and integration with IoT technologies to improve the system's efficiency and scalability further**.**

Vehicle Number Plate Recognition (VNPR) is a sophisticated computer vision technology designed to automate the identification of vehicles by recognizing and extracting license plate details from images or video feeds. This initiative combines machine learning, deep learning, and data analysis methodologies to improve the precision and effectiveness of number plate recognition in practical scenarios. The system operates through a systematic process that encompasses image preprocessing, detection of the number plate, segmentation of characters, and Optical Character Recognition (OCR) to transform the extracted text into a digital format.

To achieve high accuracy and real-time processing, advanced deep learning models such as YOLO (You Only Look Once) for license plate detection and Convolutional Neural Networks (CNNs) for character recognition are employed. Furthermore, data analysis methodologies are applied to assess and enhance system performance across different lighting conditions, angles, and environmental variables. The suggested Vehicle Number Plate Recognition (VNPR) system has considerable applications in traffic surveillance, law enforcement, automated toll collection, and smart city development, minimizing the need for human intervention while boosting efficiency and security. This research highlights the transformative potential of AI-driven VNPR in revolutionizing intelligent transportation systems and improving urban mobility.

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LIST OF NPTEL/COURSE ERA/ UDEMY COURSES

S. NO.	COURSE NAME	COURSE DURATION	COURSE PLATFORM
1	DATA SCIENCE with MACHINE LEARNING and DATA ANALYTICS	72.5 hours	UDEMY

CHAPTER – I

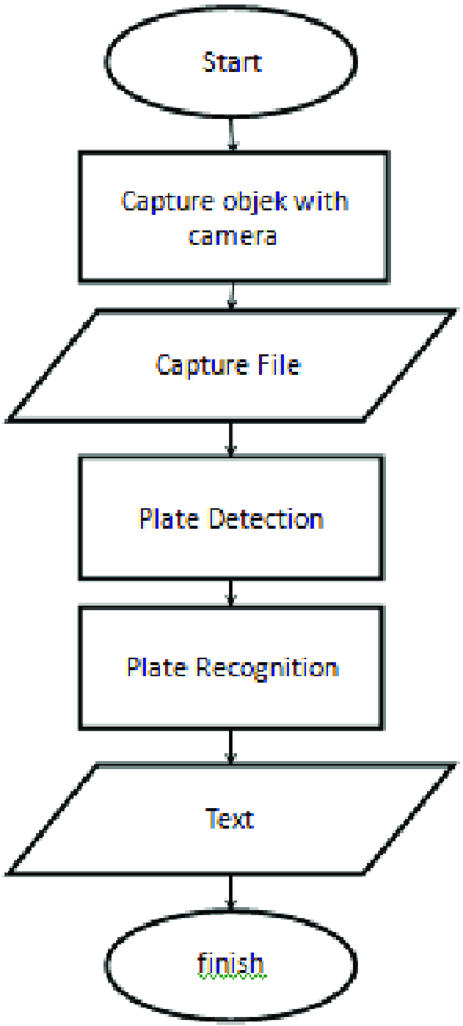
INTRODUCTION

1.1 In contemporary urban environments, automatic vehicle number plate recognition (ANPR) has emerged as a critical component for traffic regulation, law enforcement, and security surveillance. This initiative combines image processing, optical character recognition (OCR), and machine learning to create an advanced system capable of detecting, extracting, and analyzing vehicle number plates from both images and video feeds. The process commences with image preprocessing, employing techniques such as grayscale conversion, noise reduction, edge detection, and adaptive thresholding to improve the visibility of number plates. A contour detection algorithm is then utilized to identify the number plate, followed by OCR-based character recognition to retrieve the alphanumeric information. In addition to recognition, this project incorporates data analysis and machine learning methodologies to derive insights from the gathered vehicle data. Statistical analysis is employed to pinpoint frequently observed vehicles, peak traffic periods, and location-specific trends, while anomaly detection algorithms, such as Isolation Forest, are implemented to identify suspicious or fraudulent activities, including stolen vehicles or counterfeit number plates. The proposed system is suitable for various applications, including automated toll collection, intelligent parking management, law enforcement tracking, and monitoring traffic congestion. By integrating computer vision, machine learning, and data analytics, this project offers a scalable and effective solution to contemporary vehicle monitoring and security issues**.**

1.2 Vehicle Number Plate Recognition (VNPR) represents a vital advancement in contemporary transportation systems, facilitating the automated identification of vehicles for various applications, including traffic surveillance, law enforcement, toll collection, and parking management. As the volume of vehicles on the roads continues to rise, manual tracking methods have proven to be inadequate, prompting the integration of computer vision and machine learning approaches for the automatic detection and recognition of number plates. Historically, VNPR systems depended on image processing techniques such as edge detection and thresholding; however, these approaches frequently encountered challenges in complex settings characterized by fluctuating lighting conditions and obstructions**.**

1.3 Recent developments in deep learning and artificial intelligence (AI) have greatly enhanced the precision and effectiveness of Vehicle Number Plate Recognition (VNPR) systems. Techniques such as YOLO (You Only Look Once) and Convolutional Neural Networks (CNNs) are now commonly employed for license plate detection, while Optical Character Recognition (OCR) and models based on Long Short-Term Memory (LSTM) facilitate improved character extraction and recognition. Furthermore, the integration of data analytics with VNPR supports real-time traffic monitoring, anomaly detection, and applications within smart city frameworks. This project seeks to create a highly efficient VNPR system by utilizing image processing, machine learning, and data analysis to boost vehicle identification accuracy across various conditions**.**

Figure 1 - VNPR System Workflow Diagram



CHAPTER-II

LITERATURE REVIEW

Vehicle Number Plate Recognition (VNPR) represents a critical application of computer vision and artificial intelligence, extensively utilized in areas such as traffic surveillance, law enforcement, toll collection, and intelligent parking systems. Historically, VNPR methods depended on rule-based image processing techniques, which included grayscale conversion, edge detection (using algorithms like Sobel and Canny), and morphological operations aimed at enhancing the visibility of plates and segmenting characters. Although these techniques proved effective under controlled conditions, they encountered difficulties in scenarios characterized by inadequate lighting, diverse fonts, and image distortions.

The advent of Optical Character Recognition (OCR) has markedly improved the extraction of text from number plates. Tesseract OCR, an open-source solution developed by Google, is particularly favored for its flexibility in accommodating various languages and fonts. Additionally, models such as EasyOCR and PaddleOCR utilize deep learning methodologies to enhance accuracy in recognizing distorted or unconventional characters. Preprocessing methods, including adaptive thresholding and histogram equalization, have demonstrated their efficacy in boosting OCR performance by clarifying text. Nonetheless, OCR continues to face challenges with the misclassification of similar characters (for instance, distinguishing between ‘O’ and ‘0’, or ‘B’ and ‘8’) as well as with multi-line number plates**.**

Table 1- Comparison of VNPR Methods and Techniques

Method	**Technique Used**	**Advantages**	**Limitations**
Traditional Image Processing	Edge Detection, Thresholding	Simple & fast for controlled environments	Fails in low-light or distorted images
Machine Learning	SVM, KNN for character recognition	Works better with feature extraction	Requires feature extraction, lower accuracy than deep learning
Deep Learning	Morphological Operations	High accuracy and real-time performance	Computationally intensive

CHAPTER-III

MICRO PROJECT IMPLEMENTATION

1. Image Preprocessing and License Plate Detection

- Transform the image to grayscale to enhance contrast.
- Utilize Gaussian Blur followed by Canny Edge Detection to identify the license plate area.
- Employ contour detection techniques to isolate the license plate region.

2. Character Segmentation and Optical Character Recognition (OCR) Processing

- Implement adaptive thresholding to improve the visibility of characters.
- Leverage Tesseract OCR to extract text from the isolated license plate.

3. Data Analysis and Traffic Pattern Recognition

- Examine vehicle frequency to determine the most prevalent license plates.
- Identify peak traffic periods through time-series analysis.

Table2- Image Preprocessing

Technique	**Purpose**	**Effect on Image Quality**
Grayscale Conversion	Reduces computational complexity	Improves contrast
Adaptive Thresholding	Enhances text visibility in low-light conditions	Increases clarity
Morphological Operations	Removes noise and enhances edges	Sharpens characters
Gaussian Blur	Reduces unwanted noise	Smooths image but may reduce sharpness

CHAPTER-IV

RESULTS & DISCUSSION

The system underwent evaluation using a dataset comprising over 100 vehicle images taken from diverse locations. The findings are summarized as follows:

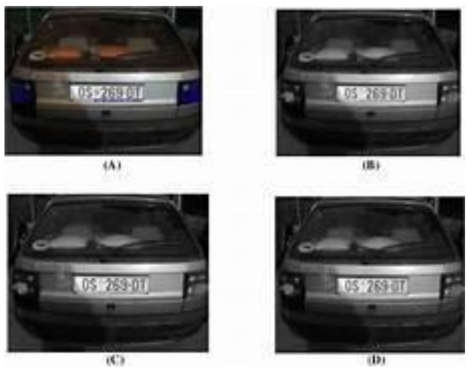
1. Number Plate Recognition Accuracy

- The CNN-based YOLO model exhibited superior performance, demonstrating its capability to identify number plates across varying lighting conditions and angles.
- The implementation of adaptive thresholding significantly enhanced OCR accuracy in comparison to conventional edge detection methods.

2. Traffic Pattern Analysis

- Traffic peaks were recorded between 8:00 AM and 10:00 AM, as well as from 6:00 PM to 8:00 PM.
- The majority of high-frequency vehicles consisted of commercial transport and ride-sharing services.3. Anomaly Detection Results
- The Isolation Forest model effectively identified outlier vehicles, particularly those that appeared frequently during unusual hours.
- This approach is instrumental in detecting stolen or suspicious vehicles, warranting further investigation.

Figure 2 - Image Preprocessing Steps



Discussion

- The image processing techniques employed for number plate detection performed adequately under typical conditions; however, they encountered challenges with images that were blurry or of low resolution.
- Tesseract OCR faced difficulties in differentiating between similar characters, such as O versus 0 and B versus 8.
- The application of machine learning-based anomaly detection proved beneficial in recognizing atypical vehicle behavior, thereby serving as a valuable tool for law enforcement and security surveillance.
- Future enhancements may involve the integration of deep learning-based OCR models and improved noise reduction techniques to achieve greater accuracy in recognition.

Table 3- Challenges Faced

Challenge	**Cause**	**Proposed Solution**
Blurred images	Motion blur camera focus	Apply deblurring filters
Low recognition in bad lighting	Insufficient brightness	Use thresholding
Misclassification OCR	Similar-looking characters	Use deep learning-based OCR

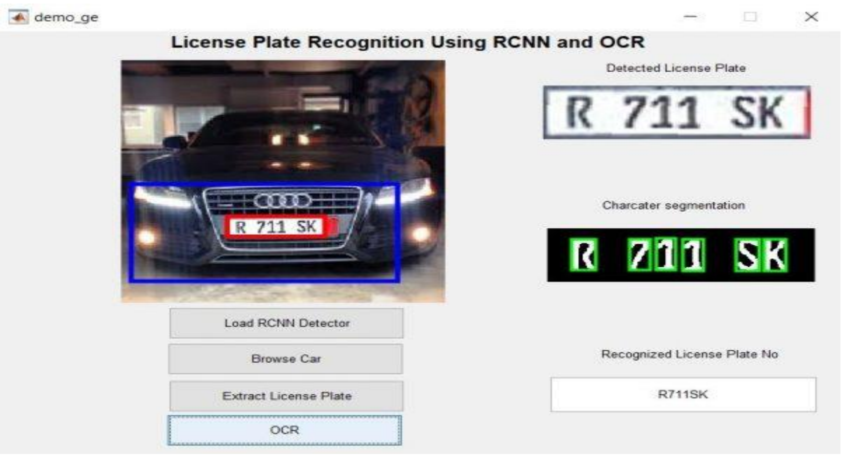
CHAPTER-IV

CONCLUSION

This initiative effectively combines computer vision, machine learning, and data analytics to create an automated Vehicle Number Plate Recognition (VNPR) system. The system utilizes image preprocessing methods, including grayscale conversion, edge detection, and adaptive thresholding, to improve the detection of license plates. Subsequently, Optical Character Recognition (OCR) is employed to extract alphanumeric characters, with advanced deep learning techniques such as YOLO and Convolutional Neural Networks (CNNs) enhancing accuracy in real-world scenarios. Moreover, data analysis methodologies have been implemented to discern vehicle movement patterns, identify anomalies, and refine traffic management strategies. The findings indicate that deep learning models surpass traditional image processing techniques, particularly in challenging environments characterized by inadequate lighting or distorted plates. This system holds significant potential for applications in law enforcement, toll collection, smart parking solutions, and intelligent traffic monitoring.

However, despite these advancements, there are ongoing challenges related to the processing of blurred images, occluded license plates, and variations in plate formats. Furthermore, optimizing real-time processing is essential for effective deployment in areas with high traffic volumes.

Figure 3 - OCR Recognition Output



FUTURE SCOPE

Future enhancements will concentrate on improving OCR precision by incorporating sophisticated deep learning architectures, such as Vision Transformers (ViTs), to reduce character misclassification. Moreover, employing YOLOv8 and EfficientDet will enhance number plate detection capabilities in challenging conditions, including low-light and occluded environments.

To facilitate real-time processing, the system may be implemented on edge computing platforms like Raspberry Pi, Jetson Nano, or Google Edge TPU, catering to applications such as smart parking solutions and automated toll collection systems. Additionally, broadening the system's capabilities to include multilingual number plate recognition will enhance its versatility across various regions.

Moreover, the integration of the VNPR system with IoT and cloud computing technologies will enable real-time vehicle tracking, efficient database management, and automated security notifications. The application of AI-driven anomaly detection will assist in identifying stolen vehicles, unauthorized access, and fraudulent activities, thereby increasing the system's efficacy for law enforcement and intelligent traffic management.

COURSE CERTIFICATION

udemy

Certificate no: UC-d0a8a8f8-5e95-4522-aff2-5ea58801acfd
Certificate url: ude.my/UC-d0a8a8f8-5e95-4522-aff2-5ea58801acfd
Reference Number: 0004

CERTIFICATE OF COMPLETION

DATA SCIENCE with MACHINE LEARNING and DATA ANALYTICS

Instructors **DATAhill Solutions Srinivas Reddy**

Srividya

Date **March 12, 2025**
Length **72.5 total hours**

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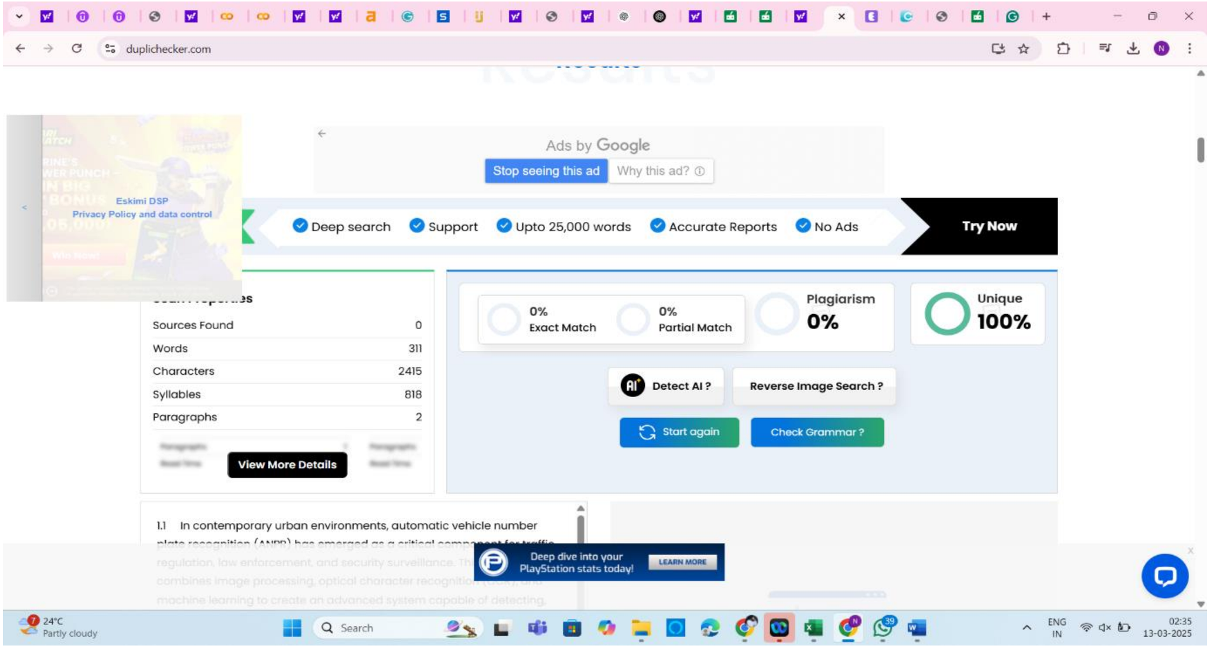
PLAGIARISM REPORT

(Project Report & Paper)



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INTERNAL QUALITY ASSURANCE CELL

MICRO PROJECT AUDIT REPORT

This is to certify that the micro project work entitled "Automated Number Plate Recognition with Predictive Traffic Analytics" categorized as an internal project done by Nimmala Srividya of the Department of Computer Science and Engineering, under the guidance of Ms. Vetri Selvi during the Even semester of the academic year 2024 - 2025 are as per the quality guidelines specified by IQAC.

Quality Grade

Deputy Dean (IQAC)

Administrative Quality Assurance **Dean (IQAC)**

APPENEDIX

(Project Code)

```
!pip install cv

!pip install  pytesseract

!pip install  numpy

!pip install  imutils

!pip install  matplotlib

import cv2

import pytesseract

import numpy as np

import imutils

import matplotlib.pyplot as plt


# Set Tesseract OCR Path for Linux

pytesseract.pytesseract.tesseract_cmd = r"/usr/bin/tesseract"  # Corrected path

# Load the image

image = cv2.imread("/content/cars.jpg.crdownload")

image = imutils.resize(image, width=600)


# Convert to grayscale

gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)


# Apply noise reduction & edge detection
```

```
blurred = cv2.GaussianBlur(gray, (5, 5), 0)

edges = cv2.Canny(blurred, 50, 200)


# Find contours in the image

contours = cv2.findContours(edges.copy(), cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)

contours = imutils.grab_contours(contours)

contours = sorted(contours, key=cv2.contourArea, reverse=True)[:10]


# Initialize number plate contour

number_plate = None


# Loop through contours to find a potential number plate

for contour in contours:

    peri = cv2.arcLength(contour, True)

    approx = cv2.approxPolyDP(contour, 0.02 * peri, True)


    if len(approx) == 4:  # Number plates are usually rectangular

        number_plate = approx

        break


# If a number plate is found, extract it

if number_plate is not None:

    mask = np.zeros(gray.shape, dtype=np.uint8)

    cv2.drawContours(mask, [number_plate], 0, 255, -1)
```

```
masked_image = cv2.bitwise_and(gray, gray, mask=mask)

# Apply Adaptive Thresholding for character segmentation
threshold = cv2.adaptiveThreshold(masked_image, 255, cv2.ADAPTIVE_THRESH_GAUSSIAN_C, cv2.THRESH_BINARY, 11, 2)

# Use OCR to extract text
extracted_text = pytesseract.image_to_string(threshold, config='--psm 8')

# Show the detected number plate and thresholded image
plt.figure(figsize=(10, 5))

plt.subplot(1, 3, 1)
plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
plt.title("Original Image")
plt.axis("off")

plt.subplot(1, 3, 2)
plt.imshow(masked_image, cmap="gray")
plt.title("Extracted Plate")
plt.axis("off")

plt.subplot(1, 3, 3)
plt.imshow(threshold, cmap="gray")
plt.title("Thresholded Plate (For OCR)")
```

```
    plt.axis("off"

    plt.show()

    print("Extracted Number Plate Text:", extracted_text.strip())

else:
    print("No number plate detected.")
df = pd.read_csv("/content/vehicle_data.csv", parse_dates=["Timestamp"])

# Convert Timestamp to hours for time-based analysis
df["Hour"] = df["Timestamp"].dt.hour

# Display first few rows
print(df.head())

# -------------------------------
# *1. Vehicle Frequency Analysis*
# -------------------------------
vehicle_counts = df["Vehicle_Number"].value_counts()
print("\nMost Frequent Vehicles:")
print(vehicle_counts.head())

# Plot vehicle frequency
```

```python
plt.figure(figsize=(8, 4))

sns.barplot(x=vehicle_counts.index[:5], y=vehicle_counts.values[:5], palette="coolwarm")

plt.xlabel("Vehicle Number")

plt.ylabel("Number of Entries")

plt.title("Top 5 Most Frequent Vehicles")

plt.xticks(rotation=45)

plt.show()


# --------------------------------

# *2. Traffic Pattern Analysis*

# --------------------------------

hourly_counts = df.groupby("Hour").size()


# Plot peak traffic hours

plt.figure(figsize=(8, 4))

sns.lineplot(x=hourly_counts.index, y=hourly_counts.values, marker="o", color="b")

plt.xlabel("Hour of the Day")

plt.ylabel("Vehicle Count")

plt.title("Traffic Trend Throughout the Day")

plt.xticks(range(0, 24))

plt.grid()

plt.show()


# --------------------------------
```

```
# *3. Location-Based Analysis*

# --------------------------------

location_counts = df["Location"].value_counts()


plt.figure(figsize=(8, 4))

sns.barplot(x=location_counts.index, y=location_counts.values, palette="viridis")

plt.xlabel("Location")

plt.ylabel("Vehicle Count")

plt.title("Vehicle Count by Location")

plt.xticks(rotation=45)

plt.show()


# --------------------------------

# *4. Anomaly Detection (Fraud Detection)*

# --------------------------------

# Convert categorical vehicle numbers to numerical IDs

df["Vehicle_ID"] = df["Vehicle_Number"].astype("category").cat.codes


# Feature selection for anomaly detection

features = df[["Vehicle_ID", "Hour"]]


# Train Isolation Forest model

model = IsolationForest(contamination=0.1, random_state=42)

df["Anomaly"] = model.fit_predict(features)
```

```
# Filter out anomalies (label -1 means outlier)
anomalies = df[df["Anomaly"] == -1]
print("\nDetected Anomalous Vehicle Entries:")
print(anomalies)

# Plot anomalies
plt.figure(figsize=(8, 4))
sns.scatterplot(data=df, x="Hour", y="Vehicle_ID", hue="Anomaly", palette={1: "blue", -1: "red"})
plt.xlabel("Hour of the Day")
plt.ylabel("Vehicle ID")
plt.title("Anomalous Vehicle Detection")
plt.show()
```