YOLO based Real-time Bangladeshi vehicle license plate identification

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FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "**YOLO based Real-time Bangladeshi vehicle license plate identification**", submitted by **Md. Tarakuzzaman Faysal** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on **15-07-2024**.

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ABSTRACT

(ALPR) Automatic License Plate identification plays a crucial role in traffic management, security applications, tools collection and various aspects of modern life. Every country has their own unique license plate model. For this reason, in every country, we need to use different dataset containing their license plate and different models to develop license plate identification. This research explores the application of YOLOv9, which are a powerful deep learning model, for real-time Identification of Bangladeshi license plates and it is so fast and efficient. The proposed approach involves training YOLOv9 on a comprehensive dataset, which has a large number of Bangladeshi license plates images of various angle, various lighting condition and various weather condition taken by mobile phone camera by me. This proposed system addresses the specific challenges associated with Bangladeshi license plates, including their unique format, classes, types and potential variations in lighting and environmental conditions. As of my knowledge there are no robust dataset available for this research. I have collected more than 4000 Bangladeshi license plate images with various angles, weather conditions and different lighting conditions. Importantly, I have collected all the classes and types of Bangladeshi license plate images for robust recognition. I train the dataset with YOLOv8m & YOLOv9c framework. YOLO (You Only Look Once) is known for fastest and efficient recognition of small characters like license plate. My proposed model achieved 96.54% accuracy for detecting all types of license plate in Bangladesh including Army, Navy, Air-force. There are existing papers available there has up to 95% accuracy rate for detecting license plate although they did not use all the classes and types of images of Bangladeshi license plates. So, I used all the types and classes of images for robust detection of Bangladeshi license plate. The proposed solution improves ALPR by including YOLOv9, a cutting-edge deep learning model, to enable rapid and accurate license plate identification. For recognition characters I used EasyOCR technique and I achieved 86.67% accuracy of identification the characters. My proposed approach has the potential to transform traffic management, security, and applications in Bangladesh, allowing for automated toll collection, improved traffic analysis, and enhanced security measures.

Keywords: ALPR, YOLOv8, YOLOv9, EasyOCR.

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LIST OF ACRONYMS

Acronym	Full form
YOLO	You Only Look Once
OCR	Optical Character Recognition
CR	Character Recognition
SVM	Support Vector Machine
CNN	Convolutional Neural Network
CM	Confusion Matrix
SWOT	Strengths, Weaknesses, Opportunities, and Threats
ALPR	Automatic License Plate Recognition
LPD	License Plate Detection

CHAPTER 1
Introduction

1.1 Overview

Real-time License Plate Recognition (RLPR) technology offers indicative advantages in traffic management, vehicle tracking, counting, collecting tolls, security, and access control by automating vehicle identification on the road. This research focuses on developing a real-time recognition YOLOv9 specifically designed for Bangladeshi License plate since there are various types and classes of Bangladeshi license plate. In Bangladesh the Number of vehicles is increasing day by day. Due to increasing vehicles endlessly the control of traffics in cities gets way more problem than ever. Alongside there are Six types of vehicles such as, Private, Commercial, Diplomatic, Army, Navy, Airforce. There are 32 classes of license plates are available in Bangladesh. Such as, অ, ই, উ, এ, ক, খ, গ, ঘ, চ, ছ, জ, ঝ, ত, থ, ঢ, ড, ট, ঠ, দ, ধ, ন, প, ফ, ব, ভ, ম, য, র, ল, শ, স, হ

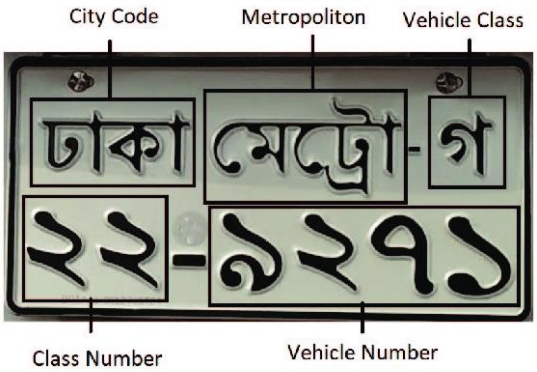


Figure 1.1.1: BRTA Standard Bangladeshi License plate.

Due to many classes of License of bangladesh it challenges for being this unique plate format. For example, 'DHAKA METRO-HA 11-1111', "ঢাকা মেট্রো-হ ১১-১১১১". There are also many city codes available in Bangladesh license plate like Dhaka, Gazipur, Rangpur and so on and all are in Bangla language. And there are 64 area code like Gazipur, Dhaka, Rangpur, Feni, Dinajpur, Sylhet and so on in Bangladeshi License plate in Bangla language. The RLPR technology in optimizing

traffic management, tolls collection, vehicle tracking, security, and access control inspires this research to explore its potential benefits in Bangladesh. This research aims to develop a real-time RLPR system. This proposed system specifically designed for Bangladeshi license plates as there are many classes and types of license plate in Bangladesh. By leveraging the capabilities of YOLO (You Only Look Once), a powerful deep learning model and Optical Character Recognition (EasyOCR), the system aims to address the unique challenges posed by Bangladeshi license plate format and diverse lighting conditions, various angles and weather conditions. Ultimately, this RLPR project aspires to contribute to improved our city life traffic flow, enhanced more security, tolls collecting, tracking and finding vehicles, and streamlined access control in Bangladesh. This RLPR system paving the way for a more efficient and secure nation. Real-time license plate recognition focuses exclusively on developing a real-time RLPR system for Bangladeshi license plates. It excludes broader applications like vehicle identification or vehicle classification. This process utilizes YOLOv9 for detection and recognition, aiming for real-time processing. This project will be evaluated using standard metrics such as precision and recall to ensure its effectiveness and simultaneous for real-world applications. This project expects the successful development an efficient real-time RLPR system specifically built for Bangladeshi vehicles. The system intends to accurately recognize and extract all types and classes of license plate information under various lighting, viewing angle and environmental conditions by EasyOCR. A new Dataset has to be added and trained YOLOv8 & YOLOv9 model configured for Bangladeshi license plates. It has the capability of demonstrating real-time detection and recognition accurately. EasyOCR a fastest way to recognize vehicle types and classes on the road in real-time. This outcome is expected to contribute significantly to the advancement of RLPR technology in Bangladesh. A study focuses on license plate recognition using live video streams. In a research they used TensorFlow object detection techniques deep Convolutional Neural Network to detect license plates in real-time and character recognition from detected license plate Islam et al. (2019). Another study used YOLLOv7 models and WBF for detection license plate and after detection license plate they implemented LOG-RSF model for extraction characters from license plate Ahmed et al. (2022).

1.2 Background and Present state

Bangladesh, a country with a rapidly expanding population and an equal increase in automobiles, has a serious problem controlling traffic congestion. The frequency with which gridlock occurs now has an adverse effect on economic productivity, public safety, and general well-being. The dynamic nature of traffic flow makes traditional systems, which rely on human data gathering and analysis, difficult to keep up with. In order to solve these traffic management problems, this project suggests a real-time automatic license plate recognition (ALPR) system designed especially for Bangladeshi license plates. The suggested ALPR system enables continuous vehicle movement tracking, allowing authorities to spot bottlenecks, track traffic trends in real time, and dynamically improve signal timings. This translates to improved traffic flow and less congestion, resulting in a more efficient transportation network. The proposed system can help law enforcement identify stolen automobiles, track down traffic violators, and even bolster border security efforts. This real-time identifying capacity has the potential to discourage illegal activities while also improving general traffic safety in Bangladesh. Furthermore, the proposed ALPR technology has the potential to revolutionize data collection. Manual approaches are frequently slow, prone to errors, and have a limited scope. In contrast, the system can automatically collect massive amounts of traffic data, providing significant insights into traffic management tactics and infrastructure development. Importantly, the research will verify that the system can correctly read Bangladeshi license plates even under difficult settings such as sunlight, angles, or occlusions. Creating a real-time Bangladeshi license plate recognition system provides a data-driven approach to traffic management, resulting in a more efficient, secure, and ultimately enjoyable traffic experience for Bangladeshis

1.3 Problem statement

Bangladesh's traffic problems, exacerbated by population increase and automobile ownership, necessitate new solutions. Traditional manual traffic control techniques are insufficient for the dynamic nature of traffic flow. This project presents a real-time automatic license plate recognition (ALPR) system tailored to Bangladeshi license plates. Manual data collecting is slow, prone to errors, and has limitations. Real-time ALPR provides continuous vehicle surveillance, allowing authorities to spot bottlenecks, track traffic patterns, and dynamically optimize signal timings. This leads to smoother traffic flow and better traffic management. Furthermore, ALPR helps law enforcement detect stolen vehicles, trace violators, and improve overall road safety. This study tries to overcome these challenges by creating a real-time license plate identification system that employs YOLOv9 for detection and EasyOCR for character recognition. The suggested system uses advanced deep learning and computer vision techniques to improve the accuracy and efficiency of license plate recognition under a variety of scenarios. This system will help law enforcement identify and penalize traffic violators, track unregistered vehicles, and better regulate traffic flow, ultimately enhancing overall road safety and contributing to the upgrading of Bangladesh's traffic management infrastructure.

1.4 Objective

The major goal of this project is to create a reliable and efficient real-time license plate identification system adapted to Bangladesh's specific demands, employing YOLOv9 for detection and EasyOCR for character recognition. This broad purpose can be divided into various distinct objectives.

- **Designing and developing the recognition system:**

To develop a comprehensive system for reliably detecting and recognizing Bangladeshi license plates in a variety of environmental situations, including lighting, angles, and weather. To incorporate YOLOv9 for high-speed, real-time object detection and EasyOCR for precise character recognition, ensuring that the system meets the accuracy and

efficiency criteria for practical use.

- **Improve Traffic Law Enforcement:**

To aid law enforcement authorities in quickly discovering and penalizing traffic rule violations, such as speeding, illegal parking, and unauthorized vehicle use.

To allow for the automatic identification and tracking of unregistered, stolen, or questionable automobiles, consequently improving public safety and lowering the frequency of vehicular crimes.

- **Optimize traffic management:**

To give real-time data on vehicle movement and traffic patterns so that traffic authorities can better control congestion and optimize traffic flow in urban areas.

To aid in the planning and implementation of traffic control measures by providing accurate and timely information about traffic conditions.

- **Support Data-Driven Decision Making:**

To make it easier to gather and analyze complete traffic data, authorities may identify problem regions, influence policy decisions, and prepare for future infrastructure improvements. To help build a centralized database of traffic offenses and vehicle movements, which will aid in long-term traffic management and policy design.

- **Promote technological advancements:**

To demonstrate the relevance and usefulness of sophisticated deep learning and computer vision techniques in real-world problem solving, with the goal of promoting future research and development in this area. To create a scalable and adaptive system that can be quickly adopted in multiple locations and tailored to different types of license plates and environmental conditions.

1.5 Scope and Limitations

The scope of this project is the creation and implementation of a real-time license plate identification system adapted specifically for Bangladesh, with YOLOv9 for detection and EasyOCR for character recognition. The project intends to handle a variety of traffic management difficulties, such as strengthening law enforcement, tracking unregistered vehicles, and managing traffic congestion by accurately and efficiently recognizing vehicle license plates. The system will be designed to perform under a variety of environmental situations, including changing illumination, weather, and angles. It will be tested against a large dataset of Bangladeshi license plates to ensure its robustness and dependability. The project will also look into integrating this technology with existing traffic management infrastructure to provide real-time data and support to law enforcement agencies. However, there are certain limits to consider. Poor image quality, obstructed license plates, and extreme weather conditions can all have an impact on the system's accuracy. Another potential constraint is EasyOCR's ability to recognize characters from license plates with unique fonts or patterns. Furthermore, the implementation of this system necessitates large computational resources and infrastructure, which may pose barriers to wider adoption, particularly in rural areas with low technological capabilities. Despite these constraints, the study intends to develop a scalable and adaptive solution that can considerably enhance traffic management and enforcement in Bangladesh, setting the way for future technological advances in this field.

1.6 Report Organization

Chapter 1: Introduction

The study is introduced in this chapter, which also gives background information on Bangladesh's need for an effective system for recognizing license plates. It describes the problem description, the goals of the research, and the project's overall importance.

Chapter 2: literature review

This section explores the body of knowledge on deep learning models, license plate recognition systems, and their applications from earlier studies. It points up weaknesses in the approaches used currently, which this study seeks to fill.

Chapter 3: methodology/ requirement analysis & design specification

This chapter describes the technical foundation, data collection techniques, and study design that went into creating the recognition system. It consists of an extensive design specification as well as a study of the system requirements.

Chapter 4: experimental result

The experiments with EasyOCR for character recognition and YOLOv9 for detection are presented in this chapter. Performance indicators, accuracy assessments, and graphic depictions of the results are all included.

Chapter 5: result and analysis

An extensive examination of the experimental findings is given in this section. It analyzes the system's efficacy, juxtaposes it with other options, and explains the implications of the results.

Chapter 6: impact on society, environment and sustainability

The wider effects of the research findings on Bangladeshi public safety, law enforcement, and traffic management are examined in this chapter. It also discusses the sustainability of the suggested system and environmental factors.

Chapter 7: conclusion and future work

The study's main conclusions are outlined in the last chapter, along with recommendations for real-world implementations. It also suggests possible directions for further study, emphasizing ways to develop or enhance the current work.

1.7 Summary

This paper describes the creation of a real-time license plate identification system tailored exclusively for Bangladesh, using YOLOv9 for detection and EasyOCR for character recognition. The study focuses on the need for effective traffic management and law enforcement solutions in Bangladesh. The research begins with an introduction that explains the project's goals and significance, followed by a literature assessment that identifies gaps in existing approaches. The methodology chapter describes the research strategy, data collection procedures, and technical framework. Experimental data are shown, demonstrating the system's performance and accuracy. A thorough analysis explains these findings, comparing them to existing solutions. The influence on society, the environment, and sustainability are examined, with a focus on the research's broader ramifications. The report finishes with major findings, recommendations for practical applications, and ideas for further research. This research seeks to improve traffic management and public safety in Bangladesh by utilizing innovative technology.

CHAPTER 2
Background

2.1 Overview

To develop a real-time ALPR system for Bangladesh, it is necessary to comprehend essential words and concerns particular to the local context.

- **Terminologies:**

BRTA Standards: The Bangladesh Road Transport Authority (BRTA) regulations specify the format and layout of license plates used in the country. Understanding these standards (e.g., color scheme, font style, character alignment) is critical for training the ALPR system to recognize Bangladeshi plates accurately.

Data Augmentation: ALPR systems in Bangladesh face real-world challenges, such as intense sunshine, dust, and rain. Data augmentation approaches use artificial fluctuations in training data (brightness, noise, and blur) to improve the system's robustness to these situations.

Resource Constraints: Hardware restrictions are common in Bangladesh. To achieve real-time performance on easily available hardware, the project must investigate "lightweight" deep learning models or resource-efficient optimization strategies.

- **Preliminaries and Contextual Considerations:**

Traffic Scenario: Traffic in Bangladesh can be chaotic, with a variety of vehicle types (cars, motorcycles, and rickshaws) doing unpredictable movements. The ALPR system's design should account for these difficulties and be flexible to different traffic patterns.

Privacy concerns: Data privacy is a major global concern. The project must handle any privacy concerns related with ALPR adoption in Bangladesh while adhering to local data protection requirements. Integration into existing infrastructure: For effective deployment, the ALPR system must be smoothly integrated with Bangladesh's current traffic control infrastructure. This could include working with necessary authorities to create compatible data formats and communication protocols.

2.2 Related Works

In [3], A real-time license plate recognition system is essential for traffic management system. BangIa's license plate recognition systems rely on character segmentation and lack real-time capabilities. According to another paper traffic control and car owner identification are serious challenges in many nations, making it difficult to catch and penalize people who break traffic laws and drive too quickly. Automatic number plate recognition (ANPR) solutions are required to overcome this issue. However, problems such as high vehicle speeds, non-uniform number plates, language, and lighting conditions can all have an impact on identification rates [9]. Another author described Automatic License Plate Recognition (ALPR) systems are designed to identify and locate License Plates (LP) region from moving cars that are visible in image and recognizing character from license plate by OCR. This work presents a cascaded architecture for detecting license plates using YOLOv7, a cutting-edge object detection model, and a proprietary Bangla OCR engine. They achieve 96% accuracy for detecting license plate and 97% accuracy on recognizing the characters from this. They have used 1928 images to create their dataset. With the exception of Army, Police, Government vehicles they used practically every vehicle image for making their dataset [2]. In a Research [1] the dataset includes 1500 Bangladeshi vehicle license plate images trained with the YOLOv3 method, as well as a Bangla scene character dataset trained with a deep Convolutional Neural Network based on ResNet-20 which contain more than 6400 characters. This research [8] presents a two-stage Convolutional Neural Network (CNN) based on the YOLO3 architecture to provide accurate ALPR for Jordanian license plates. The method employs temporal information to eliminate incorrect predictions and an array data structure to track vehicle license plates. The JALPR dataset is used to compare commercial software programs. In the research [10] describes a two-stage detection pipeline that incorporates a Vision API to improve real-time inference speed as well as detection and recognition accuracy. It employs a haar-cascade classifier, temporal frame separation, and generates an image and video dataset for license plate recognition in the wild. The research proposes an ideal end-to-end method for the ALPR system for Bangladeshi automobiles based on Deep Neural Network models, including an algorithm that removes segmentation and generates formatted output efficiently [11]. This paper [12] focuses on creating an algorithm for detecting license plates in Bangladesh using image processing and machine learning models which has three

steps, detection, shape verification, tilt correction, and recognition. For detection license plate they used the RGB color space, median filtering, binarization, morphological analysis, and region attributes. For character recognition part they used bounding box parameters, and recognition is achieved via Histogram Oriented Gradient (HOG) and Local Binary Pattern features. The suggested approach segments characters and recognizes number plates using LPR systems using Support Vector Machines (SVM). The process begins with a set of sample numbers, trains each character, and then tests each number separately to determine the maximum value between SVM outputs, which yields recognition results [16]. This research offers a robust ANPR system for License Plate Detection that uses deep neural networks to pre-process observed plates before conducting License Plate Recognition with the LSTM Tesseract OCR Engine [13]. This study refined a pre-trained SSD model using Tesseract tessdata-fast training data on over 2,000 license plate photos, along with a character segmentation technique, and tested it on 200 vehicles [14]. The suggested method [4] uses computer vision and YOLOv3 algorithms to identify Bangla number plates from different cities and automobiles. Convolutional neural networks are used for character recognition, and Tesseract optical character recognition is used for vehicle indexing. The study shows that computer vision and YOLOv3 have 91% and 95% accuracy in license plate detection, while Tesseract and convolutional neural network achieve 90% and 91.38% accuracy respectively.

2.3 Comparison between existing works

The research paper "YOLO based Real-time Bangladeshi vehicle license plate identification" presents a comparison study that is essential to comprehending the relative effectiveness and applications of optical character recognition (OCR) and advanced computer vision technologies. In the particular context of Bangladeshi license plate recognition, this study systematically evaluates the effectiveness of EasyOCR and the YOLOv9 object detection algorithm, contrasting these cutting-edge approaches with conventional image processing techniques. The study demonstrates the advantages and disadvantages of EasyOCR and YOLOv9 with respect to robustness, processing speed, accuracy, and environmental circumstances through extensive experimentation and

analysis. The paper demonstrates how YOLOv9's sophisticated deep learning capabilities allow for accurate and successful license plate recognition even in challenging and changing circumstances. In comparison, the efficiency of EasyOCR is examined, with a focus on how well it performs in various lighting and angle conditions while accurately extracting alphanumeric letters from the identified plates. The study illustrates how YOLOv9 and EasyOCR complement each other and shows how integrating them can improve the overall dependability of real-time license plate identification systems by contrasting both approaches. The results highlight how crucial it is to combine cutting-edge deep learning algorithms with conventional OCR approaches in order to produce better results in real-world scenarios. In conclusion, this comparative analysis provides a thorough assessment of EasyOCR and YOLOv9, opening the door for further developments in the automated license plate recognition space. It lays the groundwork for additional study, real-world applications, and advancements in associated technologies, all of which will lead to the development of more effective and efficient intelligent transportation system.

2.4 Open Issues

While the built real-time license plate detection and recognition system based on YOLOv9 and EasyOCR shows potential for enhancing traffic management in Bangladesh, a number of unresolved concerns remain. First, the system's accuracy under diverse environmental conditions, such as low lighting, extreme weather, and different angles, need additional improvement. These factors can have a considerable impact on the accuracy of license plate identification and character recognition. Furthermore, the system's performance may suffer with license plates with unusual fonts or designs, which is a prevalent problem in real-world circumstances. Another major issue is the computational power needed for real-time processing. The requirement for high-performance technology, notably GPUs, may limit the system's deployment, particularly in remote areas with poor technological infrastructure. Furthermore, integrating the system with current traffic management and law enforcement databases presents hurdles in terms of data privacy, security, and interoperability. Furthermore, the dataset used to train the models must be continuously expanded and updated to cover the wide diversity of license plates and situations

found in Bangladesh. Addressing these concerns is critical for strengthening the system and ensuring its practical application. Future study should concentrate on optimizing the system for different settings, improving data privacy safeguards, and expanding the dataset to increase overall performance and dependability.

2.5 Summary

Creating a YOLO based Real-time Bangladeshi vehicle license plate identification poses various obstacles. To begin, the diversity of license plate styles, typefaces, and colors in Bangladesh complicates the recognizing procedure. Furthermore, image quality varies owing to varied lighting settings, angles, and weather conditions, which affects detection and recognition accuracy. Another key difficulty is a lack of high-quality, annotated datasets relevant to Bangladeshi license plates, which impedes model training and evaluation. Furthermore, limited computer resources and the need for real-time processing hamper the system's construction and deployment

CHAPTER 3
Methodology

3.1 Overview

This project uses cutting-edge deep learning techniques to create and implement a real-time license plate recognition (LPR) system for automobiles in Bangladesh. The study focuses on successfully identifying license plates from video streams by utilizing YOLOv9, a cutting-edge object detection system. It also uses EasyOCR to handle the distinct Bangla script and numerals, as well as to identify and extract characters from the recognized plates. The objective of this study is to tackle the difficulties presented by the unique features of license plates from Bangladesh, including differences in font, size, and format, as well as the various environmental circumstances that arise in practical situations. We will carefully assess the system's performance in terms of processing speed, accuracy of recognition, and accuracy of detection. Additionally, an investigation will be conducted into how the LPR system may be integrated with the current automated toll collecting and traffic control infrastructure. The goal of this project is to improve traffic monitoring, law enforcement, and toll collecting systems in Bangladesh by offering a reliable, accurate, and efficient real-time license plate identification system.

3.2 Proposed Methodology

Datasets:

This is one of my main Contribution of my project. There are datasets existed of ALPR but size of images is low and they did not coverage all the license plate in Bangladesh. They did not include Army, Navy or Air Force License plate to their Dataset. I personally Included all those License plate images to make this devices Dataset. I captured over 6000 images and after removing some bad quality images I finally took 4047 images for Dataset. My dataset contains all types of License plate from different cities in Bangladesh. The captured images are in different lightning conditions, different angles, day and night images. After selecting 4047 images I annotated those images in Roboflow and trained with different preprocessing technique and augmentation technique to make robust Dataset. For preprocessing I used

Auto-oriented, resize to 640*640 and grayscale image. For augmentation I used 90 degree rotate to clockwise and counter clockwise, rotate between -15 degree to +15 degree and blur up to 1px. The primary dataset was split into 70% train data, 10% test and 20% validation data. After using augmentation technique the dataset was 9708 images and split by closely 87% training, 4% testing and 8% validation dataset.

TABLE 3.2.1: Raw Images Used in the Train, Test and Validation Sets

Train	Test	Validation
2833	405	809

TABLE 3.2.2: After Augmentation the final dataset

Train	Test	Validation
8494	405	809

Training YOLOv8m Model:

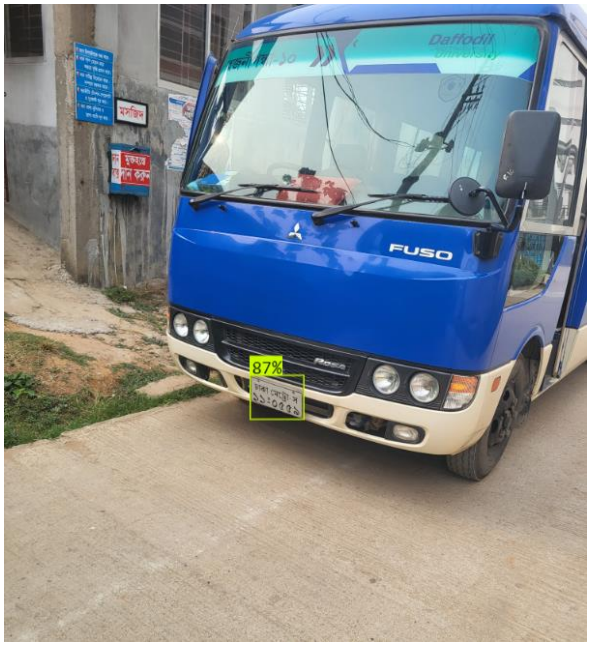
After making a robust Dataset of license plate there comes Training process. Since I have chosen YOLO framework for training. There are many versions of YOLO and the recent one is YOLOv8. And YOLOv8 has five variants. From those variants I chose YOLOv8m to train and make my custom model. In my training process the summary was model trained with 218 Layers and 25.84 million parameters and 78.7 GFLOPs. This custom YOLOv8m model can detect all types of Bangladeshi license plate included Army, Air-Force, Diplomatic and Navy license plate since there are difference between the general and those license plate. Detection was so accurate in any weather condition or blurry condition or even in less lighting condition. The custom model has no issues to detect different types of vehicle license plate.

YOLOv8:

YOLOv8 is quite good at detecting objects in real time. It uses two distinct strategies to accomplish this amazing achievement. To begin with, the Focus module functions as a spotlight by emphasizing key aspects for objects and muting background sounds. This simplifies the algorithm to enable quicker detection. Secondly, feature maps from different scales are combined using the Path Aggregation Network (PAN). This makes it possible for YOLOv8 to accurately identify objects by capturing both high-level information (such as "car") and low-level characteristics (such as automobile models). Improved mean Average Precision (mAP) for better object localization and classification, faster inference speeds on a single GPU, and even lower model sizes than its predecessors make it perfect for resource-constrained environments.

Training YOLOv9c Model:

For training YOLOv9c model I needed to create another small dataset 0f 1200 images because of GPU issue. Everything was same as YOLOv8n Dataset just has smaller amount of dataset. YOLOv9c has almost double amounts of layers add same amount or parameters. This custom model overperformed YOLOv8m even though the it contains smaller amount of dataset, smaller epochs and batch size. The model's detection result was so accurate. Some samples of detections are given below in different condition in Figure:3.2.1 & Figure: 3.2.2.



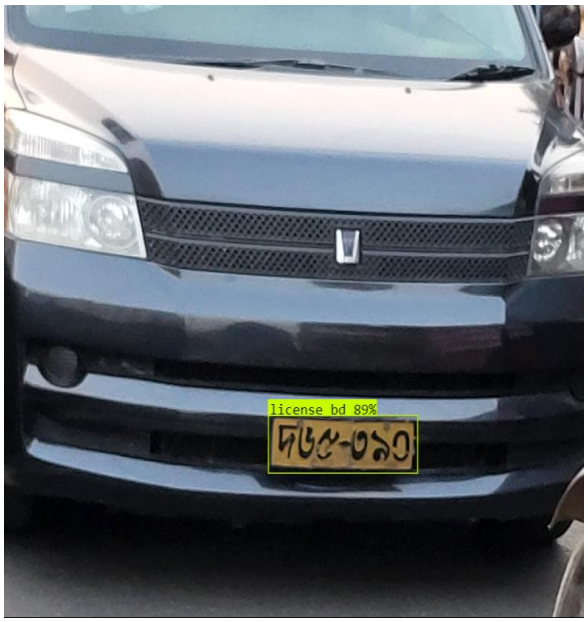


Figure 3.2.1: Detection results in normal daylight condition in different license plate

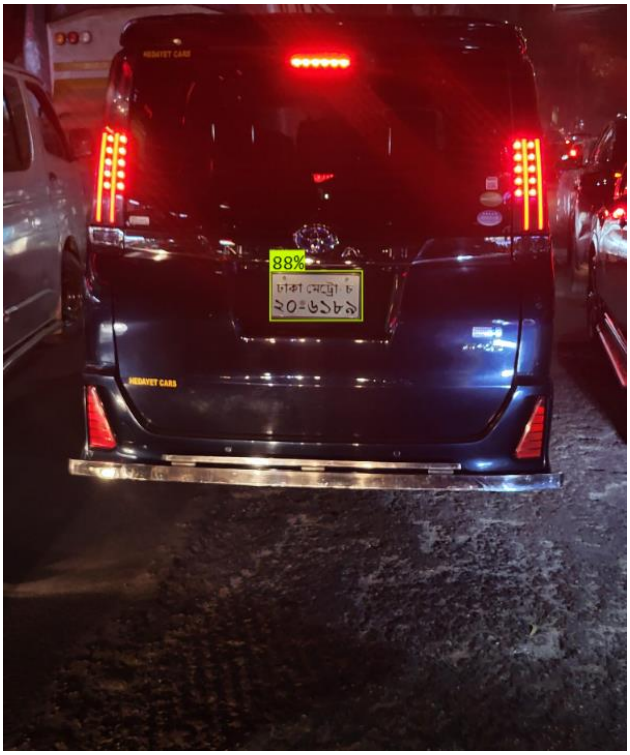


Figure 3.2.2: Detection in bad lighting & blurry condition

EasyOCR:

EasyOCR, an open-source Optical Character Recognition (OCR) application that supports more than 80 languages, including complicated scripts such as Chinese, Bangla, Japanese, and Korean. It uses deep learning, primarily convolutional recurrent neural networks (CRNNs), to identify and recognize text. EasyOCR is based on the PyTorch architecture, which makes it speedy and adaptable. I used EasyOCR for this project because of it's user-friendly API enables simple integration into a variety of applications while maintaining excellent accuracy and performance. This application can extract text from photos, scanned documents, and even videos, making it useful for character identification from License plate.

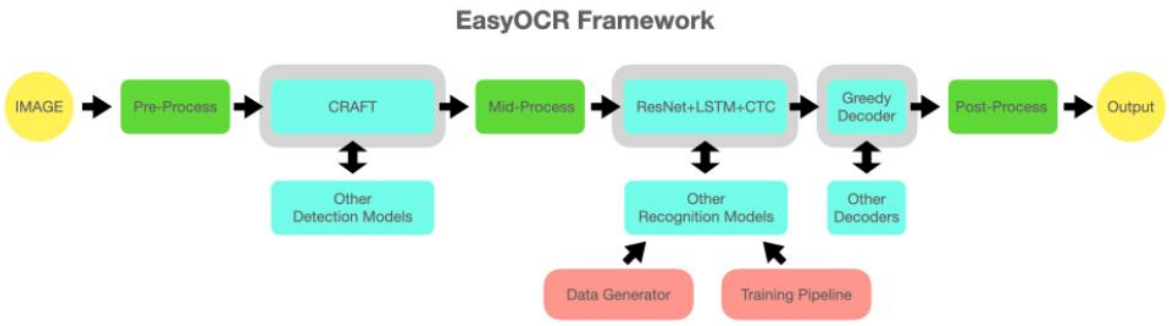


Figure 3.2.3: EasyOCR Framework

Process of Experiments

Process of this Experiment divided into three stages. First Collection of the raw image data to make dataset. After collection of images, it split for train, test, validation set for training process. Secondly, For training process, I used Roboflow. After making the dataset it trained with YOLOv9c model to make a custom model. Lastly from detected license plates the OCR model extracted the characters in it.

Image Acquisition:

Images were taken by myself from different road and different cities in Bangladesh. Images were taken in different angles of, different weather conditions, different daylight condition and night for robust result.

Image Augmentation:

In augmentation step I used three steps, 90 degree clockwise and counter-clockwise, Rotation between -15 degree and +15 degree, Blur up to 1px. By replicating different angles and a little blurriness, these strategies improve the dataset and increase the accuracy and robustness of the mode

Classification:

EasyOCR will be utilized in my project to identify and extract characters from license plate data that has been discovered. OCR will process the cropped images once YOLOv9 has identified and isolated the license plates in the video frames. It will translate the visual data into legible text by being specially taught or set up to handle Bangla script and numerals. Subsequently, this text data will be employed in further applications such as automated toll collection, traffic monitoring, and vehicle recognition, guaranteeing precise and effective real-time identification of Bangladeshi license plates.

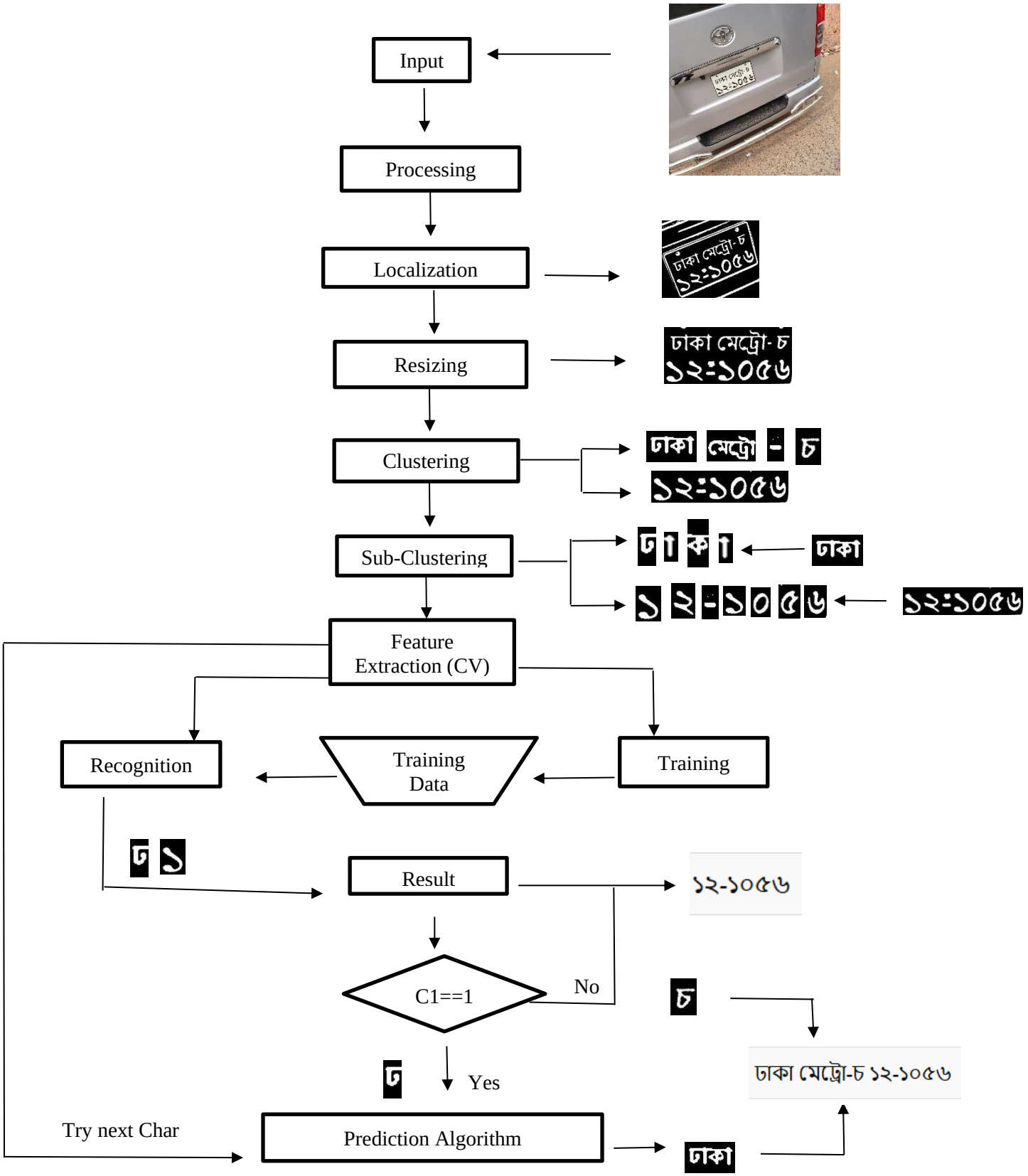


Figure 3.2.4: Process of Character Recognition [15]

Results:

For character recognition the model first read the video and extract frame from video then by YOLOv9 model, it detect license plate region from the frame. It's called Localization the license plate. After Localization it preprocess the detected image. By going through the processes it can recognize character from the image frame. The two chosen YOLOv8m and YOLOv9c model achieved up to 95.44% and 96.54% accuracy respectly. For character recognition EasyOCR achieved 86.67% accuracy. That's how it works in real-time.

3.3 Hardware and Software requirements

The effective implementation of the "YOLO based Real-time Bangladeshi vehicle license plate identification" project entails numerous essential criteria, encompassing hardware, software, and data aspects

Hardware Requirements:

- **High-resolution cameras:** To record crystal-clear footage of cars in a range of traffic scenarios.
- **GPU:** A high performance are essential for efficiently training and operating deep learning models in a high-performance computing environment. For model train I used google colab A100 GPU.
- **Servers:** For integrating with traffic control systems and processing data in real time.

Software Requirements:

- **Deep Learning Framework:** Train the YOLOv9 model. Real-time license plate detection from video frames using the YOLOv9 algorithm.
- **EasyOCR:** Adaptable to Bangla script and numerals, this program recognizes and extracts characters from detected license plates.
- **Libraries for image processing:** OpenCV for feature extraction and preprocessing. Python is a programming language that can be used for integration, modeling, and

scripting.

- **Database Management System:** To save information from recognized license plates for later retrieval and analysis.

Dataset requirements:

- **Annotated Dataset:** A large dataset of Bangladeshi license plates in varied circumstances and orientations, along with full annotations for training and evaluation which I created with 4047 real world Bangladeshi vehicle license plate images. A huge number of images were used to make the dataset.
- **Augmentation Techniques:** I used data augmentation to improve the dataset, including 90-degree rotations, tiny angle rotations ranging from -15 to +15 degrees, and up to 1px blur.

Integration requirements

- **Traffic Management Systems:** Integration with current infrastructure enables real-time deployment in applications such as traffic monitoring and automated toll collection.
- **API development:** Enables seamless connection between the detection-recognition system and other software components.

Testing and Validation

- **Test Environment:** A setting that simulates real-world traffic situations to thoroughly test the system's performance. Performance metrics include detection accuracy, identification accuracy, frame rate, and robustness to different environmental circumstance.

3.4 Project management and Financial Analysis

SWOT analysis involves assessing the Strengths, Weaknesses, Opportunities, and Threats of a project. Here's a SWOT analysis for the Bangladeshi License Plate Recognition:

Figure 3.4.1: SWOT analysis

Communication Plan:

A. Stakeholder Meetings:

Update stakeholders on project requirements gathering progress and gather feedback. The participants will be me and stakeholders and it could be weekly or as specified in the project plan.

B. Change Control Meetings:

To Discuss and approve any changes to the project scope or requirements. Frequency as needed when change requests arise.

TABLE 3.4.1: Financial Analysis

SN	Components	Estimated cost (BDT)
01.	Hardware/Infrastructure	40,000-50,000
02.	Software and Tools	5,000-10,000
03.	Data Collection and Processing	50,000-80,000
04.	Documentation and Report Writing	5,000-10,000
05.	Miscellaneous (e.g., licenses, tools)	10,000-20,000
06.	Contingency (10% of total)	11,000-17,000
Total Estimated cost		1,10,000-1,70,000

3.5 Summary

This section describes the development process (Methodology). It describes how requirements were obtained and analyzed (Requirement Analysis) to better understand user needs. Finally, it discusses how these requirements are converted into a technical blueprint (Design Specification) for system development. This guarantees that the final product meets the defined requirements.

CHAPTER 4
Implementation

4.1 Overview

Instrumentation:

A number of essential parts required for creating and executing the real-time license plate recognition (LPR) system are included in the instruments for this project. High-resolution cameras that are positioned strategically to record video streams of cars in varied traffic situations make up the main gear. These cameras need to be able to take crisp pictures from a variety of angles and with varying lighting. To detect license plates in the video frames, the software instrumentation consists of the YOLOv9 algorithm, which is implemented using a deep learning framework like TensorFlow or PyTorch. Furthermore, the identified license plates will be subjected to character extraction and recognition using EasyOCR, an open-source optical character recognition engine particularly trained to handle Bangla script and numerals. To ensure real-time processing capabilities and train the deep learning models, a high-performance computing environment equipped with GPUs would be necessary. A strong software pipeline that consists of pre-processing stages to improve image quality and post-processing processes to format and store the recognized plate numbers in a database will handle the integration of the detection and recognition modules. To guarantee the system's efficacy and accuracy in practical applications, a large dataset of Bangladeshi license plates will be used for testing and validation.

4.2 Train Model

YOLOv8m Performance:

The trained model’s performance measured by F1-Confidence curve, Precision-Confidence curve, Recall-confidence curve and Precision-Recall curve. Those performance curves shows that the model is so precise and accurate.

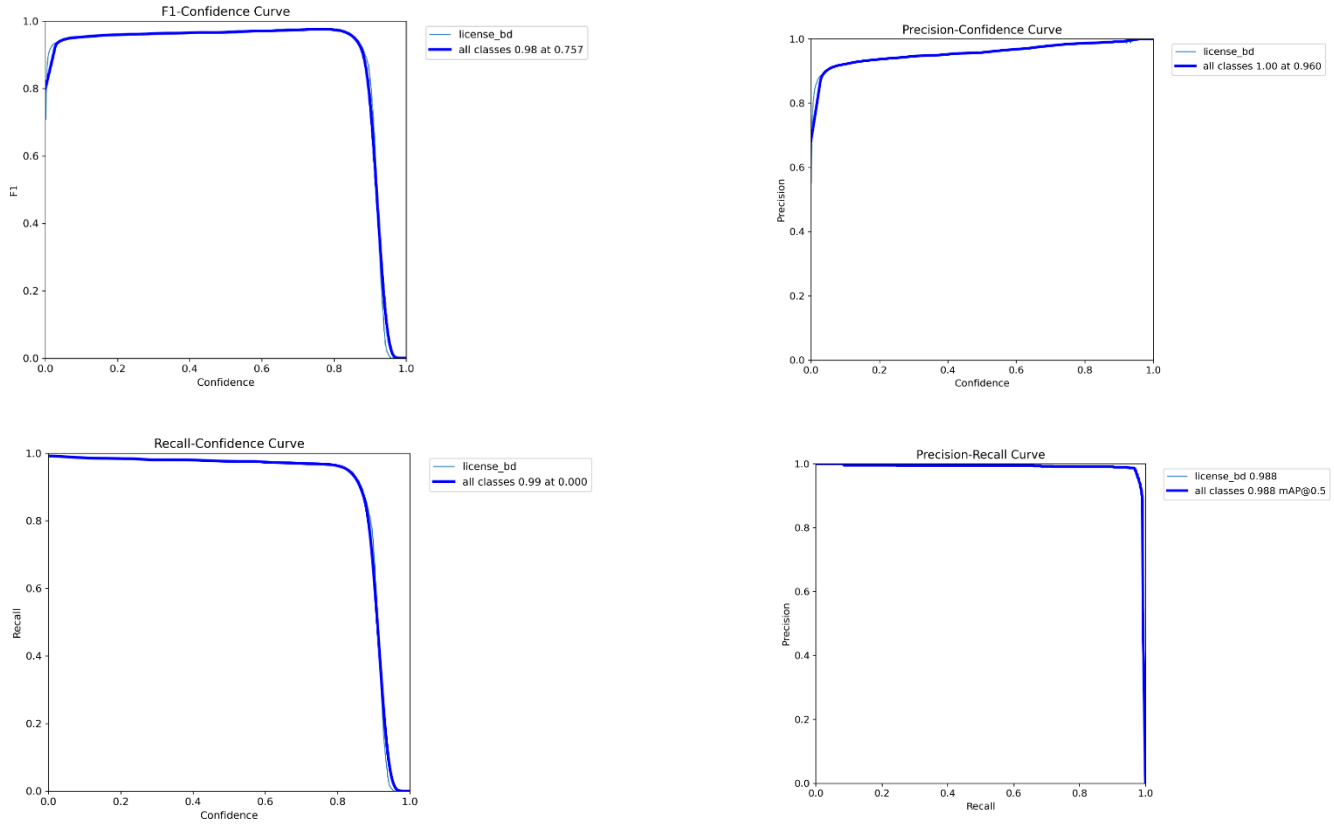


Figure 4.2.1: YOLOv8m Model Performance measure graphs

YOLOv9c Performance:

This YOLOv9c model was trained by nearly 1200 license plate images. Due to GPU issue I could not train with the big dataset I have. So, I created another dataset which contains 1200 images. This was also annotated by me in Roboflow. The epochs was 50, imgsize was 640*640 and the batch size was 16.

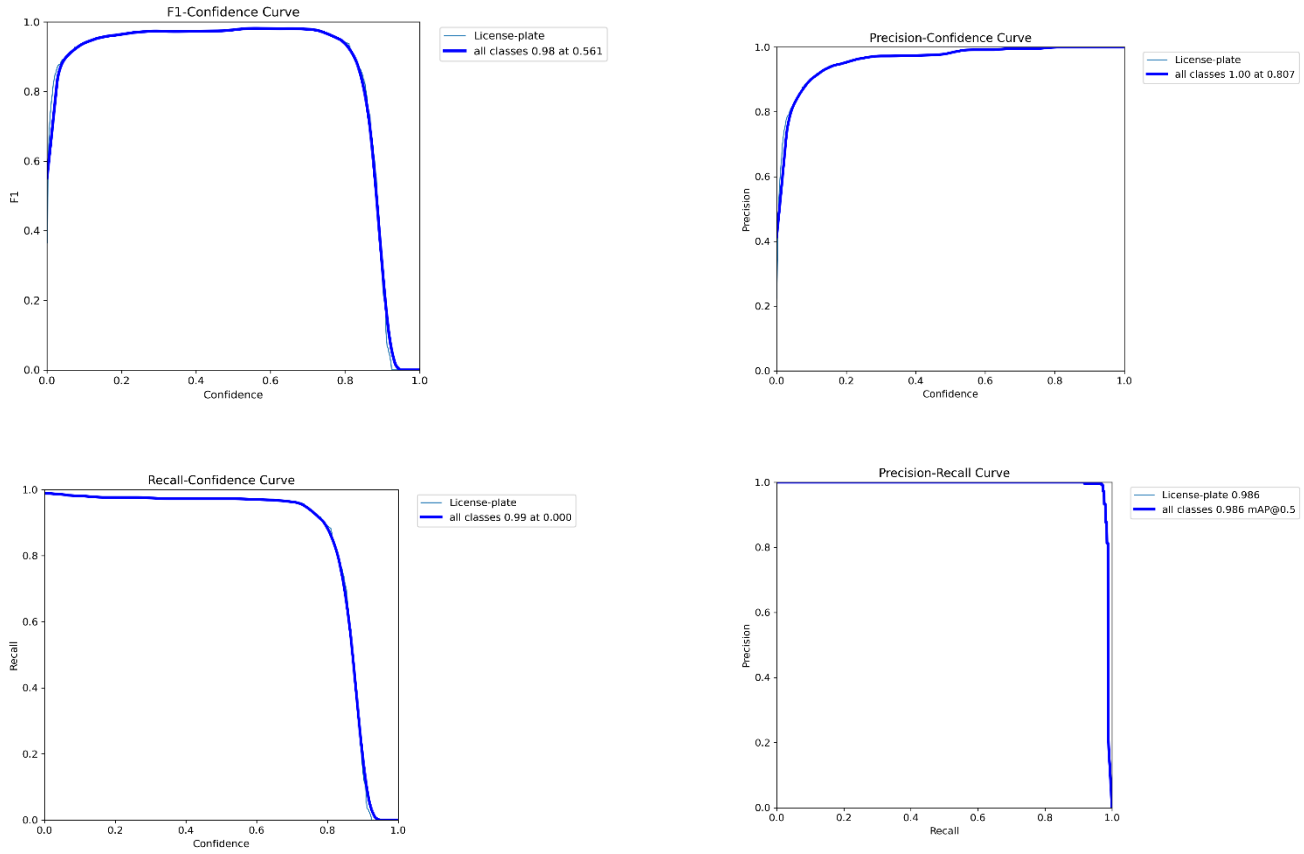


Figure 4.2.2: YOLOv9c Model Performance measure graphs

4.3 Model Evaluation:

For making this project I had to use two dataset for each YOLO model. Because of GPU issue I made first dataset of 4047 annotated images and I trained it in YOLOv8m. The second dataset contains 1200 annotated images and train in YOLOv9c. Despite of less amount of images and less epochs and batch size the YOLOv9c overperform the YOLOv8m model for detecting the license plate region. So, I end up the conclusion of if I can train YOLOv9c by the large dataset I created then the custom model will be more accurate and will give more precise result. For character recognition EasyOCR perform same result. The YOLOv9c trained with 384 Layers, 25.32 Million parameters and 102.3 GFLOPs. On the other hand YOLOv8m has 218 layers, 25.8 million parameters and 78.7 GFLOPs.

TABLE 4.3.1: Training Properties of YOLO models

Architecture	Dataset	Epochs	Layer	Parameter	GFLOP
YOLOv8m	4047 images	185	218	25.8 million	78.7
YOLOv9c	1198 images	50	384	25.32 million	102.3

4.4 Summary

The real-time license plate recognition system created in this study employs two main models: YOLOv9 for detection and EasyOCR for character recognition. YOLOv9, a upgraded deep learning model, is used because of its high efficiency and accuracy in detecting license plates from video feeds or photos. This model scans the full image at the same time, allowing for the rapid detection and localization of license plates in a variety of dynamic traffic scenarios, which is critical for real-time applications like traffic monitoring and law enforcement. Once YOLOv9 detects a license plate, EasyOCR, a powerful open-source optical character recognition engine, extracts and recognizes the characters. EasyOCR supports many languages and scripts, which is very useful given Bangladesh's diverse and occasionally non-standardized license plates. It translates visual data to text, allowing for automated record-keeping, verification, and additional data analysis. By combining YOLOv9 and EasyOCR, the system provides quick identification and precise reading of license plates, solving the unique problems given by Bangladesh's traffic circumstances and regulatory regulations. This complete approach improves traffic management and law enforcement, resulting in increased road safety, more efficient traffic flow, and better public security.

CHAPTER 5
Result and Analysis

5.1 Overview

My project, " YOLO based Real-time Bangladeshi vehicle license plate identification" used a combination of hardware and software components for its experimental setup. A powerful GPU-equipped workstation was part of the hardware configuration to enable real-time video stream processing. In terms of software, I used updated version of YOLO, highly experienced object identification model renowned for its quickness and precision in identifying license plates from video frames. Alphabetic letters were extracted from the identified plates using EasyOCR, an optical character recognition (OCR) engine. The Python programming language provided the foundation for the seamless integration of these technologies into one system. I used OpenCV to handle video streams with efficiency and compatibility by performing image preprocessing and video input/output operations. The purpose of the experimental configuration was to attain real-time performance by utilizing the GPU's parallel processing capabilities to manage many video streams at once. This configuration not only proved that real-time license plate identification from Bangladesh is feasible, but it also confirmed that EasyOCR and YOLOv9 work well together in this particular application domain.

5.2 Experimental

Result of Experiment: YOLOv8 & YOLOv9

Two models YOLOv8 and YOLOv9 performance criteria are used to assess YOLO based approaches. Evaluations include precision, recall, F1-score, and confusion matrix (CM). In those measures, there are additional variables called TP, TN, FP, and FN (FN).

Accuracy:

Classification model accuracy is one metric. Accuracy is the model's predicted percentage. Accuracy is the percentage of properly classified pictures to total samples. Accuracy

equation.

Accuracy=(TP+TN)/(TP+TN+FP+FN)

Precision:

By determining the percentage of accurate forecasts among all predictions, accuracy evaluates a model's overall efficacy. It is a crucial indicator that shows how frequently the model is accurate and is used to assess the overall effectiveness of classification algorithms.

Precision=TP/(TP+FP)

Recall:

Precision measures the accuracy of positive forecasts by dividing the true positive predictions by the total number of positive predictions. It is critical in cases where the cost of false positives is large to ensure that positive forecasts are accurate.

Recall=TP/(TP+FN)

F-1 Score:

Recall, also known as sensitivity, assesses the model's capacity to detect all relevant occurrences by measuring the ratio of genuine positive predictions to total positive instances. It is critical in instances when missing positive cases is costly.

F-1 Score=2*(Precision*Recall)/(Precision+Recall)

TABLE 5.2.1: Accuracy for different model

Architecture	**F1-score**	**Precision**	**Recall**	**Detection Accuracy**
YOLOv8m	0.97	0.98	0.97	95.24%
YOLOv9c	0.98	0.99	0.97	96.54%

Confusion Matrix of YOLOv8:

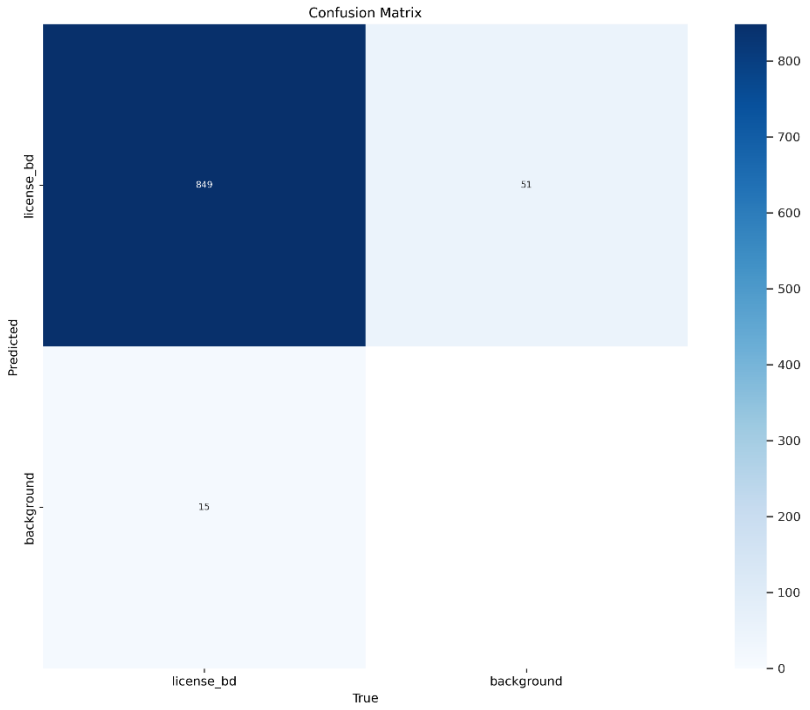


Figure 5.2.1: CM of YOLOv8

Confusion Matrix after YOLOv9:

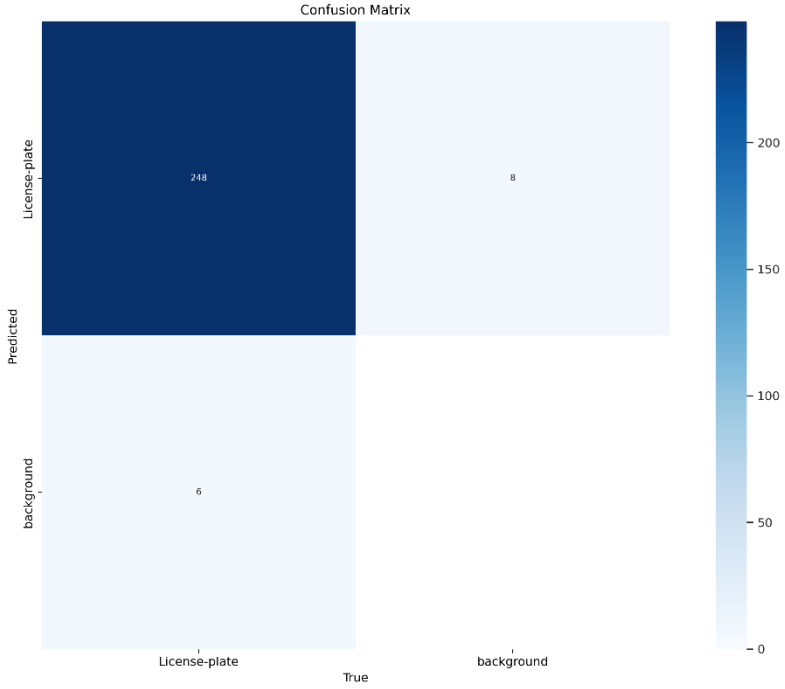


Figure 5.2.2: CM of YOLOv9

EasyOCR results:

In this project, the character recognition part was completed by EasyOCR which is a open source Character Recognition model and it can recognize more than 80 languages including Bangla. After the license plate region detection process the detected license plate region image was processed with preprocessing technique Grayscale and then adaptive threshold was implemented with gaussian c and converted into binary image with the block size of 43 and constant of 11. After that a Morphological operation were implemented to reduce noise in the image with kernel shape of 3, 3. After those preprocessing technique the EasyOCR can recognize the characters in the license plate.

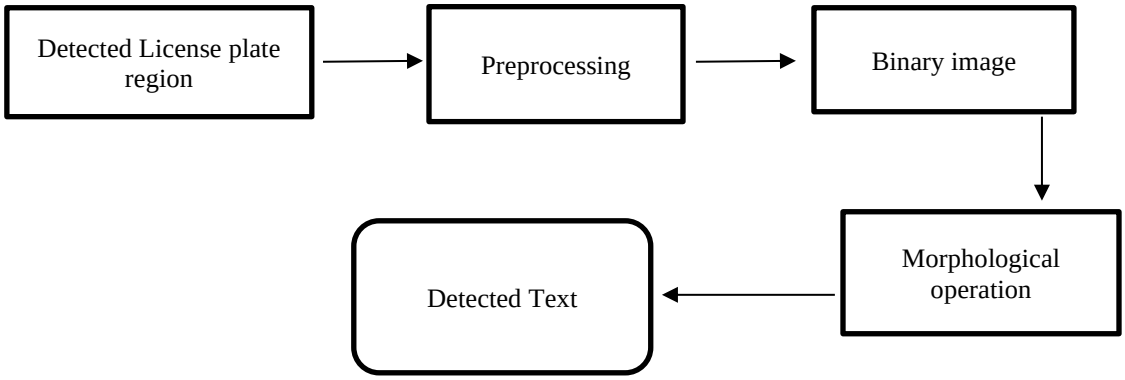


Figure 5.2.3: Character Recognition process

With this process I achieved 86.67% Character recognition accurac

5.3 Comparative Analysis

TABLE 5.3.1: Comparative Analysis Table

Study	Detection Accuracy	Recognition Accuracy	Dataset Used	Algorithms/Methods	Notable Features
Islam et al., 2019	98%	91.6%	Dataset contains 292 images	Deep Convolutional Neural Network, CNN, SSD	Real-time processing, high accuracy
Ahmed et al., 2022	96%	97%	Dataset contains 1928 images	DNN, YOLOv7 different versions, ResNet50, LoG-RSF.	Can detect white and green background of license plate
Abdullah et al., 2018	95%	92.7%	Dataset contains 1500 images	YOLOv3, ResNet-20 bases CNN	Works for Dhaka metropolitan city.
Ashrafee et al., 2022	82.7%	F1-score is 60.8%	Dataset contains 1000 images	MobileNet SSDv2,	High speed, adaptable to different fonts
Suvon et al., 2020	95%	91.38%	Dataset contains up to 1500 images	YOLOv3, Tesseract OCR, CNN.	They worked with Dhaka and Chattogram area license plate for detect and recognition
My Proposed Approach	96.54%	86.67%	4047 images	YOLOv9c, EasyOCR	Large dataset than everyone and achieved good accuracy in both Detection and Recognition

5.4 Summary

This study compares the real-time license plate identification system with YOLOv9 for detection and EasyOCR for character recognition. YOLOv9 outperformed other models in terms of speed and accuracy when detecting license plates under a variety of situations, making it perfect for real-time applications. EasyOCR outperformed other OCR technologies in Bangladesh by effectively reading different and non-standardized license plates. The integrated system of YOLOv9 and EasyOCR demonstrated great detection rates and letter recognition accuracy while using less processing power. This reliable and efficient system has the potential to significantly improve traffic management and law enforcement in Bangladesh.

CHAPTER 6
Impact On Society, Environment and Sustainability

6.1 Impact on life

The implementation of a YOLO based Real-time Bangladeshi vehicle license plate identification has the potential to dramatically alter many facets of daily life. Improved traffic management and law enforcement will increase road safety by lowering the number of accidents caused by unregistered or illegally driven cars. This method will help to identify and apprehend traffic violators, resulting in more disciplined driving and adherence to traffic laws. This technology can assist decrease congestion in metropolitan areas by allowing for effective traffic flow monitoring and management. Automated license plate identification can help to streamline procedures like toll collecting, parking management, and entry/exit monitoring in restricted areas, making inhabitants' everyday trips more efficient. In terms of security, the technology will help trace stolen vehicles and monitor suspicious activity, ultimately improving public safety. This technology can help law enforcement agencies swiftly identify and respond to possible threats, making the community a safer place for everyone. Furthermore, integrating the system with smart city projects has the potential to boost long-term urban growth. Real-time traffic data allows municipal planners to optimize infrastructure projects and public transit networks, thereby increasing citizens' quality of life. Eventually, the use of this advanced technology has the potential to alter traffic management, improve public safety, and aid in the development of smarter, more efficient urban settings in Bangladesh.

6.2 Impact on Society & Environment

The project " YOLO based Real-time Bangladeshi vehicle license plate identification" has the potential to benefit society in a variety of ways. The key benefits include increased public safety and law enforcement efficiency. Law enforcement organizations can identify automobiles implicated in crimes or traffic infractions quickly and accurately by identifying license plates in real time. This feature can result in speedier response times and increased road safety. The project helps with traffic management by gathering data on traffic flow patterns and detecting congested locations. This data can be utilized to improve

traffic management methods, reduce congestion, and shorten commute times for the public. Furthermore, automated license plate recognition (ALPR) systems can help with toll collection and parking management, streamlining administrative procedures and eliminating manual labor. Traffic congestion will reduce. Vehicle tracking, stolen vehicle can be found by this technology. Every cars data can be stored by the authority.

Furthermore, the technology's applications extend beyond law enforcement and traffic control. For example, it can be included into smart city projects to improve urban planning and development. By providing vital data on vehicle movements and trends, municipal planners may make more informed judgments about infrastructure improvements and transportation policy. From a social standpoint, the initiative fosters technical innovation in Bangladesh by demonstrating the country's potential to design and implement advanced computer vision and machine learning solutions. This not only increases local competence, but also creates chances for future research and development in adjacent sectors.

The project " YOLO based Real-time Bangladeshi vehicle license plate identification has considerable environmental benefits. By improving traffic management, the system can minimize congestion, resulting in lower fuel use and greenhouse gas emissions. This helps to enhance air quality and reduce carbon footprints in metropolitan areas. Furthermore, the system promotes smart city projects by giving reliable data on traffic patterns, which can assist city planners in designing efficient public transit systems and developing infrastructure that encourages eco-friendly transportation options such as cycling and walking. This decreases reliance on private automobiles, which further reduces emissions. The project's real-time monitoring capabilities also help with environmental enforcement by identifying vehicles that do not meet emission requirements, allowing authorities to take corrective action and ensure that only environmentally friendly vehicles are on the road. This helps to limit toxins emitted into the atmosphere. Furthermore, improved traffic flow and management result in more efficient fuel usage, which saves resources and reduces the environmental impact of transportation. Lastly, the project improves the environment greatly by reducing traffic congestion, promoting sustainable urban design, assisting with environmental compliance, and optimizing fuel usage, all of which contribute to a greener and more sustainable future

6.3 Ethical Aspects

This research initiative brings up significant ethical issues. Privacy is one of the main issues. Personal information is collected during the collection and analysis of license plate data, thus strong data protection procedures are required to avert misuse and illegal access. Maintaining public confidence and adhering to privacy regulations require making sure that data is anonymized and maintained securely. One additional ethical consideration is the possibility of technology misuse. The technology could be used for surveillance, resulting in the unjustified monitoring of specific people, even though its intended uses are to improve public safety and traffic management. It is crucial to set precise rules and regulations regarding the use of technology in order to guard against misuse and preserve civil freedoms. The system's correctness and impartiality must also be taken into account. In order to prevent biases that can result in the disproportionate targeting of particular groups or persons, the recognition algorithms should be rigorously evaluated. Maintaining impartiality and fairness in the system's applications is aided by making sure it is correct. Finally, the project's ethical considerations include safeguarding confidentiality, avoiding abuse, and making sure that everything is accurate and equitable. Public safety and better traffic management can be morally benefited by the project's implementation of stringent data privacy procedures and regulatory requirements.

6.4 Sustainability Plan

The sustainability plan for the project is designed to ensure the system's long-term viability and good impact. This strategy includes technological, financial, and operational methods for sustaining and increasing the project's effectiveness over time. Technologically, the sustainability strategy calls for continuous updates and maintenance of the YOLOv9 and EasyOCR algorithms to keep up with advances in computer vision and machine learning. This guarantees that the system remains accurate, efficient, and able to handle changing license plate designs and environmental circumstances. Furthermore, integrating energy-efficient hardware and enhancing software performance would reduce environmental impact while also lowering operational costs. Financially, a solid finance strategy is

required. This includes gaining initial contributions from government agencies, private-sector collaborations, and prospective grants for innovative technologies and public safety. Creating a revenue model, such as subscription-based services for private businesses or cost-sharing with government agencies, can provide ongoing financial support for the project's upkeep and expansion. The plan includes training and capacity-building programs for law enforcement and traffic management professionals to ensure the system's effectiveness. Regular audits and assessments will assist identify areas for development and ensure that the system achieves its goals. Collaboration with local colleges and research organizations can boost innovation while also providing a pipeline of competent professionals to support the project. The license plate recognition project's sustainability plan calls for ongoing technology improvements, a strong financial strategy, and complete operational assistance. By resolving these issues, the project can remain effective, adapt to changing situations, and give long-term benefits in public safety and traffic management.

6.5 Summary

This section investigates the potential societal, environmental, and sustainability implications of this project. It examines how this proposed system may impact society (good or bad consequences on communities, social connections). It also assesses the environmental footprint, taking into account aspects like as resource use, potential contamination, and long-term ecological repercussions. Finally, it evaluates how this project contributes to sustainable practices, assessing its capability to meet present demands without jeopardizing future generations' ability to meet their own.

CHAPTER 7

Conclusion and Future work

7.1 Conclusions

This study demonstrates the viability and effectiveness of applying advanced computer vision algorithms for real-time license plate recognition in Bangladesh. The combination of YOLOv9 with EasyOCR offers an effective option for improving traffic management and public safety. However, careful consideration of ethical issues and a detailed sustainability strategy are required to ensure the project's beneficial impact and long-term success. From this combination we can achieve most accurate results for detection and recognition for future betterment. YOLOv9 is updated object detecting tool and EasyOCR is advanced optical character recognition tool I used for this project and achieved robust result for precision, recall, F1-score and accuracy. The Dataset was the key of my project which contains 4047 Bangladeshi license plate images contains normal formate of license plate and also Army, Navy, Air-forces, Diplomatic vehicles license plate images. From this proposed methode I achieved 96.54% detection accuracy for Bangladeshi all kinds of license plate and 56% Character recognition accuracy.

7.2 Further work

Further research into the " YOLO based Real-time Bangladeshi vehicle license plate identification" project could considerably improve its performance and application. Collecting a larger and more diversified dataset of license plate photos under various conditions would strengthen the system's resilience. Implementing and comparing additional models, such as Faster R-CNN, SSD, and newer YOLO versions, can help determine the best technique for various cases. The YOLO’s another version announced to release. My future work will be collecting more license plate images and create very large amount of images containing dataset and trained with YOLO’s new version. Exploring various OCR engines, such as EasyOCR or ABBYY, may help improve the accuracy of Character recognition. Furthermore, optimizing picture preprocessing techniques such as augmentation, noise reduction, and super-resolution can improve the system's ability to deal with low-quality data. Real-time processing enhancements via edge computing and

hardware acceleration will aid scalability and deployment in complex situations. Collaboration with data privacy and ethics specialists is critical to ensuring that the system meets legal and ethical requirements. These initiatives will result in a more reliable and widely used license plate recognition system.

7.3 Limitations

While the project represents substantial progress in traffic management, it has numerous limitations when considering the full range of potential applications in the Bangladeshi context. The project's restricted focus on license plate recognition and monitoring leaves out important components like vehicle counting, helmet detection, and toll collecting. These extra elements are required for effective traffic management and safety enforcement. The absence of helmet detection for motorcyclists means that a critical part of road safety is overlooked, resulting in missed opportunities to prevent injuries and fatalities. Similarly, the method fails to account for vehicle counts, which are critical for understanding traffic flow, congestion patterns, and urban planning. Another crucial area that has not been integrated is toll collecting automation, which could expedite operations and decrease manual intervention at toll booths. Furthermore, the project lacks detection capabilities for other traffic offenses such as seatbelt use, over speeding, and signal violations, which limits its efficacy in improving road safety and compliance. Because of the system's concentration, it may be difficult to interface with larger smart city programs or provide full data analytics for authorities to make informed decisions. These constraints underscore the need for a more comprehensive strategy to traffic management in Bangladesh.

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Appendix A

Course Outcomes, Complex Engineering Problems (EP) and Complex Engineering Activities (EA) Addressing

Title:
YOLO based Real-time Bangladeshi vehicle license plate identification

Student ID: [192-15-13346]

CO Description for FYDP

CO	CO Descriptions	PO
Phase -I		
CO1	Integrate newly learnt and previously acquired knowledge to identify a **License plate recognition** problem for the Final Year Design Project (FYDP).	**PO1**
CO2	Analyze several components of the aims while building a solution for this ALPR system.	**PO2**
CO3	Conduct a Research to investigate several problem domains, identify the concerns, and set the objectives for the FYDP.	**PO4**
CO4	Throughout the FYDP's development life cycle, conduct cost estimating and economic review and use appropriate project management techniques.	**PO11**
Phase -II		
CO5	To design and develop technical solutions and system components or processes that meet stated requirements, maintaining compliance with public safety standards, while also considering cultural, socioeconomic, and environmental concerns in this FYDP.	**PO3**
CO6	Select and implement suitable techniques, resources, and modern engineering and IT technologies to handle intricate engineering procedures, including modeling and prediction, while abiding by pertinent restrictions in this FYDP.	**PO5**
CO7	Using logical thinking informed by contextual knowledge, analyze societal, safety, legal, and cultural factors as well as related duties in the context of professional engineering practice and the solution to this issue.	**PO6**
CO8	Recognize and assess how professional engineering undertakings can address complex technical difficulties within social and environmental contexts, as well as their long-term sustainability.	**PO7**
CO9	In this FYDP, apply ethical concepts and follow professional standards and norms.	**PO8**
CO10	Ability to function well in this FYDP as a leader or team member in a variety of teams and multidisciplinary environments, as well as independently.	**PO9**
CO11	Throughout this FYDP, effectively communicate with the engineering community and the general public about complicated engineering projects. This includes being able to understand and produce thorough reports and design documentation as well as giving and receiving clear directions.	**PO10**

CO12	Recognize the need of self-directed and life-long learning in the ever-changing technological landscape, and have the preparedness and competence to engage in lifelong learning activities.	**PO12**

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP), and Attainment of Complex Engineering Activities (EA)

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP):

SN	EP Definition	Attainment	CO	Justification (With Knowledge Profile)	References
1.	**EP1: Depth of Knowledge required**	Yes	CO1, CO2, CO3, CO5, CO6, CO7 and CO8	This project demonstrates **fundamental engineering (K3)** principles by employing Convolutional Neural Network like YOLO, data augmentation techniques, and diverse CNN architectures for image processing and classification tasks. The project demonstrates **specialist knowledge (K4)** by conducting transfer learning with advanced CNN architectures EasyOCR, enhancing License plate detection and recognition.	**Page no:** [14-22] **Section:** [3.2] **Page no:** [1-2] **Section:** [1.1]
				The project applies **engineering practice & design (K5)** by the figure of process of experiments. The project addresses **engineering practice & technology (K6)** by employing CNN model.	**Page no:** [14-22] **Section:** [3.2] **Page no:** [24-25] **Section:** [3.4]

				This project ensures to **K8 (Research Literature)** by synthesizing insights from recent studies, to advance License plate detection and recognition, showcasing a comprehensive understanding of current methodologies.	**Page no:** [10-12] **Section:** [2.2, 2.3]
2.	**EP2: Range of Conflicting Requirements**	Yes	CO2, and CO7	This project addresses **EP-2** by recognizing the hurdles in License plate detection and recognition including limitations of traditional methods and the complexities of integrating character recognition techniques and deep CNNs. Through comparative analysis.	**Page no:** [12-13] **Section:** [2.4, 2.5]
3.	**EP3: Depth of analysis required**	Yes	CO2, and CO6	This project addresses **EP-3** by meticulously comparing experimental outcomes, highlighting Convolutional Neural Network as the chosen significant solution for enhancing License plate amidst multiple potential approaches.	**Page no:** [27-29] **Section:** [4.2]
4.	**EP4: Familiarity of Issues**	Yes	CO8	The interdisciplinary approach of this project affects law enforcement and traffic management in addition to computer science and engineering. It advances public safety and urban planning techniques by improving real-time vehicle surveillance and data processing, which shows **EP-4**	**Page no:** [10-13] **Section:** [2.2, 2.4]
5.	**EP5: Extends of application codes**	No	CO5	N/A	N/A

6.	**EP6: Extends of stakeholders involved and conflicting**	No	CO8	N/A	N/A
7.	**EP7: Interdependence**	Yes	CO5	This project's comprehensive approach addresses high-level problems by integrating various components across data collection, statistical analysis, and proposed methodology, ensuring a holistic solution to complex challenges in License plate detection and character recognition which ensures **EP-7**.	**Page no:** [14-25] **Section:** [3.2, 3.3, 3.4]

Addressing CO11 with Complex Engineering Activities (EA):

SN	EA Definition	Attainment	CO	Justification	References
1.	**EA1: Range of resources**	Yes	CO11	My project utilizes diverse resources such as high-performance computing infrastructure, GPUs, deep learning frameworks, annotated datasets, and ethical considerations to ensure systematic research and contribute to advancements in License plate detection and recognition through YOLOv9 and deep CNNs like OCR.	**Page no:** [26] **Section:** [3.5]
2.	**EA2: Level of interaction**	No		N/A	N/A
3.	**EA3: Innovation**	No		N/A	N/A
4.	**EA4: Consequences for society and the environment**	Yes		This project contributes to different cities in Bangladesh by improving traffic management system through advanced license plate detection and recognition methods, while also promoting road efficient factors, car tracking sustainability by employing efficient computational resources and adhering to ethical guidelines for patient data privacy.	**Page no:** [31-35, 37] **Section:** [5.1, 5.2, 5.4]

5.	**EA-5: Familiarity**	Yes		This project expands upon existing research by examining a novel approach in license plate detection and recognition deep learning and deep CNNs, demonstrated through preliminary terminologies and a comprehensive comparative analysis, offering new insights into the traffic management field.	**Page no:** [9, 11-12] **Section:** [2.1, 2.3]

Addressing CO (4, 9, 10, and 12):

SN	COs	Attainment	Justification	References
1	CO4	Yes	This project addresses **CO4** by integrating effective project management and financial oversight, ensuring meticulous planning, resource allocation, and budget estimation for optimal resource utilization throughout the research lifecycle.	**Page no:** [7-8] **Section:** [1.6]
2	CO9	Yes	The project displays adherence to ethical principles by prioritizing data privacy, guaranteeing transparent documentation, and responsibly deploying advanced license plate recognition technology to improve society well-being, which is in accordance with **CO9**.	**Page no:** [36] **Section:** [5.3]
3	CO10	No	N/A	N/A
4	CO12	Yes	The project demonstrates a commitment to staying up to date and refining techniques to address modern challenges through its thorough data collection, rigorous analysis, meticulous methodology development, and thorough experimental results. These reflect the project's dedication to continuous learning (**CO12**) and adaptation within the dynamic technological landscape.	**Page no:** [14-26, 27-29] **Section:** [3.2, 3.3, 3.4, 3.5, 4.2]

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