Automatic Bangla Digital Number Plate detection and recognition system using image processing and Deep learning

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A Capstone project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

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Declaration

We, **Noshin Faria, Adri Saha, and Student 3** hereby, declare that the work presented in this capstone project report is the outcome of the investigation performed by us under the supervision of **Dr. Md. Nawab Yousuf Ali**, Designation, Department of Computer Science and Engineering, East West University. I/We also declare that no part of this project has been or is being submitted elsewhere for the award of any degree or diploma, except for publication.

Countersigned

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Letter of Acceptance

The capstone project report entitled "Automatic Bangla Digital Number Plate detection and recognition system using image processing and Deep learning" is submitted by Noshin Faria, Adri saha, and Student 3 to the Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh is accepted for the partial fulfillment of the requirement for the degree of Bachelor of Science in Computer Science and Engineering on 16 March, 2023..

Board of Examiners

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Abstract

In recent years, with a rapidly growing population, vehicle utilization has risen dramatically. A recent survey says that there are a minimum 1400 vehicles being registered daily. For this reason, many problems have been raised like car robbery, car parking, traffic violations, reckless driving. Recognizing the characters from a vehicle's number plate is important for automobile tracking, traffic management,parking area data management. Automated number plate detection and recognition can play a significant role in these scenarios but it's a challenging task for careless use of a number plate. This research was performed to develop a web application to detect and recognize Bangladeshi number plates automatically from CCTV cameras. The YOLO V7 model and several image processing algorithms are used to detect the number plate in its initial state. Then, localizing characters is performed using image processing techniques. Several pre-trained models have been trained and evaluated for the recognition phase. The dataset was created by capturing images from the field, collecting from multiple sources and preparing the dataset manually. Several preprocessing and postprocessing techniques have been used in every phase to improve the model's performance. Then, compare the result of these models to get the suitable technique for development. YOLO V7 performed excellently in plate detection phase and had accuracy of 0.91, precision of 0.994, recall of 0.901 and map at 0.5 of 0.938. Character localization is calculated manually and has 0.85 precision and 0.97 recall rate. In the final phase, from several deep learning models, VGG19 out performs and has 0.936 accuracy, 0.912 precision and 0.947 recall rate. These techniques have been used to develop flask web applications which can detect and recognize plate numbers automatically without human interaction and store them in a database.

Acknowledgments

As it is true for everyone, We have also arrived at this point of achieving a goal in our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one's mother language. Therefore, We would not like to make efforts to find best words to express my thankfulness other than simply listing those people who have contributed to this thesis itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

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We would like to thank "Rashedul Islam, Assistant Professor, ICT department, Rajuk Uttara Model College" for his overall support by providing dataset; "Dr. Mohammad Rezwanul Huq, Associate Professor, CSE department, East West University" for his helpful suggestions in solving tricky technical problems, "Sabik Alam Rahat" for his excellent collaboration during performance evaluation studies. Last but not the least, We would like to thank our parents for their unending support, encouragement and prayers.

There are numerous other people too who have shown me their constant support and friendship in various ways, directly or indirectly related to our academic life. We will remember them in our heart and hope to find a more appropriate place to acknowledge them in the future.

Noshin Faria
March 2023

Adri Saha
March 2023

Plabon Banik
March 2023

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March 2023

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List of Algorithms

List of Acronyms

CNN	Convolution Neural Network
VGG16	Visual Geometric group 16 layer
VGG19	Visual Geometric group 19 layer
YOLOV7	You Only Look Once Version 7
ROI	Region of interest

List of Notations

Chapter 1

Introduction

Background

Bangladesh is a small country with a rapidly growing population, vehicle utilization has risen dramatically in recent years. There are still numerous issues with auto parking, toll collection, and car robbery among the 4.47 million registered vehicles [1]. Major accidents have also occurred because of crimes such as car robbery, traffic violations, reckless driving, and excessive overtaking [2].

The only authority in Bangladesh that can issue several sorts of car license plates is the Bangladesh Road Transport Authority (BRTA). BRTA license plates were first issued in 1973, however, digitalization of these plates just began in 2012 [11]. The government wants to make Bangladesh digital by 2021, hence the BRTA (Bangladesh Road Transport Authority) has launched the Retro-Reflective number plate, also known as a digital number plate. Digital license plates must now be used on both the front and back sides of a vehicle, with the rear license plate permanently connected [28].

Figure 1.1: Retro-Reflective license plate

There are too many traffic-related problems happening every day. These traffic congestions are mainly happening for breaking the rules of traffic, overtaking, non-expert drivers and many more. Toll collection on flyover and bridge areas has become a problem for this increasing number of vehicles. Sometimes, all the vehicles have to wait a long period of time to pay the toll fee and it causes traffic congestion.

Moreover, the parking facilities are inadequate, and there is no way to track vehicles entering or exiting the area. They usually do these checks manually which is time-consuming and not so correct. Furthermore, cars must wait for long periods of time while being manually logged one by

one. This procedure can take a long time for all parties involved [2].It will be crucial to Bangladesh's traffic monitoring system if we can systematize this manual process. Numerous research studies have been conducted in other nations in the area of automatic number plate detection and recognition, but Bangladeshi number plate detection has gotten comparatively little exposure.

Problem Statement and Analysis

There are too many traffic-related problems happening every day. These traffic congestions are mainly happening for breaking the rules of traffic, overtaking, non-expert drivers and many more.

Toll collection on flyover and bridge areas has become a problem for this increasing number of vehicles. Sometimes, all the vehicles have to wait a long period of time to pay the toll fee and it causes traffic congestion.

Moreover, the parking facilities are inadequate, and there is no way to track vehicles entering or exiting the area. They usually do these checks manually which is time-consuming and not so correct. Furthermore, cars must wait for long periods of time while being manually logged one by one. This procedure can take a long time for all parties involved [2].

Project Objectives

The aim of this project is to build a system that can collect license plate numbers from a moving vehicle using a variety of modern technologies, including image processing, deep learning, and so on. The principal objective of this study is to propose a system that can detect and extract a number plate from an image, localize characters and segment them from a number plate and finally recognize those characters to collect the license plate’s number.

Project Contributions

The project's outcomes will aid society in automating various systems. The manual procedure of maintaining parking lot data takes a lot of time, and the alternative technology is costly. So, this project will automate it at a lower cost so that information from the CCTV footage can be saved without any human interaction. Despite having no impact on the environment, it can provide a support system for the people who live in our society.

Project Outlines

In this project, deep learning and image processing methods are used to determine a vehicle's license number. A literature study has been conducted in order to accomplish this goal by examining current, pertinent publications. The limits of earlier methods for locating and identifying license numbers are discovered. Then, two datasets were gathered. After pre-process the dataset, deep learning algorithm was performed to detect the number plate. Also, certain post-processing techniques were used to lower the False positive rate. The next step is to localize the identified plate's character set. This involved certain morphological procedures. Several deep learning methods were then applied to identify the license number.

After performing deep learning algorithms, the ability to predict was evaluated using a few criteria to determine the most accurate predictive model. The outcomes of the experiments are then compared and examined. For subsequent use, the model with the best accuracy is chosen. Eventually, a web application is created that automatically detects license plate numbers from CCTV images and stores the information in a database for further use.

Chapter 2

Related Works

Survey of the State-of-the-art

In [1] authors proposed an automatic approach for detecting plate area and character recognition on Bangladeshi automobile license plates. They used five sequential steps: license plate detection, extraction, character localization, character extraction, and character recognition for the whole process. The suggested method obtained 91 percent accuracy in ROI extraction, 94.6 percent accuracy in character extraction, and 100 percent accuracy in character recognition.

In [2] authors suggest an automated approach for detecting and recognizing license plates. They divided the system into four parts: plate detection, extraction, character segmentation and recognition. They classified numbers and letters using two distinct Convolutional Neural Networks (CNN). For district names, Tesseract OCR is utilized. The suggested system has a detection success rate of 96.8 percent, an extraction success rate of 89.5 percent, a segmentation success rate of 98.6 percent, and a character recognition success rate of 98.0 percent.

In [3] they developed a Bangla LPR system based on the CNN paradigm. They used CNN and various epochs to achieve the best results. They discovered that a high number of samples and epochs improve accuracy throughout the training and testing phases. They attained testing accuracy of 81.09 % and 82.28 % for distinct samples.

In [4] authors developed techniques for detecting, extracting, recognizing, and authenticating Bangla license plates. In this project, they created a database of 250 car license plate photos that were used in various environmental situations, as well as two databases of templates for recognition and registered cars for authentication. They didn't work on real time systems in the future. they didn't use algorithms like SVM, neural networks while detecting ambiguous characters for template matching. The proposed technique has a detection accuracy of 94%, a character recognition accuracy of 96.1 percent, and a vehicle number plate authentication accuracy of 100%.

In [5] authors detected a two-stage detection pipeline linked with Vision API that can accurately detect license plates from video footage while also providing real-time inference speed and consistently accurate detection and identification performance is offered. To identify between

several vehicle license plates in the same clip, they deployed a haar-cascade classifier (a machine learning model) as a filter on top of their backbone MobileNet SSDv2 detection model and imposed a temporal frame separation technique. They achieved 86% of AP0.5 score on training their image datasets and tested their pipeline on the video dataset and observed reasonable detection and identification performance (82.7 percent detection rate, and 60.8 percent OCR F1 score) with real-time processing speed (82.7 percent detection rate, and 60.8 percent OCR F1 score) (27.2 frames per second).

In [6] authors offered a method for recognizing Bangla number plates that include four key steps that are preprocessing, number plate extraction, character segmentation, and character identification. The character recognition accuracy was 95.74 %, and their overall approach accuracy was 90%. Out of 50 photographs, 47 number plates were successfully extracted, accounting for 94 percent of test images.

In [7] authors proposed software to reduce criminal activity like the stolen vehicle and road traffic monitoring that involves the use of motor vehicles using MATLAB. Also, they were working on CCTV footage or input image in RGB format then converted it to a gray image and detected license plates from the image. To recognize characters using the OCR technique i.e., optical character recognition to Compare the Number with the database and give Challan if suspected. They developed software to detect number plates.

In [8] Naaman Omar and his team [8] offer a cascaded deep learning strategy to build an efficient ALP detection and recognition system for northern Iraqi automobiles in this work. For both Arabic number identification and city determination, the calculated license plate areas are input into two independent convolutional neural networks (CNN) models. An end-to-end CNN model was built and trained for Arabic number recognition, while a pre-trained CNN model was fine-tuned for city recognition. The suggested methods' performance was assessed in terms of both detection and recognition. Recall, precision, and F-measure scores were utilized for detection, while classification accuracy was used for recognition. Authors achieved detection and recognition accuracies of 96.7 percent and 92.2 percent, respectively. 150 color photos were utilized in the study, with a detection accuracy score of 94.0 percent and a recognition accuracy score of 92.0 percent. The suggested method has a success rate of 97.21 percent for plate locating and 95.0

In [9] an automated system for detecting and recognizing License Plates (LPs) in complicated scenarios. Mask area convolutional neural networks are employed for LP detection, segmentation, and identification in their approach. Although other studies have focused on LP detection, LP identification, LP segmentation, or just two of these steps, their research leverages the mask r-CNN in all three. Extensive tests demonstrate the resilience and effectiveness of their proposed system, which obtains an accuracy rate of 99.3% on the AOLP dataset and 98.9% on the Caltech dataset.

In [10] authors developed a system called Intelligent Neural Classifier. Which can extract a vehicle's number plate from a picture, given certain parameters. Intelligent Neural Classifiers often employ an algorithm known as the Number Plate Classifier Algorithm, which is mostly used for detecting vehicles, and Object Character Recognition (OCR), which recognizes the character from the license plate. They did not apply any machine learning or deep learning algorithm and accuracy was not mentioned. Their model is not so flexible, allowing it to operate from various angles and distances.

In [12] authors presented an approach in which these words are divided into single linked components and then identified using the word template matching. Numbers and individual letters are divided and recognized as distinct characters on the license plate. They have shown that by utilizing Matra's feature in this way, the algorithm's complexity is reduced, and the suggested system performs well for photographs collected under a variety of settings.

In [13] authors devised a system that included three primary phases: pre-processing, detection, and recognition. In the pre-processing step, many image processing techniques such as morphological transformation, Gaussian smoothing, and Gaussian thresholding are applied. Following that, contours are applied by boundary following and contours are filtered based on character dimensions and spatial localization for number plate segmentation. After filtering and de-skewing the region of interest, the K-nearest neighbor method is utilized for character recognition. The K Nearest Neighbors (KNN) technique was used to train the model. The system correctly detected 98 percent of the number plates in a sample of 101 plates, including Indian and foreign plates, and it correctly recognized over 96.2 percent of the characters on the plates.

In [14] they proposed a new technique for vehicle number plate detection which is “Threshold Modification” that was successful in recognizing number plates even in low light, extreme brightness, and other situations where earlier machine learning systems failed. The system is built under six modules as follows: Preprocessing, Threshold Optimization, Plate Localization, De-noising, Character Segmentation, and Character Recognition. This model proved to be successful in detecting number plates even in low light conditions, and extreme brightness.

In [15] authors looked at a variety of license plate image databases. These datasets were compared and discussed by them. They do not have accuracy.

In [16] a Class Letter recognition system is presented that uses a cascaded combination with the CNN model to reduce computation time while maintaining good accuracy. The model is being used to create a Vehicle class letter identification system that only works with information from a License Plate and only accepts videos as input. They also do not have accuracy.

In [17] they applied Tesseract, a popular and widely used Optical Character Recognition (OCR) engine. They tested their code on images and obtained an accuracy of 88%, which isn't impressive.

In [18] authors developed a model on number plate detection and classification. For number plate identification, a YOLOv2 sensor with ResNet attribute extract core is proposed and convolutional neural network architecture (CNN) is also proposed in their model. They have worked with multi language number plates from the US, UAE, EU and India. They have achieved an average accuracy of 99.57%.

In [19] authors presented a completed dual deep learning based automatic license plate identification model to Indian drivers on the road in their proposed work. They have a unique feature that, even if the image is blurry, their system can deblur that and apply it to Machine Learning models. The YOLO V3 model for Region of Interest [ROI] and the Convolution Neural Network [CNN] for optical character recognition have been used in

their feature. Their accuracy of 91.5 percent is obtained for the OCR model and 96 percent accuracy for the YOLO model.

In [20] authors worked on ANPR systems that rely on complex optical, computer, and digitization capabilities, which might cause plate detection to be delayed. This research article provides a simple introduction of vehicle license plate detection, detection techniques for successful vehicle tracking, and assessment of the methods' dependability. This research contains a thorough assessment of progress and future trends in the identification and detection of modern car license plates, which may be useful to scholars interested in this area.

In [21] They took a damaged number plate, attempting to recognize it, and recording real-time data in the form of video has been developed in this work. To recognize vehicle number plates, they use OCR technique. They do not have accuracy. There is nothing new. They approach the feature through image processing.

In [22] authors proposed an effort to deal under such conditions by incorporating multiple features extraction and fusion. The proposed architecture is comprised of four primary steps: (i) selection of luminance channel from CIE-Lab color space, (ii) binary segmentation of selected channel followed by image refinement, (iii) a fusion of Histogram of oriented gradients (HOG) and geometric features followed by a selection of appropriate features using a novel entropy-based method, and (iv) features classification with support vector machine (SVM). Their model accuracy is achieved maximum up to 99.5%.

In [23] authors implemented an ANPR (Automatic Number Plate Recognition) method-based case study for smart car towing management using Machine Learning models and developed an android mobile-based application. This app enables law enforcement personnel to take a snapshot of the towed vehicle, which is then automatically and in real-time recorded in the automobile towing management system. Owners can also use the app to locate their vehicles, monitor the status of their cases, and pay fines. They applied a boundary box to extract the number plates and convert them

into grayscale images. Then applied filters to detect alphanumeric characters, K-Nearest Neighbors (KNN) model to detect the actual number plates. Their model identified number plates with 95% accuracy in various places throughout the world.

In [24] authors implemented their work by 4 steps which are preprocessing, number plate localization, character segmentation and character recognition. Turning RGB images to grayscale images, eliminating noise with a bilateral filter, boosting picture contrast using CLASH, converting the image to a binary image, and lastly dilating the image are all part of the preprocessing process. Then, using Sobel vertical edge detection, number plate localization retrieves the number plate region from the image. The accuracy of this procedure is 90.9 percent, according to experimental results. Character accuracy for k-NN was determined to be 83.40 % in the end.

In [25] authors used a combination of template matching and bounding box algorithms. They first input the image, remove noise, and use the bounding box method to determine the area of the number plate, after which they segment each character individually. The template matching approach with the correlation coefficient is used in the last stage to recognize each character of the car number plate. According to the results of the testing, the accuracy is at least 80%. Some letters and digits, such as 0, O, D, B, and 8, are sometimes misidentified. This is conceivable because the input image is soiled because of poor image capture, such as blur, capture angle, illumination, and so on.

In [26] a proposed system used a data clustering (K-means clustering) process to generate knowledge. The hidden information pattern inside the database of identified number plates is employed to provide insight into vehicle data for decision-making and analysis. The suggested system's experimentation findings reveal 85.3% plate identification, 90.5% rear plate recognition, 83.2% localization, 80.5%-character segmentation, and 73.4%-character recognition.

In [27] authors proposed lightweight and effective deep convolutional neural networks to address the problems of real-time license plate detection and recognition. Extensive tests on two public datasets, CCPD and AOLP, revealed that detection and recognition

accuracy may be improved significantly. The proposed solution has a 98.1% accuracy rate, which is encouraging given the improvement in speed of their comprehensive ALPR (automated license plate recognition) system.

Summary

Research on automated license plate detection and recognition for vehicles in Bangladesh has been ongoing for less than a decade (judging by the paper published in various sources). Many of them used morphological operations for plate detection, extraction, character localization, segmentation, and recognition. Some of them perform plate detection and extraction in a single step and character localization and segmentation in another step. For all sorts of methods, they reported an accuracy of around 70% to 89%.

Chapter 3

Materials and Method

Materials

In this project we developed a web application which can detect license numbers from CCTV footage. To develop this application, we have collected appropriate datasets and trained multiple deep learning models.Also used image processing techniques in some scenarios. Based on validation accuracy and loss, The best suitable model has been selected for the web app. We integrated the trained model with the web app so that users can get data from a user friendly environment.

To collect the dataset, we mainly used two techniques. First, we collect some images from Rashedul Islam, Assistant Professor, ICT department, Rajuk Uttara Model College, which were captured for his previous study. Secondly, we captured some images from Aftabnagar, Dhaka area manually. We preprocessed those images to get the appropriate dataset for this project.

After finalizing our dataset, we trained the models in Google Colab. It provides a suitable environment for collaborative work. We used Pytorch, tensorflow python libraries to develop our models. To integrate the trained model with our web app, we used Flask framework to build the Web APIs. We used Flask as backend server and MySQL as database to store the data. We develop the application using Pycharm IDE. When any CCTV connects with the application, it processes the frames and identifies the number plate and finally retrieves the license plate number from it.. Then, it stores the information in the database. Then the application shows the result to the user.

Dataset Collection

The dataset that has been used in this experiment contains one class (number plate). We used two separate datasets: one is collected from Rashedul Islam, Assistant Professor, ICT department, Rajuk Uttara Model College. He is one of the authors of our reviewed papers.They physically gathered this data from the vehicles of various Bangladeshi metropolises, including Dhaka, Chittagong, and Khulna. The dataset contains 630 images of different vehicles in different lighting conditions.

Another dataset of 1800 images is collected manually from Aftabnagar, Dhaka area. Some data was collected from the road and some from parking areas. This dataset contains fresh, clear images as well as fizzy, dull, unclear images.

Figure 3.2: Images of vehicle's number plate

A dataset of Bangla characters is prepared using these two datasets. Each character is stored in a respective folder prepared for it and under each folder, there are almost 100 images of the respective characters. Each folder is labeled by a name similar to the nature of the characters such as the folder consists of digits (**০, ৫, ৯**) are labeled as **০, ৫, ৯** respectively. In the dataset, there are 10 Bangla digits (**০-৯)**, some Bangla letters that are used in the vehicles of different categories authorized by the BRTA. So, we have almost 18000 images of 24 classes.

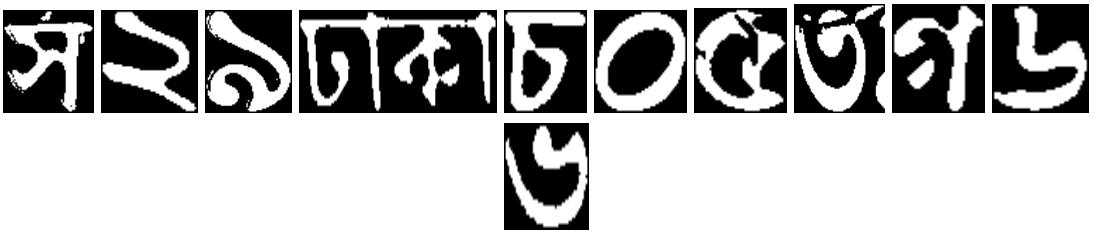


Figure 3.3: Images of Bangla Characters and strings

Dataset Exploration

Initially, both datasets have only one class which is 'number plate'. First dataset contains 630 images and the second one has 1800 images. The images that Rashedul Islam provided are scaled to 500x500 pixels. The number plate region is clearly apparent since the images are captured

from a close position. Uncleaned photos can be found in the second dataset. Images are captured from a variety of angles, leaving the plate area messy and blurry in many of them. These pictures are not resized.

The character dataset was generated manually. Using algorithm 2, we take the area of each character, crop the area and save them. After that, create folders for each class and put all the images in the appropriate folder.

Dataset Sampling

Data is sampled into three sections: train, test, and validation. Simple Random Sampling is used to sample them. It is a reliable technique for gathering data in which every single image in a population is picked at random: 70% of the images in the training set, 20% in the testing set, and 10% in the validation set.

Dataset Processing

Our main dataset is collected in image format. We resize the second set of data and define a bounding box around every plate because our initial ROI is "License Plate Area". There are several plate regions in certain photos. And therefore, there will be more than one bound box for such images. To prepare our dataset and obtain the coordinates of the number plate for the training phase, we process all of the images in this manner using Roboflow. Roboflow is a platform for computer vision that offers better methods for data collecting, preprocessing, and model training, enabling users to create computer vision models more quickly and precisely.

Research Environment and Devices

The use of technology is a must for our project. We can divide the specifications into two categories. They are given below:

Hardware Specification

Hardware specification is basically the minimal configuration of the hardware that must be needed in order to run the Software smoothly and correctly. The Graphics processing unit (GPU) was used in the virtual environment to build our models.Central Processing Unit (CPU) was used during development. The total 8GB of RAM was available. Our machine is powered by AMD

Ryzen 3 3100 4-Core Processor along with (GeForce GTX1630 Super with 4 GB of VRAM. Our windows are installed in a 256GB M2 SSD and also connected to 10 ITB (HDD).

Software Specification

Software specifications are essentially the features or programs that were employed to create our project. Our choice of programming language is Python. We used the "Google Colaboratory" web-based Python IDE to create our models. Google Colab provides 12GB GPU having 2496 CUDA cores, 2.3Ghz 1xsingle core hyper threaded Xeon CPU (1 core, 2 threads), 12 GB RAM, 33 GB HDD storage. In order to create application on our local system, we utilized Python 3.7.1. To build our model, we used a variety of frameworks, including Scikit Learn, Keras, Pytorch, and TensorFlow. We utilized conventional engineering and IT tools like Spyder, Pycharm, etc. for implementation. We utilized MySQL, Flask framework, HTML, CSS, Bootstrap, and javascript to create our system.

Method

In this experiment, several pre-trained CNN models have been employed for number plate detection and character recognition phase. The models are selected based on the literature review. A combined dataset has been created by collecting images from multiple sources to train, test and validate the models. The dataset contains RGB images. The images are converted into grayscale and segmented images and fed into a model (YOLO V7). The images have been preprocessed before fed into the model. From this phase, we get our ROI(number plate area). Then, we apply some morphological operation to get the location of the characters. After determining the location, we extract them and create a dataset using them. All the selected models are trained and validated on this character dataset. Keras image data generator class has been employed to fit the images into the model according to batch size, so that main memory did not exceed. To validate each model's performance, Accuracy, Precision, Recall and F1-score has been used. The working flow of this experiment is shown in Figure x. After finalizing the model, a web application has been developed integrated with the suitable model and connected to a Flask backend server to identify all the components.

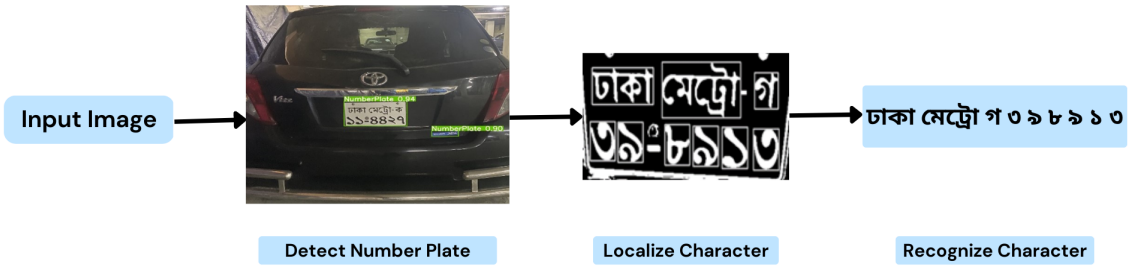


Figure 3.1: Three phases output

Proposed Model

Figure 3.5 depicts the framework we proposed in this project. The overall process of the training phase is divided into the following steps.

Detection and extraction of ROI:

Preprocessing:

The images are normalized and rescale by multiplying each intensity value with 1/255 because the highest intensity value for the images is 255. It bound the intensity value from 0 to 1. The network can learn faster if the inputs are normalized. Then the images are resized into 244*244*3 to make sure all images have the same shape.

Detect number plate:

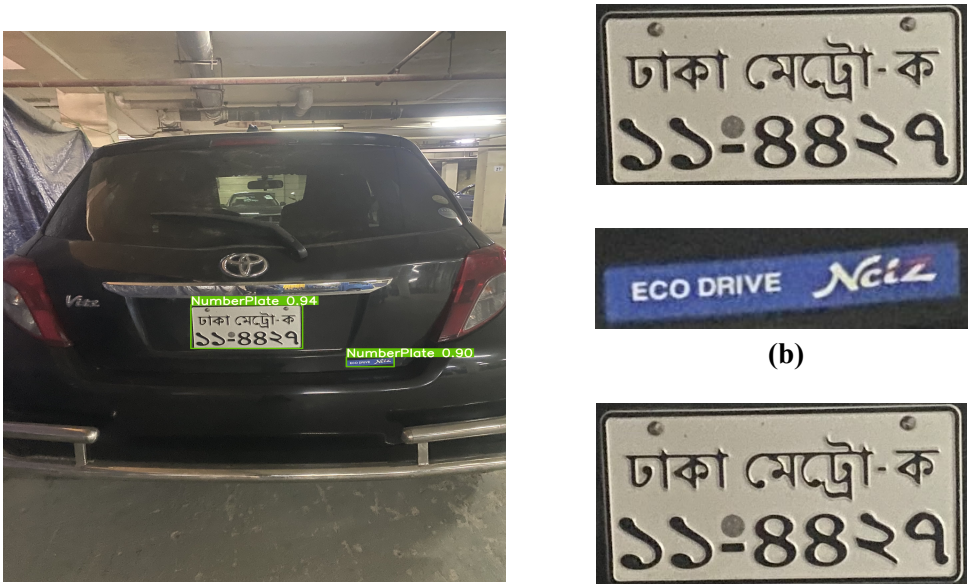
This is the most crucial step of the proposed framework. If the model fails to detect the plate area or (ROI) properly, the rest of the process won't work. So, for detecting plate area, we use You only look once (YOLO) V7 model. It is one of the most popular model architectures and object detection algorithms known for its speed and accuracy.

extraction of number plate:

After detecting ROI, we crop the plate areas based on the bounding box's location.

Post Processing:

After extraction, we may get multiple areas as ROI shown in figure x(b). To reduce the false positive, we applied some geometric properties of the number plate. Usually, the ratio of weight and height of Bangladeshi vehicle's number plate is 1.8. If the ratio of predicted area falls in 1.5-2.6, then that bounding box is taken as ROI, otherwise not. This way, we get our actual ROI like figure x(c)



(a) **(b)** **(c)**

Figure 3.5 (a) detected ROI; (b) Extracted areas; (c) get actual number plate after post-processing

Text localization and extraction:

Pre processing

The retrieved license plate from the prior stage has to be quickly resized. We, therefore, scale them down to (500, 250) weight and height accordingly.

Next, we turn them into grayscale. It facilitates the simplification of algorithms and also removes the difficulties associated with computing needs.

Text localization:

Getting the individual characters location is necessary to perform recognition phase.After extracting the plate area, we follow some steps to get every character's location. The algorithm of the text localizing process is given below.

Steps:

Apply adaptive Thresholding to separate desirable foreground image objects(text) from the background based on the difference in pixel intensities of each region like figure x(1)

Apply morphological filters dilation to expands the foreground object (text)

Perform connected components analysis on the image. Each element in labels is 0 if it is background or >0 if it belongs to a connected component.

A heuristic approach is used to detect which white blob is character, set a lower boundary and an upper boundary of number of pixels and draw a boundary if any component fall in between them

Get a bounding box for each contour.

Sort the bounding boxes from left to right, top to bottom to get the proper sequence of characters.

If the total number of bounding boxes is zero that means the border of the license plate is captured so that the contours present inside this rectangle don't come into consideration. So go to step 3. Based on the 2.5:1 weight and height ratio of license plates, we will find our desirable contour and crop it to remove the border. Then go to stop 4.

(a) (b) (c)

Figure 3.6 (a) adaptive Thresholding; (b) morphological filters dilation; (c) bounding boxes around characters

Recognize Characters:

The process of recognition of characters is divided into two steps. In the first phase, we resized images, balanced the dataset and applied augmentation techniques to get more variation in data. Then we use multiple state-of-the-art models of convolutional neural networks to train models. Several pre-trained CNN models such as Inception, VGG16, VGG19, Xception, DenseNet, Alexnet have been employed to conduct this experiment. Transfer learning (TL) has been used in this experiment. To train an efficient generalized model, it is necessary to feed lots of data. Pre-trained models are trained on large dataset of multiclass images. The models have a lot of trainable parameters, and it takes a significant amount of time to train. By integrating pre-trained models can generalize any domain specific model with less data and less number of trainable

parameters. Since a large number of parameters already have pre-trained weights, it takes less time to train and gives better performance in a generalized manner.

Design/Framework

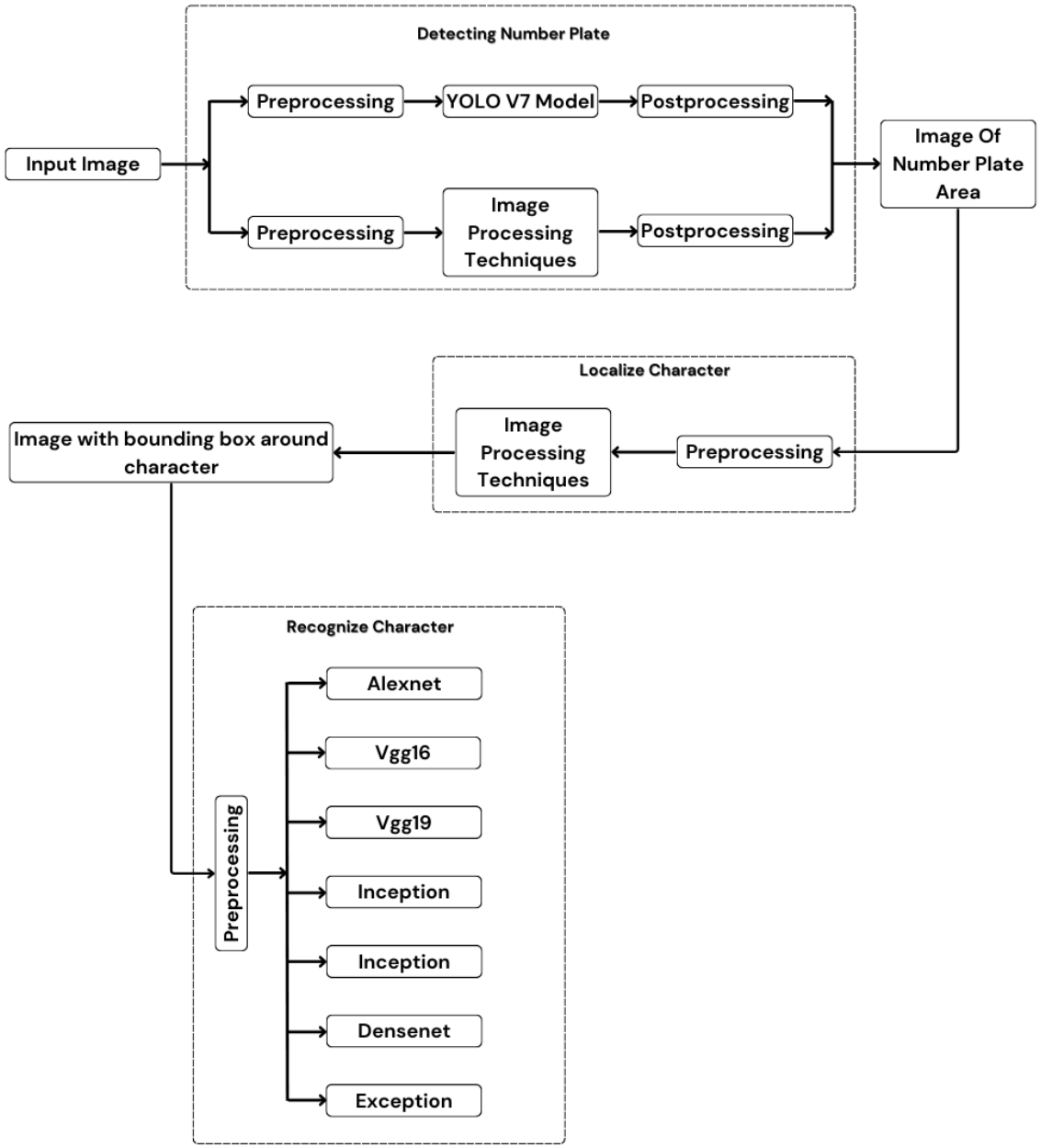


Figure 3.7 Proposed Framework

Algorithm/Model Formulation

Algorithm 1: Number plate detection

Load the dataset from directory
Pre-process the images
    Normalize and rescale
    Resize images into 224*224*3
Split the image dataset into train-test-validation sets
Train YOLO V7 model on the training dataset
Test the model with test dataset
Extract the predicted areas
post processing
    Calculate aspect ratio of extracted areas
    if aspect ratio is falls among this range (1.2- 2.6), store it as number plate

Algorithm 2: Character Localization

Pre-process the images
    resize image into (500, 250) shape
    convert into grayscale
Apply adaptive Thresholding on license plate image
Apply morphological filters dilation
Perform connected components analysis
 set a lower limit and an upper limit of number of pixels
if any component fall in between them then draw a boundary around them
Sort the bounding boxes from left to right, top to bottom
If the total number of bounding boxes is zero then store the output of step 5 in a variable
using loop, find out which connected component has 2.5:1 weight and height ratio[that is our license plate's border] and then go to step 6

.**Algorithm 3:** Recognize Characters

Pre-process the images
    Normalize and rescale
    Resize images into 224*224*3
    Data augmentation
        Horizontal shift
        Vertical shift
        Random zoom
    Create one-hot encoded 2D array for class labels
Split the image dataset into train-test-validation sets
Train several CNN models on the training dataset
    Take images in batches from the training dataset
     Calculate the weight of each neuron and apply activation function
    Calculate the categorical cross-entropy loss
     Update the weights using Adam optimizer and back propagate
    Repeat the steps for each epoch
    Evaluate the models with validation dataset

Experiment Setup

We set up the environment and models for this experiment by fine tuning some hyper parameters. The selected values of the hyperparameters shown in Table 3.

Table 3: The selected values for the hyperparameters tuning

Hyperparameters	Value(s)	
Image Size	224 x 224 x 3	
Class Mode (CNN)	Categorical	
Transfer Learning Weights	ImageNet	
Test Split	20%	
Validation Split	10%	
Pooling	Max-Pooling	
Activation	Hidden Layers (CNN)	ReLu
	Output Layer (CNN)	Softmax
Optimizer	Adam	
Learning Rate (CNN)	0.0001	
Loss	CNN	Categorical Cross Entropy
Metrics	CNN	Accuracy, Precision, Recall, F1-score
Epoch	CNN	30
Batch size	CNN	32

Summary

The aim of this project is to identify license numbers using web application. For achieving the aim, we trained CNN models using transfer learning, used image processing techniques and integrated the best model with the web app. Our project has three major steps: Number plate detection, character localization and character recognition. Other steps are necessary to support the major phases. In the training phase, YOLO V7 model is trained using license plate's images. Then post process the output to get the accurate result.

By applying adaptive thresholding, dilation, connected component-based analysis, and some geometric properties of character, characters are extracted. Then resize and reshape these images to train multiple deep-learning models to recognize characters. To find out the suitable model, we used several pre-trained models such as Inception, VGG16, VGG19, Xception, AlexNet, DenseNet. Those models were trained on the ImageNet dataset which contains thousands of classes. This experiment was performed on RGB and Grayscale images. This way we will get our final result as a string. Then, evaluate the performance based on Accuracy, Precision, recall and loss on validation dataset.While training, we used callbacks to save the best model based on validation accuracy.

After the model evaluation, we deployed the suitable model into the backend server using the Flask framework. We used a MySQL database to store the records. Users can connect CCTV cameras and get the license numbers passed through that camera.

Chapter 4

Results and Discussion

Obtained Results

Our goal is to develop a system that can detect number plates, localize characters on that plate and recognize them more efficiently. Record keeping, identifying vehicles and it's owner will become automated, faster, and easier through this concept..So, our study has three key output, which are as follows:

Table 4.1.1: Experimental Results on Validation dataset for Number Plate Detection

Model Name	Accuracy	Precision	Recall	mAP@.5	mAP@.5:.95:
YOLO V7	0.91	0.994	0.901	0.938	0.827
Image Processing Techniques	–	0.936	0.915	–	–

Table 4.1.2: Experimental Results on Validation dataset for Character Localization

Precision	Recall
0.85	0.97

Table 4.1.3: Experimental Results on Validation dataset for Recognition character

Model Name	Loss	Accuracy	Precision	Recall
Inception	0.3522	0.8696	0.8807	0.8587
VGG16	0.5226	0.9157	0.9187	0.8413
VGG19	0.5379	**0.9369**	0.9127	**0.9476**
Xception	0.3726	0.9026	**0.9539**	0.8261
DenseNet	**0.3254**	0.8985	0.8994	0.8565
Inception	0.3574	0.8312	0.8801	0.820

In-Depth Result Analysis

4.2.1 Detection of ROI(license plate) from images

We have identified the ROI (license plates) from the images using YOLO V7, and our findings are 91.38% accurate. Figure x provides a graphic representation of the predictions. It presents a table of all the predicted and actual values of number plate detection. Here, our model predict 91% license plate accurately and can't identify 9% plate.

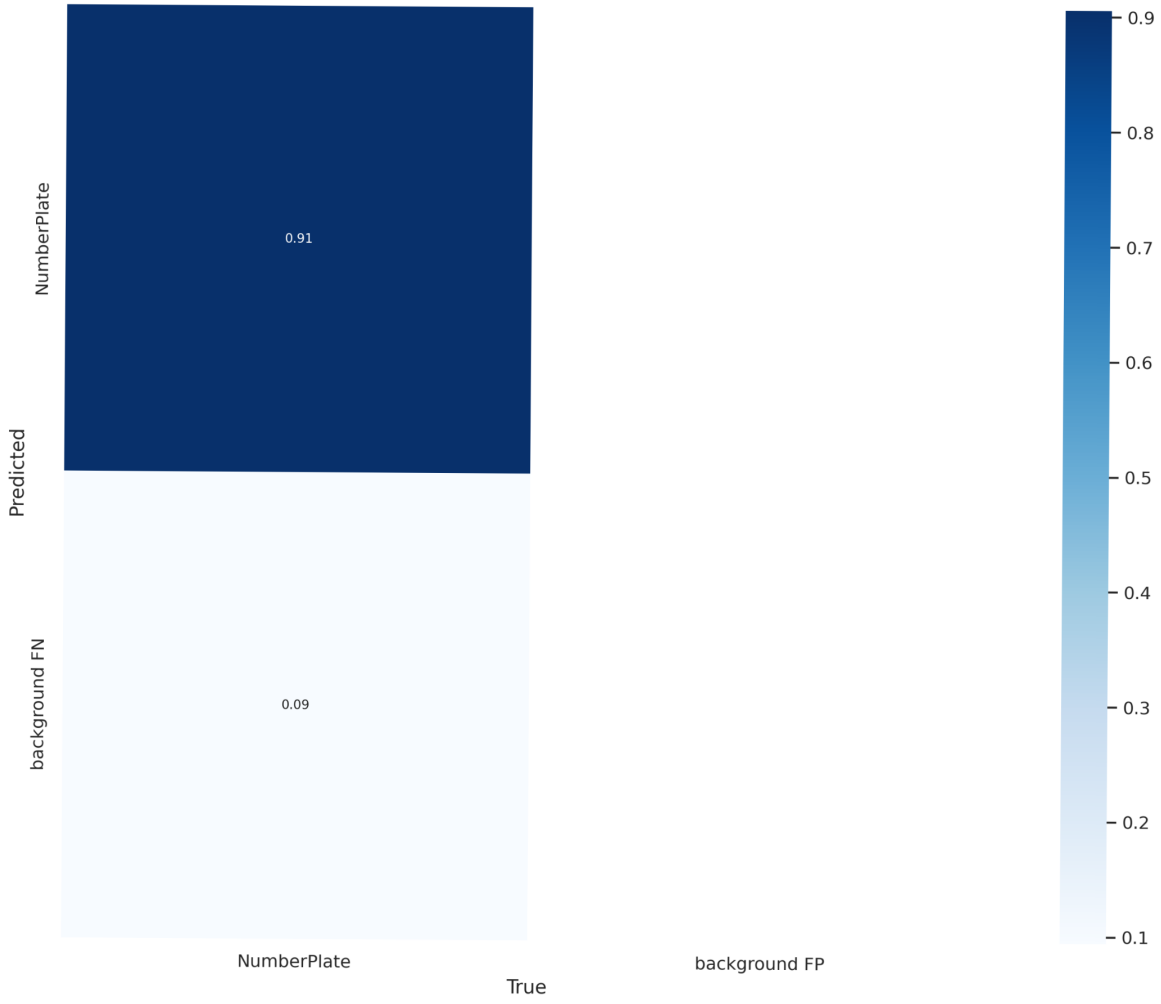


Figure 4.2 Confusion Matrix

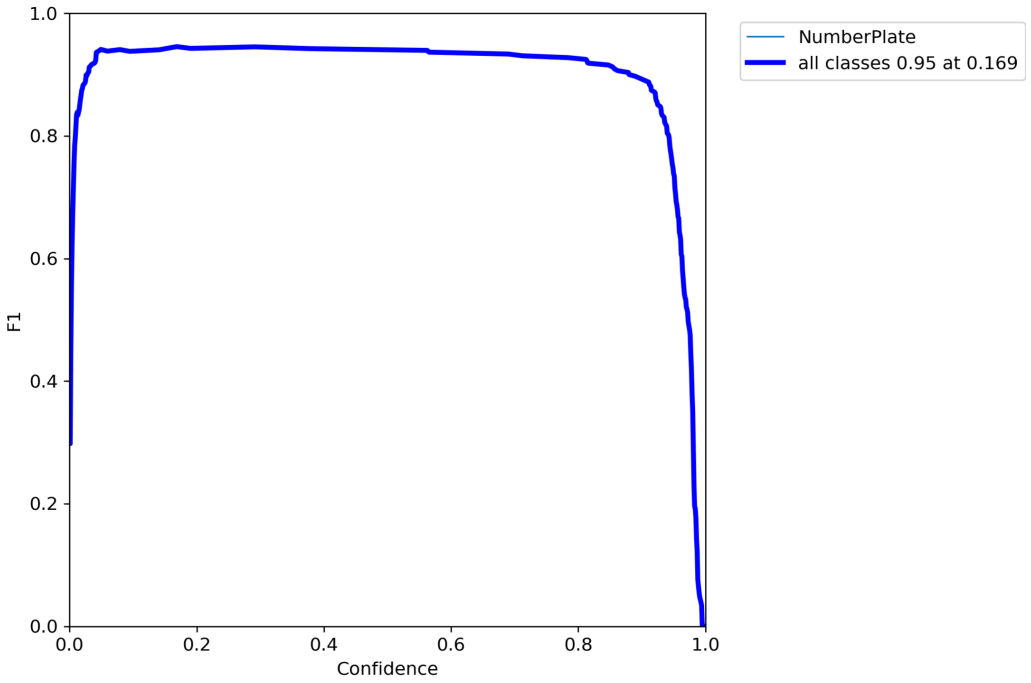


Figure 4.3 F1 curve

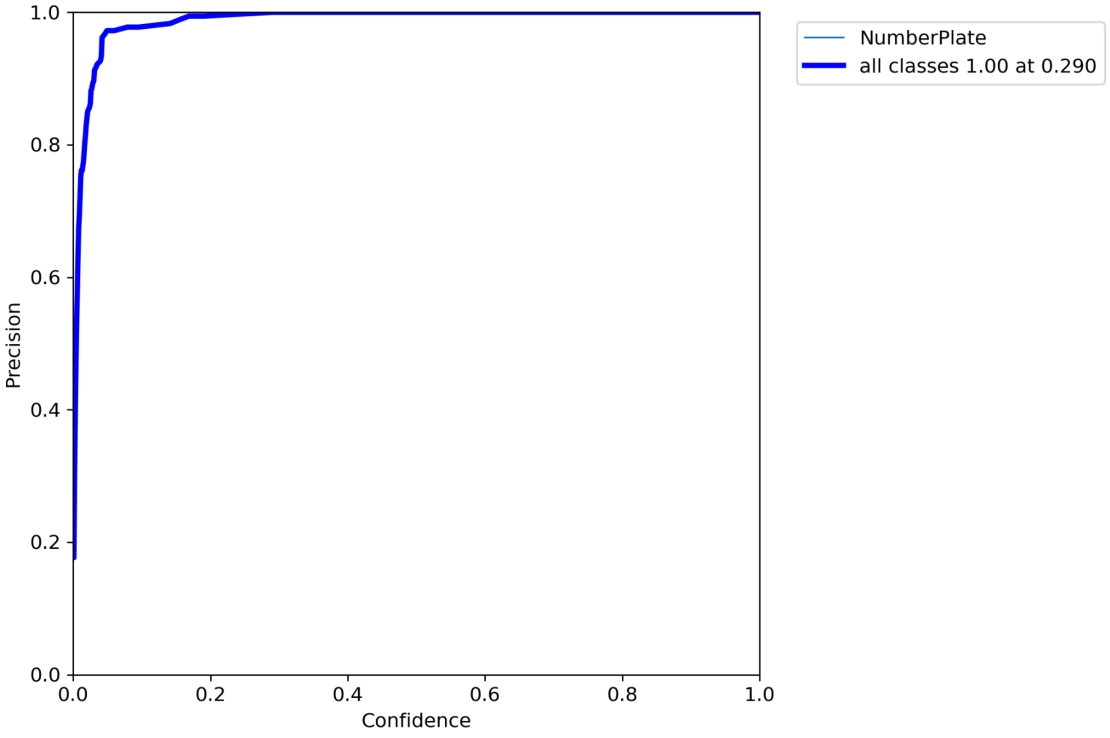


Figure 4.4 Precision curve

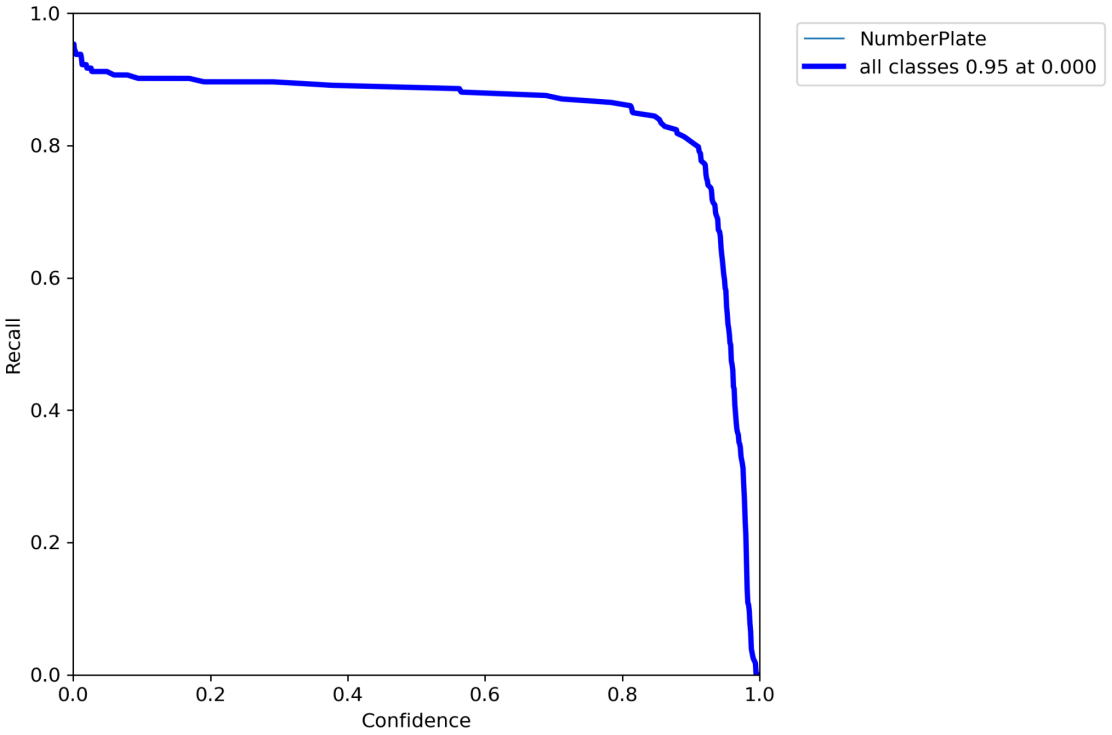


Figure 4.5 Recall curve

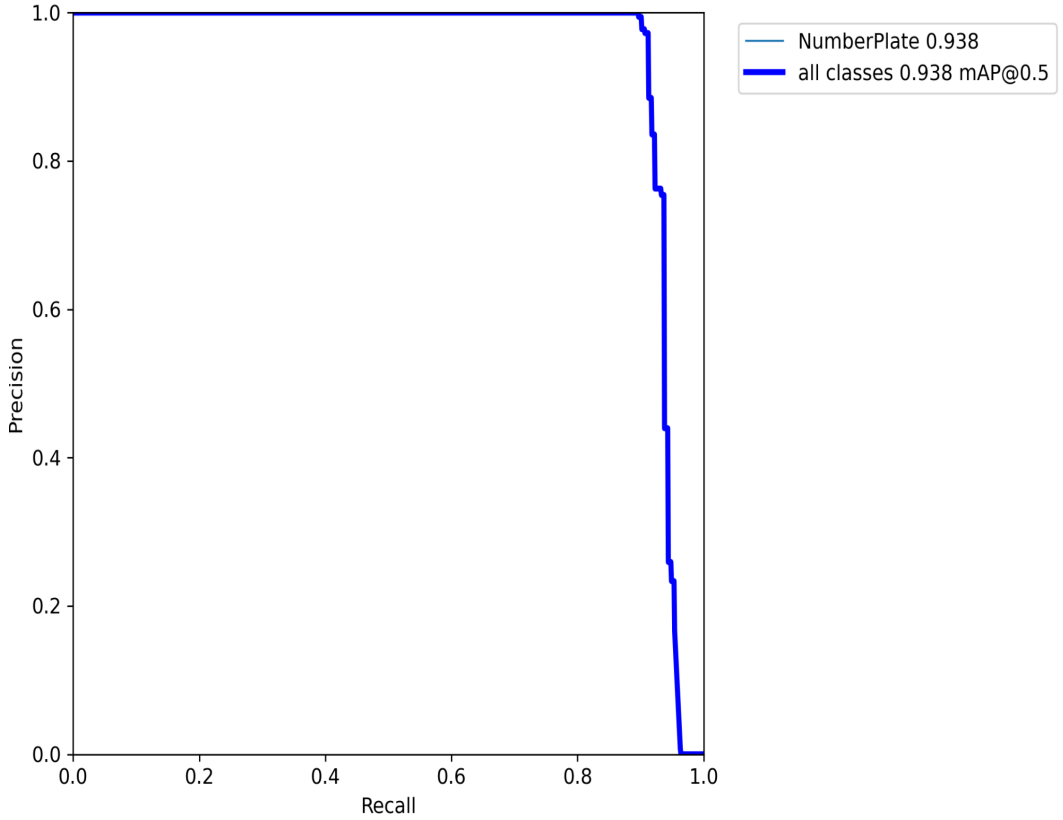


Figure 4.6 Precision recall curve

Table 4.2.1: a comparative study of the license plate detection system

Method	Accuracy (%)
YOLO V7	91.38%
Others(using same dataset)	89.10%

4.2.2 Extraction of Bangla character

To analyze the results of Bangla text extraction, we have used two methods, they are precision, recall based on the following parameters .

True Positives (TP): Correctly detected character's location are treated as true positives.

True Negatives (TN): The background area and noise which does not detect as character is treated as true negatives.

False Positives (FP): The regions which do not contain any characters, but they have been detected by the algorithm as text regions are treated as false positives.

False Negatives (FN): The regions which contain actual characters, but they have not been detected by the algorithm are called false negatives.

Table 4.2.2:Confusion matrix result of license plate detection

TP	FP	FN	Precision	Recall
1042	183	29	0.85	0.97

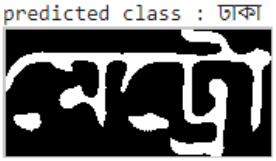
4.2.3 Character Recognition

We used 7 models to recognize Bangla characters from two sets of data. These are:

Our best model for recognizing Bangla characters is VGG-19, which gives a 98.11 % accuracy result.

Figure x shows the result for recognizing characters

```
1/1 [==============================] - 0s 386ms/step
prediction accuracy : 1.0
predicted class : ঢাকা
```



```
1/1 [==============================] - 0s 403ms/step
prediction accuracy : 1.0
predicted class : মেট্রো
```

```
1/1 [==============================] - 0s 401ms/step
prediction accuracy : 1.0
predicted class : গ
```

```
1/1 [==============================] - 0s 398ms/step
prediction accuracy : 1.0
predicted class : ৩
```

```
1/1 [==============================] - 0s 394ms/step
prediction accuracy : 1.0
predicted class : ৭
```

```
1/1 [==============================] - 0s 401ms/step
prediction accuracy : 1.0
predicted class : ৬
```

```
1/1 [==============================] - 0s 392ms/step
prediction accuracy : 1.0
predicted class : 8
```

```
1/1 [==============================] - 0s 391ms/step
prediction accuracy : 1.0
predicted class : ৭
```

```
1/1 [==============================] - 0s 408ms/step
prediction accuracy : 1.0
predicted class : ৭
```

Figure 4.7: Character recognition using VGG-19

Performance Evaluation

We saw that YOLO V7 has the highest accuracy (91.38%) in Table-4.2.1. VGG-19 performs in the recognition phase. And our morphological image processing model can identify the maximum character's location.

Work breakdown structure (WBS)

To complete our whole project, we breakdown the project into step by step approaches..By breaking down our project into smaller components, the method, approaches, scopes, cost calculations, and budget estimation has become convenient.

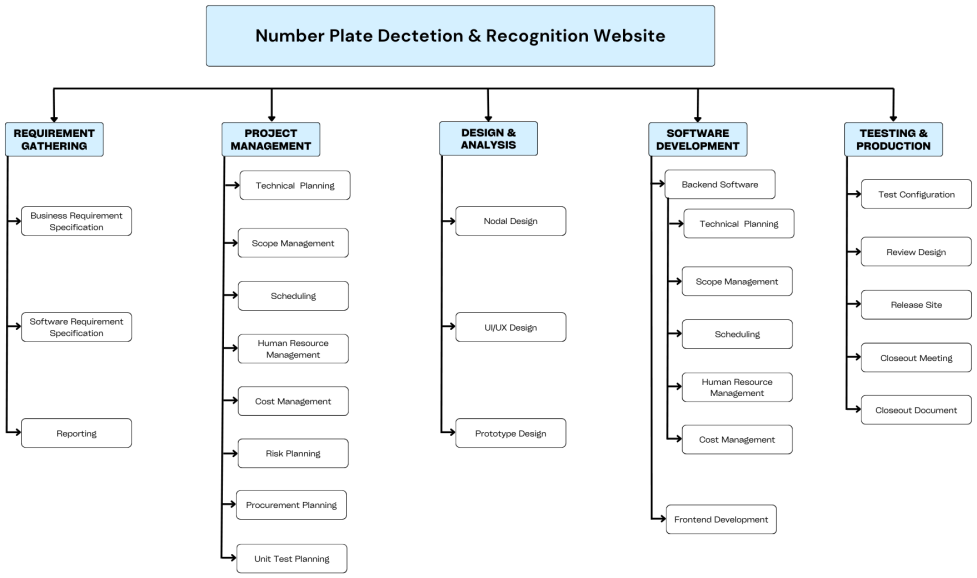


Figure 4.8 Work Breakdown structure

Cost Factor

Following the breakdown structure in case of commercial use of our system, we estimated the budget.

Cost Factor	Resources	Duration(Days)	Budget
1 Requirement Gathering			
1.1 Business requirement specification		2 Week	
1.2 Software requirement specification	Materials		

1.3 Reporting			5,000
2 Project Management			
2.1 Planning technical		3 Week	10,000
2.2 Scope management			
2.3 Scheduling			
2.4 Human resource management	Spreadsheet		
2.5 Cost management	software tool		
2.6 Risk management			
2.7 Procurement planning			
2.8 Unit test planning			
3 Design & Analysis			
3.1 Model design	Designing tools,	3 Week	40,000
3.2 UI/UX design	visualization &		
3.3 Prototype design	analysis tool		
4 Software development			
4.1 Backend Software		8 Week	1,00,000
4.1.1 Database implementation			
4.1.2 Middleware development	workspace, database,		
4.1.3 Security Subsystem	security certification,		
4.1.4 Catalog Engine	version controller		
4.1.5 Transaction Processing			
4.2 Frontend Development			
5 Testing & Production			
5.1 Test Configuration		4 Week	30,000
5.2 Review Design	unit testing tools,		
5.3 Release Site	hosting service		
5.4 Closeout Meeting			
Total			1,85,000
Staff			
Project Manager(1 person)		5 Months	425,000
Business Account Officer(1 person)			166,666
Senior Developer and Designer(1 person)			212,500

Junior developer(4 person)			83,333
Quality Assurance Officer(1 person)			111,111
Total			998,610
Total Cost of the Project			11,83,610

Figure 4.9 Cost Factor of project

As a project manager we also estimated wages for staff who would be contributing to our project. And after planning, evolution, and executing our system the total cost for our project could be 11,83,610 TK.

Earn Value Management:

Budget At completion(BAC) = 11,83,610/-BDT(details in budgeting section)

Time	PV	AC	Completed Work	EV	SV	CV	SPI	CPI	CR	ETC	EAC
T1 = 5 weeks	2,95,903	375,000	20%	59,181	-236,722	-315,819	0.20	0.16	0.032	14,79,513	18,54,513
T2 = 10 weeks	5,91,805	750,000	53%	3,13,657	-278,148	-436,343	0.53	0.42	0.23	662,257.00	14,12,257
T3 = 15 weeks	8,87,708	11,25,000	72%	6,39,150	-248,558	-485,850	0.72	0.57	0.41	4,36,067	15,61,067
T4 = 20 weeks	11,83,610	1,500,000	98%	11,59,938	-23,672	-340,062	0.98	0.77	0.754	30,743	15,30,743

ETC = (11,83,610 - 1159938)/0.77 = 30743
EAC = 30743 + 1500000 = 1530743
VAC= EAC - BAC = 1530743-11,83,610 = 3,47,133

Figure 4.10 Earn value Management

We assume for commercial use of our project, our estimated duration is 20 weeks or 5 months. So, we can break down our work by 20 weeks/5 weeks= 4 time slots or T for EVM calculation. Expected cost to complete the whole project is = 11,83,610 TK.

So, BAC = 11,83,610 TK.

Above the EVM, we can see our whole project estimated duration is 140 days which we break down into 4 parts. Each segment carries 5 weeks of the whole work schedule. So, we see after 20 weeks when the estimated time finished, the CPI is almost 1 but less than 1. So we can say we are a little overspending on our budget. We know, the ideal CR is 1.0. In the last stage the critical ratio is 0.74 which implies the project doing little poorly on both cost and schedule. If we can complete 100% according to our plan then our project will be right on our plane. As past variances are expected to continue at the same level we see ETC (Estimated to Completion) is 30743 TK which implies additional subject is required to meet the project at given point of time. Estimated at Completion (EAC) is 15,30,743 TK which is greater than Budgeted Cost (BAC). So, the variance is = EAC- BAC= 3,47,133 TK. So, the gap between estimated project cost at the given time is 3,47,133 TK. In the 1st 5 weeks we see only 20% work has completed and in the last time period we can see 98% work has completed. So here our estimated to completion we get 30743tk and our variance is 3,47,133 tk that means we need 3,47,133 tk to add in our budget to complete our project properly 100%.

Discussion

The aim of this project is to identify license numbers using web application. For achieving the aim, we trained CNN models using transfer learning, used image processing techniques and integrated the best model with the web app. Our project has three major steps: Number plate detection, character localization and character recognition. Other steps are necessary to support the major phases. In the training phase, YOLO V7 model is trained using license plate's images. Then post process the output to get the accurate result.

By applying adaptive thresholding, dilation, connected component-based analysis, and some geometric properties of character, characters are extracted. Then resize and reshape these images to train multiple deep-learning models to recognize characters. To find out the suitable model, we used several pre-trained models such as Inception, VGG16, VGG19, Xception, AlexNet, DenseNet. Those models were trained on the ImageNet dataset which contains thousands of classes. This experiment was performed on RGB and Grayscale images. This way we will get our final result as a string. Then, evaluate the performance based on Accuracy, Precision, recall and loss on validation dataset.While training, we used callbacks to save the best model based on validation accuracy.

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Summary

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Chapter 5

Conclusion

Social and Environmental Impact

The multidisciplinary method of social and environmental impact evaluation combines the examination of the economic (based on cost-benefit ratios) and environmental aspects of a project. The environmental effect analysis's main objective is to pinpoint the environmental impact that the capstone project is anticipated to have in order to promote long-term sustainability, a safe and healthy environment, and better development. According to the environmental impact assessment (EIA), there will be varying degrees of impact on land, water, plants, animals, bacteria, and non-living things.

The capstone project we are working on involves identifying Bangla characters and detecting number plates using a variety of modern technologies, including data processing, machine learning, deep learning, and so on. It makes perfect sense to evaluate how this capstone project will affect society and the environment. To do this, we'll discuss a contemporary methodology called Environmental and Social Impact Assessment (ESIA). According to the most frequently accepted definition, an Environmental and Social Impact Assessment (ESIA) is a thorough document that examines a Project's potential environmental and social risks and effects. We must take into account two consequences in the context of our capstone project. Environmental impact assessment (EIA) is the first, while social impact assessment is the second (SIA).

EIA is a method for assessing a project's or development's possible effects on the environment while also taking into account any potential benefits or drawbacks for the economy, culture, and human health. SIA is the process of identifying and managing the social effects of industrial endeavors. It may also be used to describe plans, methods, or plans of action. SIA is used to foresee and stop unfavorable outcomes as well as to find ways to enhance benefits to local communities and society as a whole.

Our technology is extremely user-friendly and beneficial in every aspect because it presents no risk to anyone and has no negative impacts on the natural social structure. Since the technology is web-based apps that can be easily accessed in any computer or mobile phone, there is no negative influence on soil, water, or air. This work hasn't used any harmful materials, and it won't in the future either. Any related traffic agency can use this technology in parking lots to reduce traffic crimes. We know in our country there are too many traffic related problems happening everyday.

These traffic congestion are mainly happening mainly for breaking rules of traffic, overtaking, using wrong number plates etc. Moreover there is no accurate database or record of vehicles in parking lots. They usually do these checks manually which is time consuming and not so correct. That's why we made this automated number plate detection and recognition system of Bangla license plates which helps to detect unauthentic vehicles. Our project will take care of all rules & regulations in our environment. Moreover, our system is economically cost-friendly & user friendly to use. We will use it in an efficient way to detect and solve these social problems. No risk or natural imbalance will be seen while doing it. We collected number plate images and data from our surroundings, East West University in an authentic way which data is both valid and secure. Our lovely world and its amazing surroundings have not been harmed by us in any way. As a result, our approach won't cause any issues with social, health, safety, law, culture, or the environment.

Our capstone project makes a positive impact on society. In our capstone project we are detecting & recognizing number plates of vehicles for both social benefit & environmental use. Society is nothing more than a group of people who share the same basic values. And our goal is to help the people of that society by giving them the chance to stop committing social crimes related to unethical or illegal use of vehicles. And our effort is to assist the inhabitants of that society by providing them with the opportunity to remove social crimes from unethical or unlicensed use of vehicles. Our machine is not creating any disturbance to any religion, caste and culture. Our work is creating influence on the young generation to do something for the well being of our nation, to prevent social problems. It also raises awareness among the people from not running unethical business by unlicensed & unauthorized vehicles. This project has the purpose to avoid unethical business, transferring, and crimes without harming social life. The goal of the capstone project is to improve the lives of society's citizens. We'll also state that the practices we adopted for our capstone project had no negative effects on society in terms of ethics or integrity. After evaluating everything, we can be certain that our capstone project has a positive overall impact on society and the environment, with no negative social or environmental effects.

Overall Contributions:

Our supervisor has played a critical role in guiding and supporting us throughout this project. Their extensive knowledge and expertise have been instrumental in helping us navigate through various challenges, providing insightful feedback, and ensuring that we stay on track. Each of our team members has also contributed significantly to the success of the project, bringing their unique skill sets and perspectives to the table. Through effective communication and collaboration, we were able to achieve our goals and

deliver high-quality results. Additionally, we would like to acknowledge the contributions of other faculty members who have provided valuable input and support throughout the project. Together, their efforts have made this project a success, and we are grateful for their contributions.

Limitations and Future Works

The first and most crucial factor of our project is to detect the number plate. It is also the most challenging part. BRTA (Bangladesh Road Transport Authority) has launched the Retro-Reflective number plate, also known as a digital number plate. The Bangladesh government makes Retro-Reflective number plates mandatory for all vehicles. But still many people use printed laminated copy, hand written number plates like Fig 1. In this situation it's hard to find the pattern of the number plate to detect it. The more accurate the number plate detection will perform, the more will increase the performance of further steps.

Fig 5 vehicle's number without Retro - reflective number plate

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Appendix A
Mapping of Course and Program Outcomes

CSE400-A

Program Outcomes:

PO1 (Engineering Knowledge): We have chosen such a project which can be solved through the engineering knowledge we have gained in Computer Science and Engineering. Moreover, it includes the subfields of both Data Science and Software Engineering. The project is selected by considering the current traffic related problem of the world and solving it with the previously and newly collected knowledge. We have used the knowledge of programming language, image processing concepts, Artificial Intelligence, image processing, deep learning, computer vision and many more. The project was not only done by using the previous engineering knowledge we gained but also we have collected additional knowledge from different outside resources. We compared our results with previous used model results and used our models for finding better accuracy and solutions.

PO4 (Investigation): The prerequisite for starting a new research/project is reading a large number of papers as it is not possible to present something new in the field of research without being aware of the previous works. To fulfill the goals of our project, we have studied a lot of research papers published in reputable conferences and journals, related to our work for a better understanding of the methods, tools, and hardware. Finding relevant papers was an investigation of this research. We have investigated the Laws, Security, hardware and tools we needed.

CO	Details	Knowledge Profile (K)	Engineering problem (EP)

CO1	**Integrate** new and previously acquired knowledge for identifying a real-life complex engineering problem as the capstone project	**(i) Problem Analysis [K1, K2, K3, K4]** **K1: Theory-based natural sciences: -**In our capstone project about vehicle number plate detection, we placed great emphasis on the general concept of Bangladesh vehicle number plate and studied extensively about it to identify the working process, policies, problems and solutions. **K2: Conceptually-based mathematics, numerical analysis, statistics, and formal aspects of computer and information science: -** Our approach includes mathematics, statistics, and numerical methodologies to aid in the creation or use of models that replicate 'real world' behaviors. We have two types of datasets in our capstone project one is image type data another one is csv formatted data. We have done mathematical analysis and statistical analysis based on our dataset to find out the characteristics of our dataset. **K3: Theory-based engineering fundamentals: -** Data science is the major source	**(i) Problem Analysis [EP1, EP2, EP3, EP4, EP5, EP6, EP7]** **EP1: Depth of knowledge required: -** After gaining in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6, or K8, allowing for a fundamental-based, first principles analytical approach. In our system, we use our extensive engineering experience. It is difficult to achieve the aim of detecting vehicle number plates and convert it into English without in-depth engineering expertise at the level of one or more of K3, K4, K5, K6, or K8. **EP2: Range of conflicting requirements: -** We incorporate a wide range of conflicting issues.several topics were in our mind, but didn't know the working principles to choose the correct one. **EP3: Depth of analysis required: -** To choose the appropriate problem, we needed abstract thinking and analysis to come up with an appropriate topic for our project and locate the obvious solution. In this case as our project is based on number plate detection and many more, we have analyzed the problem to work on it.

		of factual information in core areas of fundamental engineering knowledge that are applicable to our engineering discipline. In our vehicle number plate detection and recognition capstone project, we applied the in-depth knowledge of machine learning and deep learning to construct different types of models to detect number plates and convert them into English language. **K4: Forefront engineering specialist knowledge for practice: -**With the help of machine learning and deep learning, our approach has a considerable depth of knowledge to support automatic toll collection,parking lot access management. Our project is built around different type of machine learning and deep learning models in order to get the best output	**EP4: Familiarity of issues: -** We make an effort to include issues that aren't commonly encountered in our detecting number plate system. **EP5: Extent of applicable codes: -** We focused on making our system understandable and maintain the code standard such that outside issues are covered by professional engineering standards and rules of practice So that it would be easy for the user to get the detection of number plate. **EP6: Extent of stakeholder involvement and conflicting requirements: -** We may include a wide range of stakeholders in our system which is detecting number plate and converting into English, each with their own set of requirements. We can, for example, include BRTA officers or non - experts in our programs and take the opinion of experts. **EP7: Interdependence: -** We have the freedom in our number plate detection project to work on high-level problems with multiple component pieces

			or sub-problems such as solving a ton of number plate detection together at a time. We choose the topic with our knowledge.
CO2	**Examine** various problem domains (literature review), **define** the problems, and **formulate** the objectives for the capstone project	**(i) Design and Implementation [K8]** **K8: Research literature: -** We engage with selected knowledge in the research literature of number plate detection. Several recent papers are chosen to analyze and find out the unique points, existing problems and study the methods used to formulate the objectives.	**(i) Design and Implementation [EP1, EP2, EP4, EP5, EP6, EP7]** **EP1: Depth of knowledge required: -** After learning in-depth engineering knowledge at the level of K3, K4, K5, K6, or K8, a fundamental-based, first principles analytical method is possible. To learn our project in-depth, we analyzed several pieces of literature to gain knowledge about existing work. **EP2: Range of conflicting requirements: -** In our number plate detection project, we learn about several literatures. All have different approaches so it's hard to learn them all in a short time. **EP3: Depth of analysis required: -** To establish the system in place, we needed abstract thinking and analysis to come up with appropriate models for our project and locate the obvious solution. In this

			case as our project is based on number plate detection and many more, we have analyzed the existing literature to learn the topic. **EP4: Familiarity of issues: -** We make an effort to include issues that aren't commonly encountered in our detecting and recognizing number plates. **EP5: Extent of applicable codes: -** we learn the code of literatures and try to find out the failings to work on them. **EP6: Extent of stakeholder involvement and conflicting requirements: -** We may include a wide range of stakeholders in our system. We find a paper with a relevant dataset and contact the author to collect them for our project. **EP7: Interdependence: -** We have the freedom in our number plate detection project to work on with our chosen research papers. We choose the literature convenient for us and learn from them.

CSE400-B

Program Outcomes:

PO2 (Problem Analysis): Detecting number plate area and recognizing characters to check whether the vehicles are authentic or not has become a major problem nowadays. So, to solve this problem, we have analyzed the problem and found the critical points. We have studied the related research papers which have been done previously and tried to collect ideas from different approaches to solve the problem. To build a solution to the problem we have identified the limitations and strengths from the related literature.

PO3 (Design/Development of Solutions): We have designed and developed a solution

of the selected traffic related problem primarily. There could be some issues with the current solution. So, we have also considered alternate solutions to the problem. The solution we have built will not affect public health and safety negatively. Cultural, Societal, and environmental issues have been considered to develop the solution.

PO5 (Modern Tool Usage): We have done meetings with our honorable supervisor and under his supervision, we learned how some of the IT tools can be used to find a solution to the problem. We have also experimented with some tools on our own. We have used modern IT tools like python, VS code, Adobe illustrator, flask, TensorFlow, and OpenCV to build the solution. We also used web based tools like Google Collaboratory to accelerate the development process.

PO6 (The Engineer and Society): The project was selected to reduce vehicles and related problems, crimes for the development of our society and traffic sectors. This project or development of this project does not have any negative impact on society or culture. We have also considered the societal and legal issues in the building and application of this project.

CO	Details	Knowledge Profile (K)	Engineering Problem (EP)
CO 3	**Analyze** various aspects of the objectives for designing a solution for the capstone project.	**Problem Analysis :** **K1:Theory-based natural sciences:** we placed great emphasis on the general concept of Bangladesh vehicle number plate and studied extensively about it to identify the working process, policies, problems, and solutions. **K2: Conceptually-based mathematics, numerical analysis, statistics, and formal aspects of computer and information science:** To work	**Problem Analysis :** **EP1: Depth of knowledge required:** we study Bangladesh's vehicle number plate and gather knowledge about problems that people face in their everyday life. For example - traffic rules breaking, car robbery, standing in the queue for toll and parking fee. **EP2: Range of conflicting requirements:** some literature worked in a

		with vehicle number plates, we have to process the image using different image processing techniques where mathematics is the base structure. **K3: Theory-based engineering fundamentals:** In the project, we will apply the in-depth knowledge of machine learning and deep learning to construct different types of models to detect number plates and convert them into English language. **K4: Forefront engineering specialist knowledge for practice:** With the help of deep learning, our approach has a considerable depth of knowledge to support security practice. Our project is built around different type of machine learning and deep learning models in order to get the best output.	structured format, and some only used the built-in function to make the application. **EP3: Depth of analysis required:** **EP6: Extent of stakeholder involvement and conflicting requirements:** We interviewed several BRTA officers to study their system and find some requirements which we don't see in our reviewed papers. So, we set the objective of our project based on those requirements. **EP7: Interdependence:** detection of a number plate from any dull, fizzy, unclear is a challenging problem in our project.
CO 4	**Design** and **develop** solutions for the capstone project that meet public health and safety, cultural, societal, and environmental considerations	**Design and Implementation :** **K5: Engineering design:** We acquire knowledge for the proper implementation of our detecting & images, extracting & recognizing characters before implementing it. We analyzed YouTube videos, online courses, and our academic course to gain technical knowledge, design approaches and relevant tools and resources to develop components, models, or processes that fit specific	**Design and Implementation :** **EP1: Depth of knowledge required:** After learning in-depth engineering knowledge at the level of K3, K4, K5, K6, or K8, a fundamental-based, first principles analytical method is possible. We apply our considerable engineering skills that we have gained over the years from our institution in our system for detecting &

		criteria. We explored a variety of approaches like CNN, machine learning model and after exhausting all options we designed our project in such a way which will be really helpful to the environment. Our detecting number plate and recognizing characters consists of importing different types of tensor flow packages, data pre-processing, data augmentation, statistical analysis of the two types of datasets, deploying CNN model, deploying machine learning model and finally detecting and predicting it.	recognizing authentic vehicles and forecasting crime related vehicles. **EP2: Range of conflicting requirements:** In our number plate detection project we applied a range of deep learning models and did the pre-processing which were conflicting over our engineering design. **EP4: Familiarity of issues: -** We make an effort to include issues that aren't commonly encountered in recognizing fizzy bangla number plates and extract the bangla characters accurately. **EP5: Extent of applicable codes:** We focused on making our system understandable and maintain the code standard such that outside issues are covered by professional engineering standards and rules of practice So that it would be easy for the user to get the detection and recognition. **EP6: Extent of stakeholder involvement and conflicting requirements:** We interviewed several BRTA officers to study their system and find some requirements which we don’t see in our reviewed papers. So, we set the

			objective of our project based on those requirements. **EP7: Interdependence: -** We have the freedom in image detection to work on high-level problems with multiple component pieces or sub-problems such as solving a ton of number plate detection & recognition together at a time. We also make an effort to incorporate it into our system. printing and typesetting industry.
CO 5	**Identify** and **apply** modern engineering and IT tools for the design and development of the capstone project	**Materials and Devices:** **K6: Engineering Practice (technology):** To use machine learning and deep learning as a form of detection and prediction, we need to explore different ML and DL algorithms. As covid-19 has been a threat to human life, many researchers have proposed various algorithms specifically for detecting covid-19 as well as predicting risk status of the patients. We have also reviewed these algorithms. Finally, we use various Convolutional Neural Network (CNN) and other deep learning algorithms. To conduct these operations and analysis, we employ latest tools and features. As we have to work with images, we need high	**Materials and Devices :** **EP1: Depth of knowledge required:** After learning in-depth engineering knowledge at the level of K3, K4, K5, K6, or K8, a fundamental-based, first principles analytical method is possible. We apply our considerable engineering skills that we have gained over the years from our institution in our system for detecting & recognizing authentic vehicles and forecasting crime related vehicles. **EP2: Range of conflicting requirements:** In our number plate detection project we applied a range of deep learning models

		performance computer with GPU system. For implementing the algorithms, we use python panda's package**.** We focus on doing everything as a team and distribute the workload evenly.	and did the pre-processing which were conflicting over our engineering design. **EP4: Familiarity of issues:** We make an effort to include issues that aren't commonly encountered in recognizing fizzy bangla number plates and extract the bangla characters accurately. **EP5: Extent of applicable codes:** We focused on making our system understandable and maintain the code standard such that outside issues are covered by professional engineering standards and rules of practice So that it would be easy for the user to get the detection and recognition.

CO 6	**Assess** and **address** societal, health, safety, legal, and cultural aspects related to the implementation of the capstone project considering the relevant professional and engineering practices and solutions	**Social and Environmental Impact of Engineering:** **K7: Comprehension of engineering in society:** In our project, we did not employ any illegal phrases or software. Our system has no negative consequences for social or environmental engineering. We incorporated new and sustainable technologies in our system's process. Our system is risk-free, and the information we provide is accurate, trustworthy, and real with valid references. We ensure that the system is safe and our execution is adequate for health. In laboratory, test, and experimental processes, the application is safe.	**Social and Environmental Impact of Engineering :** **EP2:** In our number plate detection project we applied a range of deep learning models and did the pre-processing which were conflicting over our engineering design. **EP5:** We focused on making our system understandable and maintain the code standard such that outside issues are covered by professional engineering standards and rules of practice So that it would be easy for the user to get the detection and recognition. **EP6:** We interviewed several BRTA officers to study their system and find some requirements which we don't see in our reviewed papers. So, we set the objective of our project based on those requirements.

CSE400-C

Program Outcomes:

PO7 (Environment and Sustainability): In our entire project, no harmful elements or devices were used. Since the technology will be web-based apps that can be easily accessed in any computer or mobile phone, there is no negative influence on soil, water, or air. This work hasn't used any harmful materials, and it won't in the future either. Any

related traffic agency can use this technology in parking lots to reduce traffic crimes. Our device also doesn't require a lot of electricity so we can say that the project is sustainable also.

PO8 (Ethics): In our project we were always concerned about ethics. The image dataset we collected from one of our reviewed paper authors, Rashedul Islam, Assistant Professor, ICT department, Rajuk Uttara Model College, which were captured for his previous study. Secondly, we captured some images from Aftabnagar, Dhaka area manually. We preprocessed those images to get the appropriate dataset for this project.
We have taken with the consent from Rashedul Islam and authority of our university. All the images for this are taken for our research purposes only.

PO9 (Individual Work and Teamwork): Developing this project required teamwork, though we each have our contributions to this project. Implementing this project required a sound knowledge on digital image processing, deep learning and web programming. We bought each of our expertise to finish this project.
P10 (Communication): The major communication used for this project is offline meetings at university. The secondary method used for this project would be an online meeting at Google Meet. All members of the project are well connected with one another, so there was no communication gap.

P11 (Project Management and Finance): While doing this project, we were always under our supervisor's guidance. For project management, we have maintained Work Breakdown Structure(WBS), Earn Value Management(EVM), budget and Cost Calculation. We have assigned time limits for each work and finished it by then. This is how we managed to finish our work within time.

We have calculated the cost for commercial use but there was no major cost in this project. Whichever cost was required was self-financed by the members of the project.

P12 (Life-Long Learning):): In this project we have implemented the concepts which

we learned in our previous courses. There were some more concepts which we learned during the project. Beside these, we also learned some basic things which will help us in the future which are, problem solving, critical thinking and communicating skill.

CO	Details	Knowledge Profile (K)	Engineering Problem (EP)
CO7	Environmental protection should be the top priority when starting any project, and our capstone project is in line with this principle. Since our program is computer-based, there is no risk of harmful substance release or negative environmental impact. All the tools and equipment required, including the camera, PC, and software, are not hazardous to the environment. Therefore, it is safe to say that our project is environmentally sustainable.	**K7: Comprehension of engineering in society**: Our project is aimed at addressing a common problem faced by traffic police, drivers, and mini car-parking lot owners: the difficulty of identifying cars. By providing a simple and efficient way to detect cars, our system can help save time and resources for traffic police, simplify the process of identifying cars for drivers, and provide a reliable method for mini car-parking lot owners to manage their lots. Therefore it has a great impact on society.	**EP2: Range of conflicting requirements**: Drivers may not operate the website due to lack of familiarity with technology **EP5: Extent of applicable codes:** We have taken steps to ensure data safety and integrity for the users. **EP6: Extent of stakeholder involvement and conflicting requirements:** The project has been developed in accordance with the requirements of the stakeholders.

CO8	As we planned our project, we carefully considered its ethical implications. Since our project required a large number of vehicle's photographs to train our model, we used two separate datasets. One dataset, consisting of 630 images of different vehicles in various lighting conditions, was manually collected by Rashedul Islam, an Assistant Professor at the ICT department of Rajuk Uttara Model College and the main author of one of our reviewed papers. The other dataset, consisting of 200 images, was also manually collected from the Aftabnagar area in Dhaka, with some images taken on the road and others in	**K7: Comprehension of engineering in society**: Throughout the entire project, we have placed a strong emphasis on ethics and public safety. Our data collection process was carried out with the appropriate consent, and we have taken measures to ensure that our project has no negative impact on society.	

	multiple parking areas. We made sure that the datasets contained both clear and fuzzy images of number plates, and we took care to consider the ethical implications of our data collection.		
C09	The development of this project was a collaborative effort, with each team member contributing according to their strengths and abilities. Through effective teamwork, we were able to successfully complete the project. This experience taught us the importance of open communication among team members and the need to consider each other's viewpoints to achieve the desired outcomes.		

CO10	Our capstone project report is comprehensive and includes a detailed analysis of the project's design and implementation. We have provided a thorough description of the specific aspects of our project's design and implementation in the relevant section of the report.		
CO11	Our project was of considerable size and required a significant amount of time to complete. However, we organized our project work effectively and prioritized timely submission as a crucial aspect of the project. Through good teamwork, we were able to adhere to the project schedule and ensure that the project		

	was completed and submitted within the allotted time frame.		
CO12	Our experiment involved the use of new concepts that we had to learn and apply to complete the project successfully. In addition to these new concepts, we also incorporated existing knowledge to develop the final software application. This practical application of knowledge has enabled us to create a solution that helps users detect a vehicle's number plate efficiently.		