Evaluation and Design of Automatic License Plate Recognition System

Minor Project Report

Submitted for the partial fulfillment of the degree of

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Artificial Intelligence and Machine Learning

Submitted By

Eshita Nagariya

0901AM211023

Surabhi Verma

0901AM211059

UNDER THE SUPERVISION AND GUIDANCE OF

Prof. Geetika Hazra

Assistant Professor

Centre for Artificial Intelligence

माधव प्रौद्योगिकी एवं विज्ञान संस्थान, ग्वालियर (म.प्र.), भारत

MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR (M.P.), INDIA

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January-May 2024

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(0901AM211023)

Surabhi Verma

0901AM211059

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Guided By:

Prof. Geetika Hazra
Assistant Professor
Centre for Artificial Intelligence
MITS, Gwalior

Departmental Project Coordinator

Dr. Tej Singh
Assistant Professor
Centre for Artificial Intelligence
MITS, Gwalior

Approved by Coordinator

Dr. R.R. Singh
Coordinator
Centre for Artificial Intelligence
MITS, Gwalior

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(0901AM211023)

Surabhi Verma

0901AM211059

Checked & Approved By:

Dr. Pawan Dubey
Assistant Professor
Centre for Artificial Intelligence
MITS, Gwalior

ABSTRACT

Automatic License Plate Recognition (ALPR) systems have gained significant attention in recent years due to their wide range of applications in law enforcement, traffic management, and security surveillance. In this work we introduces an Automatic License Plate Recognition (ALPR) system leveraging EasyOCR and YOLO (You Only Look Once) algorithms. The proposed system integrates EasyOCR for optical character recognition (OCR) and YOLO for license plate detection, utilizing the efficiency and accuracy of these technologies. The YOLO algorithm enables real-time license plate detection by dividing the image into grid cells and predicting bounding boxes and class probabilities simultaneously. EasyOCR, on the other hand, excels in text recognition tasks, accurately extracting characters from license plate regions detected by YOLO. The combined system offers robust performance in handling variations in lighting conditions, occlusions, and non-standard license plate formats. Furthermore, the integration of these technologies enhances the system's adaptability and scalability, making it suitable for deployment in diverse environments. The paper discusses the implementation details, performance evaluation, and potential applications of the proposed ALPR system, highlighting its efficiency and effectiveness in automating license plate recognition tasks

Keyword : Automatic License Plate Recognition, ALPR, EasyOCR, YOLO, Optical Character Recognition, OCR, Image Processing, Deep Learning, Object Detection, Efficiency, Accuracy, Occlusions, Non-standard License Plate Formats, Implementation, , Deployment, Automation, Technology Integration.

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Eshita Nagariya

(0901AM211023)

Surabhi Verma

0901AM211059

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ACRONYMS

Dfl	Distribution Focal Loss
mAP50	Mean Average Precision at threshold of 0.5
mAP95	Mean Average Precision threshold of 0.95

NOMENCLATURE

lr/pg0 : learning rate for the backbone weights.

lr/pg1 : learning rate for the YOLO layers' weights.

lr/pg2 : learning rate for any additional parameters, such as biases.

loss_bbox: a loss that measures how "tight" the predicted bounding boxes are to the ground truth object (usually a regression loss, L1, smoothL1 etc.).

loss_cls: a loss that measures the correctness of the classification of each predicted

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

ALPR (Automatic License Plate Recognition) technology automatically identifies license plate characters, finding use in law enforcement, traffic management, and security. Combining hardware like cameras with software featuring image processing and OCR algorithms, ALPR systems accurately detect and extract plate information, aiding in vehicle tracking, traffic monitoring, and security surveillance. Despite privacy concerns, ALPR's evolution driven by advancements in image processing and AI emphasizes its crucial role in modern transportation and security.

1.1 Objectives

1.1.1 **Efficient Vehicle Tracking :** Enable tracking and monitoring of vehicles for law enforcement, traffic management, and security purposes.

1.1.2 **Enhanced Security :** Identify vehicles of interest, such as stolen vehicles or vehicles associated with criminal activities, to enhance public safety and security.

1.1.3 **Improved Traffic Management :** Assist in traffic flow monitoring, congestion detection, and toll collection by automating license plate identification.

1.1.4 **Data Analysis :** Provide data insights through analysis of vehicle movement patterns, aiding in decision-making for urban planning and law enforcement strategies.

1.2 Functional Requirements:

- Capture clear images of vehicles entering the monitored area.
- Process images to detect license plates accurately.
- Perform optical character recognition (OCR) to extract characters from the license plates.
- Compare extracted characters against a database for identification and verification.
- Interface with external systems for data sharing and alerts.
- Provide real-time monitoring and reporting capabilities.

1.3 External Interface Requirements:

1.3.1 **Hardware Interfaces :** Hardware requirements for an ALPR system include high-resolution cameras, powerful CPUs or GPUs for image processing, ample RAM for data handling, storage drives for storing images and databases, networking equipment for data transfer, power backup, mounting hardware, and environmental protection measures for outdoor installations.

1.3.2 **Software Interfaces :** Software requirements for an ALPR system utilizing YOLO (You Only Look Once) for license plate detection and OCR (Optical Character Recognition) include YOLO-based object detection software, OCR libraries such as Tesseract or EasyOCR, image preprocessing tools, database management software for storing and retrieving license plate data, and integration frameworks for linking components and facilitating real-time processing and analysis.

1.4 Non-Functional Requirements :

1.4.1 **Accuracy:** Ensure high accuracy in license plate detection and character recognition to minimize false positives and negatives.

1.4.2 **Scalability:** Design the system to handle varying workloads and scale seamlessly to accommodate increased data volume and processing demands.

1.4.3 **Reliability:** Ensure consistent performance under different environmental conditions and operational scenarios to maintain system integrity.

Security: Implement measures to secure data, prevent unauthorized access, and comply with privacy regulations to protect sensitive information.

CHAPTER 2: LITERATURE SURVEY

2.1 Automatic License Plate Recognition Systems:

[1] introduced an ALPR system utilizing Optical Character Recognition (OCR) for vehicle identification. Their system focused on recognizing characters on license plates, leveraging OCR techniques. By integrating OCR into the ALPR pipeline, the system demonstrated promising results in accurately identifying license plates, contributing to the field's advancement in character recognition within ALPR

2.2 YOLO (You Only Look Once) Algorithm:

In Indonesia, Iriawan et al. (2023) implemented an ANPR system using YOLOv8 (a deep learning framework) combined with the EasyOCR algorithm. This work was presented at the 6th International Conference on Information and Communications Technology in 2023 [2].

2.3 Optical Character Recognition (OCR) Methods:

Jain et al. (2023) introduced an adaptive framework for recognizing original handwritten numerical digits using OCR methods, contributing to the development of artificially intelligent readers [4].

2.4 Integration of YOLO and OCR in ALPR System:

Safran et al. (2024) proposed an efficient multistage license plate detection and recognition system using YOLOv8 and Convolutional Neural Networks (CNNs), particularly focusing on applications in smart parking systems. This study was published in the Journal of Sensors in 2024 [3]. A comprehensive survey by Shashirangana et al. (2020) discussed various methods and techniques employed in automated license plate recognition, providing insights into the state-of-the-art approaches in this domain [5].

Additionally, platforms like Roboflow Universe [6] offer resources and tools for developing ANPR systems and other computer vision applications, potentially enhancing research and development efforts in this field.

CHAPTER 3: METHODOLOGY:

3.1 Data Collection:

License plate recognition datasets contain images and videos capturing vehicles with visible license plates. These datasets are used for training machine learning models to accurately detect and recognize license plates. They typically include various lighting conditions, angles, and backgrounds to ensure robustness in real-world applications.

3.2 Importing Libraries:

Ultralytics.YOLO: This deep learning library is used for com[puter vision tasks such as real time object detection which is implemented using YOLO(You Only Look Once).

OpenCV: This library is used to manipulate images and videos of vehicles.

Util: This is a custom built module which defines the format of number plate and read the license number from the image.

CSV: This library is used to save the evalution results in csv format.

Scipy.interpolate: The interp1d function from the scipy.interpolate module performs one-dimensional interpolation of data points.

Easyocr: It is an Optical Character Recognition library used to read vehicle licence plate number.

3.3 Yolov8 model Summary :

The code set up two model for object detection on YOLO framework, coco_model for general vehicle detection which uses yolov8 pre-trained on COCO dataset and another fine tuned model (trained on local data) which achieved best evaluation metric on validation dataset. We obtained that the coco_model has 225 layers, 3157200 parameters and fine tuned model has 225 layers and 3011043 parameters.

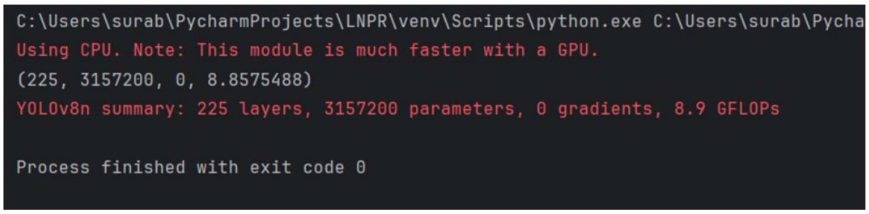

Fig 3.1 : Summary of coco model

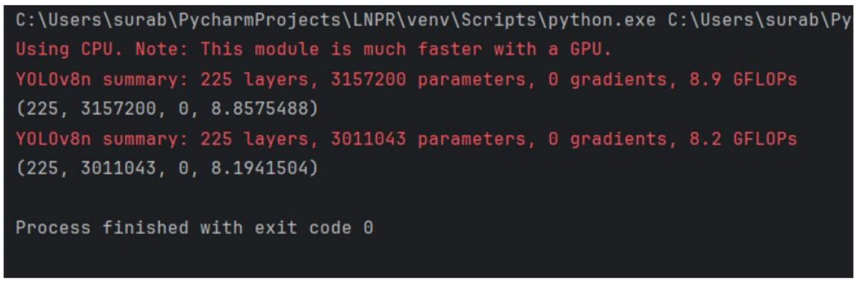

Fig 3.2 : Summary of license_plate_detector

3.4 Video loading

The input video is loaded using VideoCapture function of OpenCV library. It takes path of video as argument.

3.5 Object Detection (Vehicles):

Perform object detection using coco_model to detect various objects in the frame. Filter the detections to retain only vehicles based on prevdefined class IDs (vehicles list).

3.6 Object Tracking:

Update the object tracker (mot_tracker) using the filtered vehicle detections to track vehicles across frames.

3.7 License Plate Detection:

Perform license plate detection using license_plate_detector to identify regions containing license plates. For each detected license plate, associate it with a tracked vehicle (if possible) using get_car function.

3.8 License Plate Recognition:

Crop the detected license plate region from the frame. Process the cropped license plate image (e.g., convert to grayscale, thresholding).

Use read_license_plate function to extract and recognize the text from the processed license plate image.

Fig 3.3: License Plate Detection

3.9 Results Storage:

Store the processed information (vehicle bounding boxes, associated license plate details) in the results dictionary indexed by frame number and vehicle ID.

3.10 Visualization of mp4 video:

Load a input video file and read each frame from it and initializes an output video file. For each frame, it retrieves data from a DataFrame (`results`) based on the frame number.It iterates over each row in the DataFrame, extracting vehicle licence plate number. After this overlay a orange rectangle box over the detected license plate number. Processed frames with drawn orange color boundary box and license plate numbers are written to the output video file. After processing all frames the output video is released in output folder.

CHAPTER 4: EVALUATION

Evaluation on Training dataset :

box_loss	2.103
cls_loss	2.2096
dfl_loss	2.4839

Evaluation on validation dataset :

box_loss	1.5161
cls_loss	1.2668
dfl_loss	1.7641

Evaluation Metrices :

precision	0.92131
recall	0.80176
mAP50	0.85629
mAP50-95	0.49363
lr/pg0	0.000666
lr/pg1	0.000666
lr/pg2	0.000666

CHAPTER 5: FINAL ANALYSIS AND DESIGN:

5.1 UI using Streamlit :

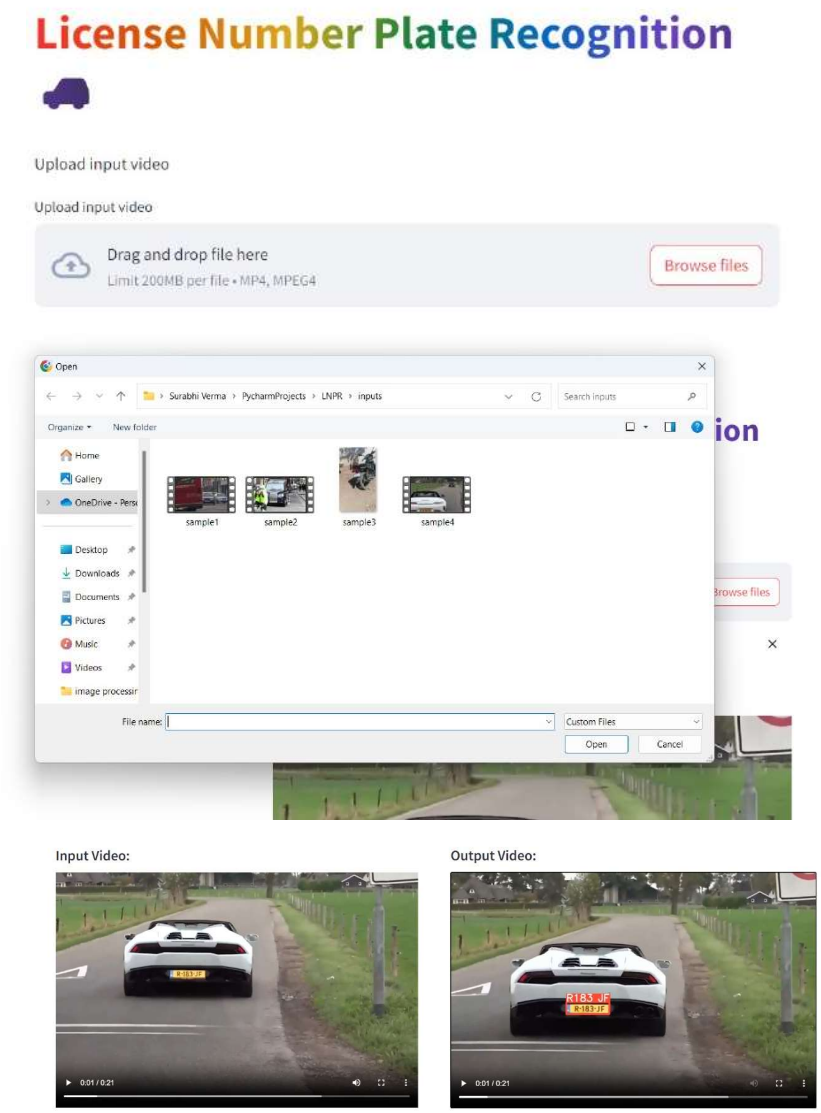

Fig 5.1 : Streamlit User Interface

5.2 Results

5.1.1 Input

Fig 5.2 : Input Frame 1 of video

Fig 5.3 : Input Frame 2 of video

5.1.2 Output:

Fig 5.4 : Output Frame 1 of video

Fig 5.5 : Output Frame 2 of video

CHAPTER 6: CONCLUSION

6.1Conclusion:

An effective method for precisely recognizing license plates from photos or video streams is provided by the combination of YOLOv8 for object detection and EasyOCR for text recognition in automatic license plate recognition (ALPR) systems. YOLOv8 locates license plates and recognizes automobiles with efficiency, while EasyOCR reliably extracts text from these areas. This combination strategy makes it possible to create ALPR systems that are reliable, accurate, and versatile in real time.

6.2 Application :

Law Enforcement and Security: It can be used to detect whether any vehicle involved in criminal activities or not .It is possible in a way such that particular vehicle number plate is found on any crime report or not.

Parking Management: It can be utilised for automation of parking system to check wheather particular vehicle belong to colony or not , if not then park it at only if has permission letter.

Toll Collection: It can be used to depict the tax amount for particular vehicle passing through the toll plaza and provide convenience to general public.

Traffic Monitoring and Statistics: It can be used for providing statistics for how much traffic usually present in particular area.

6.3 Problem Faced:

Developing automatic license plate recognition (ALPR) systems poses challenges such as variations in license plate designs, fonts, lighting conditions, and vehicle angles. Additionally, occlusions, reflections, and motion blur can hinder accurate detection and recognition. Limited availability of diverse and annotated datasets for training deep learning models further complicates development. Ensuring real-time performance while maintaining high accuracy is another significant hurdle. Furthermore, privacy concerns and regulatory issues regarding the collection and storage of license plate data add complexity. Addressing these challenges requires robust algorithms, extensive testing, and adherence to privacy regulations to create reliable and ethically sound ALPR solutions.

6.4 Limitation:

Automatic license plate recognition (ALPR) systems, despite their advancements, still face several limitations. Challenges include poor lighting conditions, obscured or damaged plates, variations in plate designs across regions, and font recognition accuracy. Additionally, ALPR systems may struggle with accurately identifying plates at high speeds or in congested traffic scenarios. Privacy concerns regarding the collection and storage of license plate data also pose ethical considerations. Moreover, the effectiveness of ALPR can be hindered by the lack of standardization in license plate formats and the potential for system errors or false positives. These factors collectively contribute to the ongoing refinement needed in ALPR technology.

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