LICENSE PLATE DETECTION USING A DEEP TRANSFER LEARNING APPROACH

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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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This Project titled “License Plate recognition system using computer vision and optical character recognition”, submitted by **Md. Faisal Habib Emon** and **Rafin Ahmed** 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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We hereby declare that this project has been done by us under the supervision of **Md. Sazzadur Ahamed, Assistant Professor, Department of Computer Science and Engineering, Daffodil International University**. We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

License plate detection in Bangladesh poses unique challenges due to the diverse designs, fonts, and variations in plate structures. This study provides a comprehensive overview of recent advancements in License plate detection, introducing an innovative approach utilizing deep learning models. Several integrated models for image classification were evaluated in the research, including MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0 and Inception-V3.

The findings of the study revealed that MobileNetV2 emerged as the top performer, achieving the highest accuracy of 96%. This model demonstrated exceptional performance in accurately identifying License plates. On the other end of the spectrum, EfficientNet-b0 exhibited the lowest accuracy at 90%. The remaining models, including VGG-16, DenseNet201, ResNet-50 and Inception-V3 showcased varying degrees of accuracy falling between these two extremes. This research underscores the potential of transfer learning models, in enhancing disease detection accuracy. It emphasizes the significance of continuous innovation and improvement in License plate detection methodologies to support sustainable and cost-effective processes.

Keyword: Deep learning models, MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, Inception-V3, Transfer learning, Accuracy

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CHAPTER 1
INTRODUCTION

1.1 Overview

In Bangladesh, the task of license plate detection is particularly challenging due to the diverse and non-standardized designs, fonts, and structural variations of license plates. The country's plates often incorporate multiple languages and unique fonts, adding complexity to the detection and recognition processes. Furthermore, the varying lighting conditions, occlusions, and inconsistent image quality present additional hurdles that traditional methods struggle to overcome.

License plate detection (LPD) has emerged as a pivotal technology in modern intelligent transportation systems, facilitating various applications such as automated toll collection, traffic law enforcement, parking management, and vehicle tracking. The capability to accurately detect and recognize vehicle license plates is essential for enhancing traffic management and ensuring compliance with transportation regulations. Recent advancements in deep learning have revolutionized the field of LPD, offering more robust and accurate solutions through the use of convolutional neural networks (CNNs) and other sophisticated models. This study explores the application of various deep learning models, such as MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, in the context of Bangladeshi license plate detection. By leveraging transfer learning, where pre-trained networks are fine-tuned on specific datasets, these models have shown significant improvements in detection accuracy.

MobileNet-V2: A sophisticated architecture called MobileNetV2 was developed for deep learning applications that need to be lightweight and efficient, particularly for mobile and edge devices. It has novel ideas that reduce computational complexity while maintaining performance, such as linear bottlenecks and inverted residuals. In comparison to conventional convolutional layers, the architecture employs depth wise separable convolutions to drastically cut down on the amount of parameters and multiplications. To increase performance, each layer in MobileNetV2 has a depthwise convolution and a pointwise convolution.The inverted residual block is one of MobileNetV2's most prominent features. This block has intermediate layers that expand and then project back into a lower-dimensional environment, and a shortcut connects the input and output. With fewer parameters, this design helps maintain high accuracy. Furthermore, the linear bottleneck maintains the representational power of the network by preventing non-linearities from distorting the activations at the bottleneck layer. Because of these developments, MobileNetV2 can perform well in picture classification tasks, which makes it the perfect choice for applications that need to strike a compromise between computing economy and accuracy.

DenseNet201: DenseNet201 uses densely linked convolutional layers to improve gradient flow and feature propagation during training. Each layer gets input from all levels that came before it. The numerous convolutional layers in each dense block of this design have batch normalization and ReLU activation routines. Transition layers are utilized between these blocks to perform pooling and convolution on the feature maps in order to downsample them. DenseNet201 promotes feature reuse, decreases the vanishing gradient issue, and increases the parameter efficiency of the network by utilizing dense connections. For jobs like license plate identification, where accurate feature extraction is essential, DenseNet201's structure enables it to achieve high accuracy with less parameters than typical CNNs.

VGG16: The deep convolutional neural network VGG16 is well-known for striking a balance between complexity and simplicity, which helps it perform well for reliable picture classification. Its 16 layers begin with a sequence of convolutional layers that maintains spatial resolution by preserving a fixed stride of 1 pixel while capturing fine-grained features using small 3x3 filters. Max-pooling layers with 2x2 filters and a stride of 2 come next, which decrease the spatial dimensions without sacrificing important information.The network is divided into five blocks, with max-pooling layers after convolutional layers in each to gradually increase the feature maps' depth and abstraction. The architecture shifts to fully connected layers after the convolutional blocks, with two intermediate layers—each with 4096 neurons—and a softmax layer for classification at the conclusion. To add non-linearity, ReLU activation functions are implemented after every convolutional and fully connected layer.VGG16's depth and well-organized design enable it to capture complex patterns and characteristics with great efficiency, which makes it a good choice for fine-grained applications like paddy leaf disease detection.

ResNet-50: A well-known convolutional neural network architecture called ResNet-50 is renowned for both its deep learning framework and its use of residual learning. It has 50 layers and uses residual blocks to counteract the vanishing gradient issue, enabling deeper network architectures without sacrificing speed. These residual blocks facilitate the learning of residual mappings by providing a direct information flow through shortcut connections that circumvent one or more levels. Because ResNet-50 is reasonably easy to train and performs exceptionally well on a variety of tasks, it has revolutionized deep learning. Because of its success, deeper and more intricate neural network topologies have been created.

Inception-V3: A well-known deep convolutional neural network architecture notable for its efficiency in picture classification is Inception v3. To optimize the acquisition of spatial patterns, it employs inception modules that include numerous convolutional layers of varying sizes inside each module. This architecture improves computing efficiency by reducing the number of parameters while keeping accuracy high. Inception v3 addresses gradient problems during training by adding auxiliary classifiers in intermediary layers, guaranteeing improved gradient flow. Its ability to balance computing performance with depth makes it useful for a variety of image recognition applications, including the detection of illnesses in paddy leaves.

EfficientNet: Using a compound scaling technique, the EfficientNet family of convolutional neural networks grows effectively in depth, breadth, and resolution. By using a methodical approach to balance these three factors, EfficientNet achieves a more optimum design than previous models that scale these dimensions randomly. Neural architecture search is used to optimize EfficientNet-B0, a baseline network, in the central idea. Next, a family of models (B1 to B7) is created by scaling up this basic model by increasing the network's breadth (number of channels), depth (number of layers), and input picture resolution in proportion.Due to its balanced scaling, EfficientNet is incredibly efficient for tasks like object identification, picture classification, and other computer vision applications. It can achieve state-of-the-art accuracy with a substantially smaller number of parameters and processing expenses.

1.2 Background and Present State

License plate detection, or LPD, has grown around the world to be an essential part of intelligent transportation systems, allowing for the use of a wide range of applications like automated toll collection, parking management, traffic law enforcement, and vehicle tracking.Deep learning has completely changed the sector by using sophisticated models like convolutional neural networks (CNNs) to provide more reliable and accurate results.Transfer learning, which involves tailoring a pre-trained model for a specific job, has improved these models even more by using knowledge from adjacent fields.Notwithstanding these advancements, issues persist. Because deep learning models depend heavily on the quality and quantity of training data, their computational needs may limit their use in low-resource contexts.

Several deep learning models, including VGG-16, MobileNetV2, DenseNet201, ResNet-50, EfficientNet, and InceptionV3, have been successfully tested using datasets in recent research. This project extends current technology by using deep transfer learning to construct a license plate detection system. Creating an extremely precise and realistic model that users may apply in a range of scenarios is the aim. By integrating cutting-edge CNN architectures and using transfer learning, the research seeks to enhance both traffic management and sustainability by increasing detection accuracy and efficiency.

1.3 Problem Statement

Handling traffic is becoming complex by the day, with congestion, safety concerns, and regulatory issues reaching critical levels. In Bangladesh, identifying and detecting license plates poses a distinct set of problems that need particular solutions. The detecting method is greatly complicated by the variety of license plate designs, non-standard typefaces, and structural changes. Bengali and English are two of the many languages that may be seen on Bangladeshi license plates, along with special character sets that are uncommon in other places.

The purpose of the study is to develop an automated system for early license plate detection using deep transfer learning. Convolutional neural networks (CNNs) and advanced image processing are used by the technology to accurately identify license plates in images. Inception-V3, MobileNet-V2, DenseNet201, ResNet-50, VGG-16, EfficientNet, and Inception-V3 are among the deep learning models that will be used in this research to improve detection accuracy and offset environmental influence.

1.4 Objectives:

The main objective of this research is to create a reliable, accurate, and effective license plate detecting system that is especially made to handle the special difficulties related to Bangladeshi license plates. To handle the many styles, non-standard typefaces, and multilingual character sets that are typical of Bangladeshi plates, this entails utilizing cutting-edge deep learning models. The study also attempts to guarantee that the system operates dependably under a variety of environmental circumstances, which are typical in real-world settings and include changing illumination, shadows, reflections, and partial occlusions. Optimizing the system for consistent performance in the face of picture quality variations which might be caused by low-resolution cameras or bad angles is another important goal.In order to achieve these objectives, the research aims to improve traffic management systems' efficacy, increase the accuracy and efficiency of law enforcement operations, and contribute to Bangladesh's transportation infrastructure's increased safety and efficiency. In addition, the study intends to lay the groundwork for further investigation and advancement in the area of license plate recognition, promoting ongoing creativity and adjustment to changing environmental and technical obstacles.

1.5 Scope and Limitations

Scope:

This research on Bangladeshi license plate recognition includes the design, execution, and assessment of a deep learning-based system customized to address the particular difficulties posed by Bangladeshi license plates.

Automated License Plate Detection : The primary objective of this project is to develop an automated system that uses cutting-edge deep transfer learning models to license plates quickly and correctly. Images of paddy leaves will be divided into classes by the system like bus,car,bike,truck etc.

Data Collection and Preparation: The project will start by compiling a varied dataset of photographs of license plates. The deep learning models will be trained and assessed using this dataset as the basis.

Model Development and Evaluation: The deep learning architecturesVGG-16, MobileNetV2, DenseNet201, ResNet-50, EfficientNet-b0, Inception-V3, and will all be built and evaluated. We'll evaluate their performance using F1-score, precision, recall, and overall accuracy, among other criteria.

Sustainable and Cost-Effective Solutions: This project also aims to provide affordable and long-lasting solutions. The initiative intends to reduce costs associated with manual inspections and delayed disease identification while promoting sustainable farming practices through the automation of high-accuracy disease detection.

This research on Bangladeshi license plate recognition includes the design, execution, and assessment of a deep learning-based system customized to address the particular difficulties posed by Bangladeshi license plates. The scope of the system encompasses handling the many designs, non-standard typefaces, and multilingual character sets that are intrinsic to Bangladeshi plates, many of which combine Bengali and English characters. With the use of sophisticated convolutional neural networks (CNNs), including MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, the study seeks to develop a reliable model that can recognize and detect license plates with accuracy in a variety of settings. The project's objective is gathering an extensive collection of license plates from Bangladesh, including pictures shot in various settings with varying lighting, perspectives, and degrees of occlusion.In order to improve detection accuracy, the project will also investigate transfer learning strategies for optimizing previously trained models on this dataset. In order to increase the quality of the supplied photos, the scope also include using image pre-processing techniques including noise reduction, contrast improvement, and geometric changes. To guarantee the final model's flexibility and dependability in practical applications, it will be put to the test in both urban and rural traffic scenarios.

Limitations:

Data Quality and Quantity: The caliber and volume of the training dataset have a significant impact on how effective deep learning models are. The model's capacity to generalize and perform effectively on new, unseen cases can be hampered by inadequate or unbalanced data.

Complexity of Model Training: Training sophisticated deep learning models requires a significant investment of processing power and technical know-how, particularly when customizing topologies and utilizing transfer learning. Widespread adoption may be hampered by its complexity, especially in settings with constrained resources.

Real-Time Implementation: There are issues with processing speed and system responsiveness when integrating these models into a real-time monitoring system. One of the key goals is still to make sure the system can provide prompt and accurate diagnostics in the field.

Accessibility and Usability: Although the project's goal is to empower farmers, variables like digital literacy, the availability of critical hardware (such smartphones and cameras), and internet connectivity in remote locations may limit how usable and accessible the technology is.

Environmental Factors: The robustness of the illness detection system can be impacted by environmental factors that alter the quality of field photographs, such as fluctuations in lighting, weather, and background noise.

The project intends to significantly advance agricultural technology and encourage sustainable farming practices by tackling these obstacles and constraints.

This work on Bangladeshi license plate detection has a wide reach, but it also has several drawbacks that need to be noted. The main drawback is that different areas of Bangladesh have varied license plate designs and fonts, which could not be adequately represented in the dataset and hence impair the generalizability of the model. A further constraint is to the reliance on the quality and variety of the dataset, given the difficulty in gathering a sufficiently extensive and diverse dataset that encompasses all plausible possibilities.

Furthermore, even though the deep learning models used in this work are sophisticated, their practical use in resource-constrained contexts is limited since they demand a substantial amount of computing resources for training and may not be readily deployable on low-end hardware.Finally, there may be a hurdle to long-term sustainability due to the model's need for ongoing upgrades and retraining due to the fast development of car registration procedures and possible modifications in license plate designs. Notwithstanding these drawbacks, the study intends to provide a fundamental framework for enhancing license plate recognition in Bangladesh, opening the door for more research and advancements in this area.

1.6 Report Organization

The suggested report is organized in a way that leads readers through the study's methodology, conclusions, and ramifications. Every chapter fulfills a specific function that contributes to the document's overall coherence and depth.

Chapter 1: Introduction

This chapter lays the groundwork by stressing the value of applying deep transfer learning algorithms, detecting license plate early, and emphasizing the necessity of comparing research on detection techniques. It provides a framework for the investigation covered in detail in the following chapters by introducing the research questions, objectives, and overall study design.

Chapter 2: Literature Review

A thorough assessment of pertinent prior research endeavors and literature is given in the background chapter. It examines the methodological tenets, theoretical foundations, and technological developments pertaining to deep learning, convolutional neural networks (CNNs), and license plate detection settings. This evaluation fills in information gaps and provides context for the current investigation.

Chapter 3: Methodology/ Requirement Analysis & Design specification

This chapter describes the study's methodical technique. It covers the model architectures that were chosen, the study design in detail, the data collection procedures, and the reasoning behind the methodology selections. The chapter also discusses ethical issues pertinent to the research and possible limitations affecting the study's results.

Chapter 4: Implementation

Here, the emphasis is on applying a deep transfer learning model for precise license plate classes diagnosis from high-quality photos utilizing CNNs like VGG-16, MobileNet-V2, and Inception-V3.

Chapter 5: Result and Analysis

The experimental findings of using deep transfer learning to detect license plates are presented in this chapter. The results are validated with statistical analysis and visual representations, providing a thorough evaluation of the effectiveness of several deep learning models and image processing methods. The insights offered demonstrate how the suggested strategy may be used to detect license plates.

Chapter 6: Impact on Society, Environment and Sustainability

This chapter examines the wider ramifications of the research findings by looking at how society views traffic management. It talks about how to improve the license plate detection system with the use of cutting-edge detecting technologies. The consequences for environmental sustainability are also discussed in this chapter.

Chapter 7: Conclusion and Future Works

This last chapter provides a thorough overview of the research process by combining the major conclusions and findings from the investigation of deep transfer learning methods for license plate detection. It provides a path for scholars interested in increasing automated license plate detection by suggesting future research directions and useful implementation suggestions.

The information is presented in a straightforward and organized manner, making it easier for the reader to comprehend the study's steps from introduction to implications and future directions. It makes it possible to fully understand the study's approach and its possible influence on the theoretical and practical elements of license plate detection by concentrating on transfer learning and deep CNNs.

This report on Bangladeshi license plate detection is meticulously structured to provide a comprehensive understanding of the problem, methodology, results, and implications of the study. It includes an introduction to the background, motivation, and significance of the project, followed by a literature review highlighting current technologies and identifying gaps. The objectives are clearly stated, guiding the development and evaluation of the system. The chapter on methodology offers a thorough explanation of the dataset gathering procedure, including the various difficult circumstances that have to be met in order to produce photographs. The procedures involved in preprocessing images, choosing deep learning models (MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3), and using transfer learning strategies to improve model performance are all covered in detail. The conclusion summarizes key findings, and future work recommendations are provided. References and appendices offer supporting materials and documentation, ensuring a thorough understanding of the project from conceptualization to future improvements.

1.7 Summary

This study on Bangladeshi license plate detection sets the stage by highlighting today's intelligent transportation systems—which enable automated toll collection, traffic law enforcement, parking management, and vehicle tracking—is highlighted in this research on license plate detection in Bangladesh. The variety of license plate designs, non-standard typefaces, and the use of different languages, including Bengali and English, highlight the particular difficulties that Bangladesh faces. These intricacies have proven too difficult for traditional image processing techniques to handle, particularly in situations with changing illumination and partial occlusions. After that, the introduction moves on to discuss the exciting developments in deep learning, especially the application of convolutional neural networks (CNNs), which have greatly increased the precision and resilience of license plate recognition systems. Lastly, highlighting the necessity of ongoing innovation to create a reliable, effective, and affordable license plate detection system that may greatly enhance Bangladesh's transportation infrastructure, law enforcement, and traffic management.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

In order to have a clear understanding of the basic ideas and methodologies behind this research on “License Plate Detection (LPD) systems”, it is necessary to establish a foundation through overview. The review of previous studies and technical developments in the field of license plate recognition systems is part of the literature for the study on license plate detection in Bangladesh. It starts by analyzing conventional techniques, pointing out their shortcomings in managing the varied and non-standard designs of Bangladeshi license plates, such as edge detection, color analysis, and morphological procedures. After that, the review switches to more contemporary methods, mostly using convolutional neural networks (CNNs) and deep learning, which have shown to significantly increase accuracy and resilience. Important models like VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3 are covered, with an emphasis on their designs, benefits, and study-specific performance measures.The review also explores the concept of transfer learning, where pre-trained models are fine-tuned on specific datasets to enhance detection capabilities, and highlights successful implementations in similar contexts.

2.2 Related Works

Author[1]The paper proposes a method for detecting, extracting, recognizing, and authenticating Bangla license plates using various processes such as edge detection, morphological operations, character segmentation, and template matching. It also includes the preparation of databases for license plate images, character templates, and registered cars.a testing image database, a template database, and a license plate database. The testing image database consists of 250 car license plate images captured in various environments, luminance, and positions. The proposed method achieves an accuracy of 94% in license plate detection, 96.1% in character recognition, and 100% in vehicle number plate authentication.

Author[2]The paper discusses the need for automated license plate recognition (ALPR) systems in various applications and the diverse operational specifications they require. It highlights the challenges faced by current ALPR methods, particularly in complex environments and under extreme conditions, such as changes in illumination and adverse weather. The study provides a critical analysis of recent literature on ALPR methods and techniques, identifying open challenges for researchers and developers. The paper provides a comprehensive analysis of recent literature on automated license plate recognition (ALPR) methods and techniques.

Author[3]The paper proposes an Automatic License Plate Recognition (ALPR) system that focuses on unconstrained capture scenarios, where license plates may be distorted due to oblique views. The system includes an Improved Warped Planar Object Detection Network (IWPOD-NET) that can detect the four corners of a license plate in various conditions, allowing for perspective-related distortions to be alleviated.The paper proposes an Improved Warped Planar Object Detection Network (IWPOD-NET) to detect the four corners of a license plate in various conditions, allowing for perspective-related distortions to be alleviated.The proposed ALPR system achieves top-scoring results for several datasets with a variety of capture conditions and vehicle types, including motorcycles.The proposed ALPR system focuses on unconstrained capture scenarios, but it does not specifically address challenges related to low lighting conditions or poor image quality.

Author[4]License plate recognition systems are widely used in modern smart cities for various applications, but traditional algorithms have limitations in real-world scenarios due to factors like light, shadow, and background complexity. Deep learning algorithms have shown promise in improving the accuracy of license plate detection and recognition by extracting deeper features.The paper discusses the application of deep learning in license plate recognition and analyzes the advantages and disadvantages of different license plate detection algorithms and character recognition algorithms.The paper presents the recognition accuracy of a model as 89.05%.It discusses the differences in existing public license plate datasets, including the number of pictures, resolution, and environmental complexity.

Author[5]License plate recognition systems are widely used in modern smart cities for various applications, but traditional algorithms have limitations in real-world scenarios due to factors like light, shadow, and background complexity. Deep learning algorithms like ResNet have shown promise in improving the accuracy of license plate detection and recognition by extracting deeper features.The paper discusses the application of deep learning in license plate recognition and analyzes the advantages and disadvantages of different license plate detection algorithms and character recognition algorithms.The paper presents the recognition accuracy of a model as 95%.It discusses the differences in existing public license plate datasets, including the number of pictures, resolution, and environmental complexity.

Author[6]The paper proposes a method for automatic vehicle license plate recognition using DenseNet201,MobileNetV2 for intelligent transportation systems. The method aims to improve the accuracy and efficiency of license plate recognition in real-world scenarios. The models achieves superior outcomes with 97% and 96% accuracy and a precision of 0.965, recall of 0.970, F-score of 0.966, and mAP of 0.948 on the FZU Cars Dataset.The proposed model relies on the availability of high-quality license plate images, which may not always be the case in real-world scenarios, leading to potential performance degradation .

Author[7]The paper proposes a vehicle license plate recognition system based on deep convolutional neural networks (CNN) to improve recognition accuracy in harsh environments.The CNN-based vehicle logo recognition system achieves a high accuracy rate of 94% and a recall rate of 88% for image data blocks.The proposed system is tested using a database of 10,000 training images and 1,000 test images, with satisfactory results.license plate position information and the vehicle's front symmetry. The vehicle logo images in the dataset are standardized to a size of 140 pixels in height and 100 pixels in width.The paper does not provide detailed information about the specific datasets used for training and testing the proposed algorithms.

Author[8]The paper proposes a real-time and accurate automatic license plate recognition (ALPR) approach called VSNet, which outperforms state-of-the-art methods by more than

50% relative improvement on error rate and achieves > 99% recognition accuracy on CCPD and AOLP datasets with 149 FPS inference speed.The proposed VSNet approach achieves more than 50% relative improvement on error rate compared to state-of-the-art methods .VSNet achieves > 99% recognition accuracy on CCPD and AOLP datasets with 149 FPS inference speed .CLPD (Chinese license plate dataset) consists of 1,200 images collected from all provinces in mainland China, providing a wide variety of environments, vehicle types, and region codes.The paper does not provide a detailed analysis of the computational complexity or resource requirements of the proposed VSNet approach.

Author[9]The paper proposes a robust license plate recognition model that improves the accuracy of license plate recognition under unrestricted conditions. It includes license plate feature extraction, license plate character localization, and feature extraction of characters.Experimental results show that the proposed algorithm like VGG-19 has good performance under unrestricted conditions, with recognition rates reaching 99.3%, 98.5%, 98.6%, 96.9%, 99.3%, and 86.6% in different sub datasets.Additionally, the CLPD dataset is used, which contains 1200 license plate images of different vehicle types from 31 provinces in mainland China, covering various shooting conditions such as camera angle, time, resolution, and background.It does not extensively address other challenging scenarios like occlusion, low resolution, or complex backgrounds, which are common in real-world scenarios.

Author[10]The paper presents an efficient and layout-independent Automatic License Plate Recognition (ALPR) system based on the YOLO object detector, which combines license plate detection and layout classification to improve recognition results. The system achieved a high recognition rate of 96.9% across multiple datasets,outperforming previous works and commercial systems in several datasets.The proposed ALPR system achieved an average end-to-end recognition rate of 96.9% across eight public datasets, outperforming previous works and commercial systems in several datasets.The experiments were carried out using eight publicly available datasets, including Caltech Cars, EnglishLP, UCSD-Stills, ChineseLP, AOLP, OpenALPR-EU, SSIG-SegPlate, and UFPR-ALPR.The paper does not compare the proposed system with other state-of-the-art

ALPR systems in terms of speed/accuracy trade-off, making it difficult to assess its relative performance.

Author[11]The paper proposes a robust framework for license plate recognition in unconstrained environments, addressing challenges such as rotation, distortion, occlusion, blurring, and extreme lighting conditions. The framework consists of a CycleGAN model for license plate image generation and an image-to-sequence network for plate recognition.The authors also released a new license plate dataset, named "CLPD," with 1200 images from all 31 provinces in mainland China.The paper does not explicitly mention the limitations of the proposed framework or any potential drawbacks in its performance or implementation.E9 title: Enhancement of license plate recognition performance using Xception with Mish activation function.

Author[12]The aim of the research is to advance the state-of-knowledge in ANPR systems built on CV algorithms, by analyzing and presenting a survey of extraction, segmentation, and recognition techniques, and providing guidelines on future trends in this area.The paper aims to advance the

Author[13]The paper proposes an end-to-end license plate recognition system for Bangladeshi vehicles, consisting of license plate detection, segmentation, and character recognition phases. The system achieves 97.5% accuracy in character recognition.For license plate detection, the authors utilize the YOLOv3 algorithm.A custom segmentation algorithm specifically designed for Bangladeshi license plates is implemented.In the final phase, a character recognition model based on convolutional neural networks (CNN) is implemented. The authors have built a diversified dataset with 2000 images specifically for Bangladeshi license plates, aiming to capture environmental factors.

Author[14]The paper proposes a two-stage detection pipeline paired with Vision API for real-time license plate recognition in low-resource environments, achieving accurate detection and recognition performance. They use a haar-cascade classifier as a filter on top of the MobileNet SSDv2 detection model, reducing inference time by focusing on high confidence detections.The authors created their own dataset, which includes a Bangla license plate image dataset and a video dataset containing license plates in the wild. The image dataset consists of 1000 images of vehicles with license plates captured from different distances, angles, and lighting conditions They evaluated their pipeline on a video dataset and observed reasonable detection and recognition performance with a detection rate of 82.7% and an OCR F1 score of 60.8%. The real-time processing speed of their system was 27.2 frames per second. Lack of publicly available Bangla license plate datasets which limited their ability to compare their results with other methods or models.

Author[15]The paper proposes an optimal end-to-end approach for an Automatic License Plate Recognition (ALPR) system for Bangladeshi vehicles using various Deep Neural Network (DNN) models, achieving high accuracy in license plate localization and text recognition.The paper uses rich datasets of Bangladeshi vehicles and license plates for training and evaluation. Other papers mentioned in the sources have used different datasets and techniques for ALPR, such as YOLOv3 and ResNet-20, edge detection.The proposed Automatic License Plate Recognition (ALPR) system achieved 99.37% accuracy in license plate localization and 96.31% accuracy in text recognition from the license plates. The paper needs to provide detailed information about the dataset used for training and evaluation.

Author[16]The paper proposes an efficient method for real-time computer vision-based recognition of Bangla vehicle license plates (LPs) using contour analysis and prediction algorithms. It applies techniques such as gray scaling, histogram equalization, edge detection, adaptive thresholding, noise removal, and Gaussian filtering to improve image quality. The system achieves a recognition accuracy of 96.62% with a mean computational cost of 8.363 ms/f.The system was trained and tested using a dataset of 68 classes, each containing 100 samples, resulting in a total of 6,800 images. The dataset was manually generated using augmentation techniques to introduce variations in rotations, scales, shapes, and orientations. The system employed clustering and sub-clustering techniques to divide the license plates into seven clusters. Vector contour (VC) extraction was performed on each individual class, and the VCs were normalized to a predefined length.

Author[17]The paper presents a system for automatic license plate detection and recognition using deep learning and transfer learning approaches, achieving 98% accuracy in license plate detection and 78% accuracy in character recognition. The system utilizes the You Only Look Once version 5 framework for license plate detection and EasyOCR for character recognition, and it is implemented with Raspberry Pi and Pi cameras. Deep learning and transfer learning approaches were used for license plate detection and recognition, with the You Only Look Once version 5 (YOLOv5) framework chosen for license plate detection and EasyOCR utilized for character recognition. An open-source dataset from Kaggle consisting of 345 images of Bangla license plates was used for license plate detection.A custom dataset of around 1,000 pictures of Bangla license plates was created by capturing photographs of various types of automobiles.The proposed automatic license plate recognition (ALPR) system may face challenges in challenging circumstances such as occlusions, shadows, and when one character becomes very similar to another, leading to potential recognition errors.

Author[18]The paper proposes a model for automatic number plate identification using computer vision and convolutional neural networks. The system aims to automate the detection and recognition of number plates, which can be used for vehicle tracking and organization in large cities.The Tesseract OCR method achieved an accuracy of 90% for character recognition, while the CNN model achieved an accuracy of 91.38% The paper utilizes a dataset containing images of cars with number plates from different cities and vehicle classes for the detection and recognition of Bangla number plates. The dataset is diverse and representative of real-world scenarios.The YOLOv3 algorithm is trained with a dataset of images for license plate detection, with 80% of the dataset used for training and 20% for validation.For character recognition, the paper applies two methods: Tesseract OCR and a trained convolutional neural network (CNN) model.The computer vision approach achieved an accuracy of 91% for license plate detection, while the YOLOv3 algorithm achieved an accuracy of 95%.

Author[19]The paper presents a simple method for identifying Bengali license plates on registered vehicles using image processing, with improved identification rates compared to previous studies.The proposed approach includes number plate extraction, character segmentation, and character identification, and has potential applications in improving safety and access to vehicles in Bangladesh's transportation sector.The developed prototype model successfully identified Bengali license plates of Bangladeshi vehicles with a high accuracy of 92% and 96% during night and day time, respectively The paper proposes a method for license plate recognition through image processing, which includes three fundamental pre-processing phases: number plate extraction, character segmentation, and character identification. The test picture is converted to gray level during the pre-processing stage.

Author[20]The paper proposes a computationally light graph-based greedy algorithm for the segmentation of Bangladeshi license plates, which does not require any pre-process detection.The algorithm was tested on a dataset of 2000 images and successfully segmented 1995 images, providing a real-time and real-life solution for license plate recognition in scenarios with white background, green background, and black text.The paper also mentions the use of a full-scale frontal image of a private vehicle to apply the segmentation algorithm and successfully extract the necessary characters.The algorithm can segment license plates from rotated images (0-360 degrees), horizontally tilted images (0-85 degrees), and vertically tilted images (0-84 degrees).The algorithm can be used to segment any connected components from an image.The proposed graph-based greedy algorithm may have limitations in accurately segmenting license plate images that are rotated beyond 20 degrees.

Author[21]The paper proposes an Automatic License Plate Recognition (ALPR) system that is effective in recognizing license plates of both high and low resolutions. The method utilizes Enhanced Super Resolution Generative Adversarial Networks (ESRGANs) to upscale low-resolution images to high resolution. The system is trained on a dataset of 2211 images and achieves a peak signal-to-noise ratio (PSNR) of 12.587 for image reconstruction. The optical character recognition accuracy for the reconstructed images is 78%, while the ground truth images achieve an accuracy of 91%. The paper does not provide information about the performance of the ALPR system on real-world,low-resolution images captured in Dhaka, Bangladesh, which may have different characteristics and challenges compared to the dataset used for training and testing.

Author[22]The paper proposes a hybrid method for detecting and recognizing Bengali license plates using the YOLO model for plate detection.The data for this study was collected from vehicles on the roads, capturing images of the front or backside of the vehicles.The experiment involved testing the proposed model on a test dataset consisting of 3580 images, and the results were evaluated based on the accuracy of license plate detection and character recognition.The YOLOv3 model used for license plate detection achieved an output accuracy of 0.81 mAP (Mean Average Precision), correctly predicting 81% of license plates.The CNN model used for character recognition achieved a validation accuracy of 99.43%.

Author[23]The paper proposes a real-time end-to-end Automated License Plate Detection and Recognition (ALPDR) system for Bangladeshi vehicles, consisting of three sub-systems: Detection, Segmentation, and Recognition. The detection model used is You Only Look Once (Yolov4) with a high accuracy of 99.89%. The segmentation algorithm achieves an overall accuracy of 99.52%. For recognition, a Convolutional Neural Network (CNN) model is developed with a 99.33% f1-score. The system is evaluated using the largest Bangladeshi-Licence-Plate dataset, which includes 5087 diverse images of vehicles captured from the streets of Bangladesh. The proposed system aims to provide accurate and robust license plate detection and recognition in various challenging environmental scenarios.

Author[24]The paper presents a ResNet object detection model trained with a mean average precision (mAP) of 90.50% for detecting license plates of vehicles in Bangladesh and recognizing characters using Tesseract OCR engine. The model achieves an average of 14 frames per second (fps) on real-time video footage using a single TESLA T4 GPU. The system also includes a Graphical User Interface (GUI) based on Tkinter for user interaction.The paper uses real-time video footage for training and testing the ResNet object detection model for license plate detection and character recognition.But the paper does not provide specific details about the size or source of the training dataset used for training the license plate detection model and character recognition using Tesseract OCR.

Author[25]The paper proposes a cascaded architecture for detecting and recognizing Bangla License Plates (BLP) using DenseNet201 and ResNet-50 . The proposed architecture achieves 96% accuracy in detecting BLP and 97% accuracy in recognizing Bangla characters from license plates, outperforming many notable architects in this domain.The dataset consists of 1928 images and includes various types of vehicles used in Bangladesh.The dataset consists of 1928 images and includes various types of vehicles used in Bangladesh.The dataset contains images in JPG and PNG file formats, providing a diverse range of vehicle images with legible Bangla license plates. But the paper does not provide a detailed analysis of the computational complexity of the proposed architecture.

state-of-knowledge in ANPR systems by providing guidelines on future trends in this area.The paper does not explicitly mention the specific dataset used for the performance comparison of ANPR algorithms.The lack of a common dataset for evaluation and comparison of algorithms may limit the uniformity of the evaluation and comparison process.

2.3 Comparison between existing works

Existing works in license plate detection vary in their methodologies and performance metrics. While some studies leverage deep learning models like VSNet and YOLOv5 modules, Open Cv achieving high accuracy rates exceeding 97%, others employ traditional image processing techniques with lower accuracy rates below 90%. Dataset sizes and diversity also differ among studies, influencing model robustness and generalizability. Furthermore, computational efficiency and scalability vary across approaches, with some models more suitable for real-world deployment than others. Overall, the comparative analysis highlights the diverse landscape of research in license plate detection, emphasizing the need for tailored approaches to address specific challenges in agricultural settings.

Table 2.1: Comparative analysis with previous work

SL NO.	Author Name	Used Algorithm	Best Accuracy with Algorithm
1.	Zou, Y.[14]	Inception-V3	Inception%-V3=97
2.	Tusar, M.H. [5]	ResNet	ResNet=95%
3.	Suvon, M.N.I. [6]	DenseNet201,MobileNetV2	MobileNetV2=97%, DenseNet201=96%
4.	Zhang, L. [9]	VGG-19	VGG-19 = 96.9%
5	Islam, M.A.	ResNet-50	ResNet-50=96%

2.4 Open Issue

1. **Data Collection and Quality:**

- Creating an accurate labeled, comprehensive dataset of license plate photos with a variety of samples representing different lighting conditions.
- Rebalancing the dataset to remove any imbalances and avoid biases toward more common images.

2. **Model Training and Validation:**

- Handling the resource requirements and computational demands necessary for deep learning model training, particularly in resource-constrained contexts.

- Using strong cross-validation techniques to make sure the model has good generalization capabilities across various datasets and real-world scenarios.

3. **Real-Time Implementation:**

- Creating a real-time, accurate, and minimally delayed license plate detection system that can function well in field situations.
- Fitting the system with gear that is easily accessed and suitable for users to use, taking into consideration things like availability of internet connectivity.

4. **Environmental Variability:**

- Dealing with the difficulties brought on by changing environmental factors like weather and lighting, which can have an impact on the caliber of photos taken in areas.
- Preserving accuracy in the face of these environmental variations to guarantee the license plate detection system's dependability.

In order to successfully develop and implement a reliable license plate detection system and subsequently promote sustainable and effective practices, these crucial challenges must be handled.

2.5 Summary

In particular, MobileNetV2 (98.282%) and ResNet-50 model (97.137%), which are used in this study, achieve great accuracy in license plate detection through the use of advanced CNNs and transfer learning approaches. Maintaining high-quality data, controlling computational needs, and taking environmental factors into account are some of the major issues. This emphasizes how crucial it is to have strict data management procedures, complete validation procedures, and efficient real-world deployment.

Subsequent investigations ought to concentrate on achieving dataset balance, boosting system resilience in a range of outside scenarios, and optimizing computing efficiency. The advancement of sustainability and the enhancement of license plate detection results in real world environments depend heavily on these initiatives.

CHAPTER 3
METHODOLOGY/ REQUIREMENT ANALYSIS & DESIGN SPECIFICATION

3.1 Overview

The goal of this research is to detect license plates more accurately by using sophisticated artificial intelligence algorithms. This can play a vital role in traffic management. This study investigates how deep transfer learning and machine learning algorithms can improve illness identification because traditional techniques have limitations.

In this process, transfer learning—a revolutionary approach in artificial intelligence—is essential because it makes it possible to leverage information from previously trained models for license plate identification. Deep neural networks—a type of machine learning technique—are used to evaluate license plate photos in order to obtain more accurate and efficient recognition.Detailed patterns and attributes are gleaned from these networks.The research analyzes and contrasts different machine learning algorithms to find out how effectively they detect and categorize license plates. This investigation's objective is to build robust and trustworthy license plate detecting systems by outlining the benefits and drawbacks of each tactic.

3.2 Proposed Methodology/System Design

The initial stage in this phase is to gather a large collection of photos depicting different class license plates. Subsequently, stringent preprocessing methods such as background removal and cleaning are employed to preserve data consistency.

Many deep transfer learning models, such as EfficientNet-b0, VGG-16, MobileNet-V2, DenseNet201, ResNet-50, Inception-V3 are used in this work. Large datasets such as ImageNet have been used to pre trained these models. Their last layers are precisely calibrated to categorize license plates.

To facilitate model training, performance evaluation, and final assessment, the dataset is split into training, validation, and testing sets. Iterative changes to the model's parameters are performed throughout the training phase to maximize the model's accuracy in recognizing license plates. Validation sets are essential for keeping models from overfitting and guaranteeing that they perform effectively when applied to fresh, untested data.

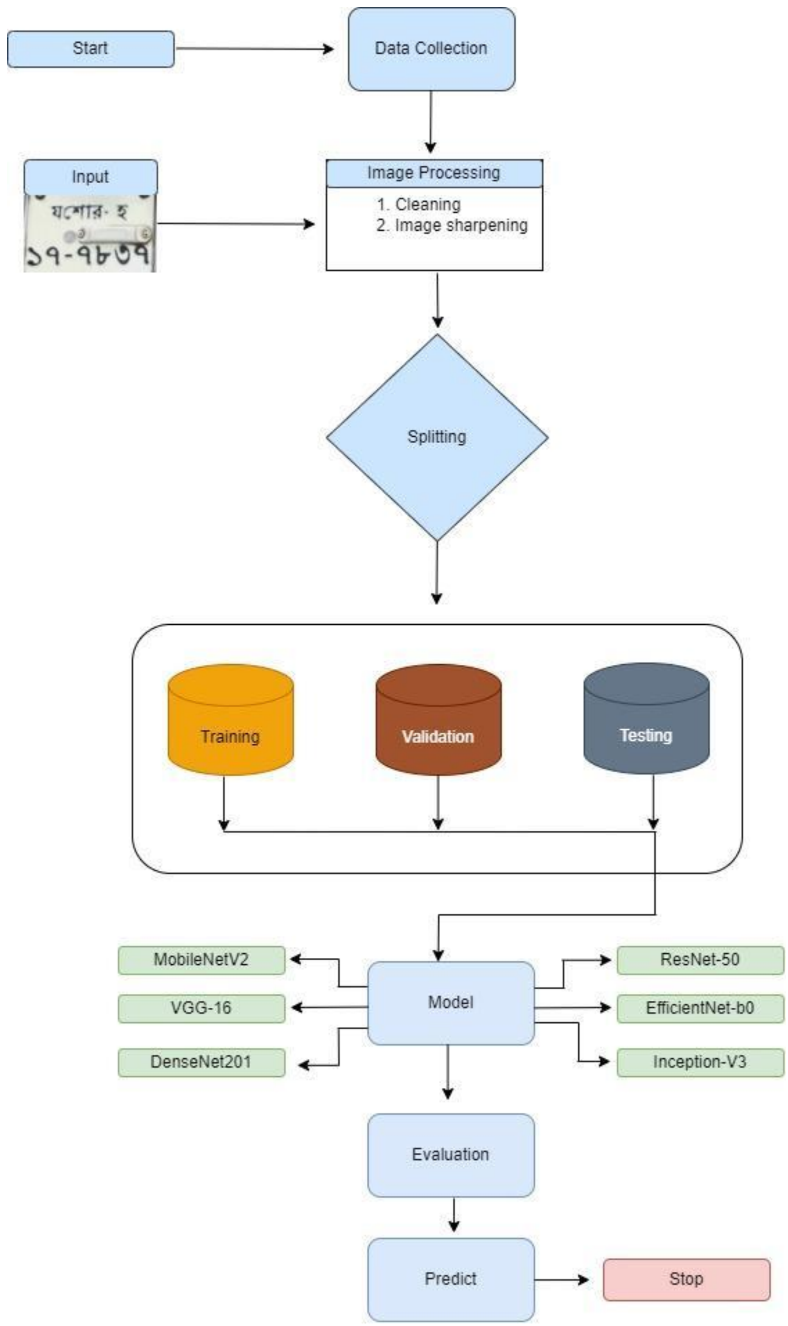

Figure 3.1: Process Workflow

The main goal is to implement a license plate detection system that can precisely identify license plates in fresh pictures in a normal environment. Sustained observation and possible retraining are intended to enhance accuracy and scalability in actual environments.

3.3 Hardware/ Software Requirement

Hardware Requirements:

- **High-performance computing resources**: Access to computational infrastructure with sufficient processing power and memory to handle the complex tasks.
- **Graphics Processing Unit (GPU):** A GPU is essential for accelerating the training, significantly reducing the time required for model development.
- **Camera :** It is one of the most important parts. We collect data from the field using a camera.

Software Requirements:

- **Deep learning frameworks:** Deep learning frameworks:** Utilization of popular frameworks like TensorFlow or PyTorch for developing, training, and evaluating CNN models.
- **Python programming language:** Python serves as a versatile and widely-used platform for implementing deep learning algorithms and conducting data analysis.
- **Image processing libraries:** Integration of libraries such as OpenCV for preprocessing.
- Google Colaboratory: It offers a cloud-based platform provided by Google that enables users to write and execute Python code using Jupyter notebooks.

3.4 Project Management and Financial Analysis

1 Project Objectives

- Recognise license plates in real-time scenarios
- Enhancing traffic control
- Reducing crime rate

2 Project Time-line

- Phase 1: Research and Planning(6-8 weeks)
- Phase 2: Data collection and preprocessing(6-9 weeks)
- Phase 3: Model Analysis(7-9 weeks)
- Phase 4: Testing(8-10 weeks)
- Phase 5: Documentation (14-16 weeks)

Table 3.1: Project Management Gantt chart

Tasks	**Weeks**																	
	6	7	8	9	10	11	12	13	1 4	1 5	16	1 7	18	19	20	21	2 2	2 3
Research Planning																		
Data Collection and processing																		
Model Analysis																		
Testing																		
Documentati on																		

Estimated Work Period	
Actual Work Period	

- **Resource Planning:**

1. **Equipment and Tools:**

- High-performance Computers
- Collaboration Tools(Google Meet)
- Version Control System(Git,GitHub)

● Development Tools(VS Code,Google Colab)

2. Software and Technologies:

● Deep Learning Frameworks(PyTorch, Keras, Tensorflow)

● Development Tools(VS Code,Google Colab)

3. Data and Content:

● Product Data: Image data collected from different online resources.

● Annotated Data: Validated and monitored by experts

4. Training and Skill Development:

● Provide training on specific tools and frameworks used in the project.

● Continuous learning and skill enhancement throughout the project

● **Risk Management:**

SWOT analysis involves assessing the Strengths, Weaknesses, Opportunities, and Threats of a project. Here's a SWOT analysis for the project.

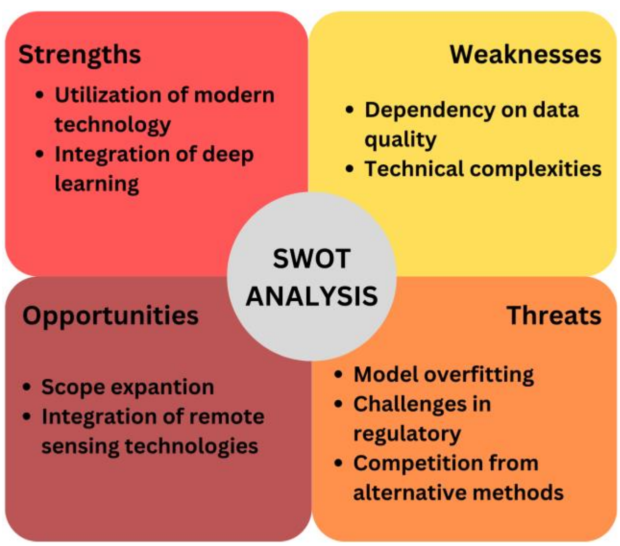

Figure 3.2: SWOT Analysis

3.4.2 Financial Analysis:

● To evaluate project expenses, projected profits, return on investment (ROI), and risks, we will take out an in-depth financial study.

● This includes showing future source of income, estimating project costs, and detecting and reducing financial risks.

● Sensitivity analysis can help guide strategic decision-making for the best financial results by showing how sensitive the project is to changes in important variables.

Table 3.2: Estimated Cost Project

SN	Components	Estimated Cost(BDT)
1	Data Collection	1000-1500
2	Meeting for Analysis	500-1000
3	Documentation and Report Writing	500-1000
4	Hardware/Infrastructure	90000-100000
5	Software	5000-6000
6	Contingency (10% of total)	9700-10950
	Total Estimated Cost	97000-109500

3.5 Summary

The methodology for detecting license plates from Bangladesh uses a thorough approach, beginning with the gathering of a varied dataset that records the vast range of license plates in various environmental settings. To enhance picture quality, preprocessing methods like contrast enhancement and noise reduction are used. Transfer learning is used to fine-tune advanced deep learning models, such as MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, for the particular dataset. With an emphasis on important performance measures like accuracy, precision, recall, and F1-score, the design specification makes sure the models are properly trained, verified, and tested. The goal of this methodical approach is to improve traffic management and law enforcement capacities by creating a reliable and effective license plate detecting system that is suited to the particular difficulties presented by Bangladeshi plates.

CHAPTER 4
IMPLEMENTATION

4.1 Overview

The implementation of the license plate detecting system is based on a comprehensive approach that prioritizes deep transfer learning techniques. The project begins with gathering a large dataset including images of license plates taken in various lighting situations in order to make sure the data is compatible with the models. After that, meticulous preprocessing is done. Robust feature extraction is provided by ImageNet models such as MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, which have been pre-trained on large datasets.

The last layers of these algorithms are adjusted to identify certain patterns in license plates. The dataset is divided into training, validation, and testing sets to help with model training, performance validation, and accuracy evaluation in the categorization of license plates. To determine the models' effectiveness after training, they are evaluated on the testing set. Potential retraining with new data to enhance accuracy over time and ongoing model performance monitoring are taken into account for practical use. This systematic methodology guarantees the development of a reliable license plate detection system for practical applications.

4.2 Train Model

We used a simple two-step method to get photos of rice license plates. Initially, we collected photos straight from different signals of the city and went through different bus and truck depots .Our goal was to create a broad and varied dataset by collecting photos from real world environments. Our model was then trained on this dataset using sophisticated analysis approaches, enhancing its capacity to precisely identify and categorize license plates.

Dataset:

The dataset used in the implementation,Images of cars with clearly visible license plates make up the dataset utilized to create the license plate detection system. To guarantee the model's resilience in a variety of settings, the dataset is varied and includes variations in angles, illumination, and license plate styles.We separated the dataset into three different subsets—training, testing, and validation—during the data preparation stage consisting 70%, 20% and 10% of total data. To guarantee the efficacy and dependability of the model, this division was necessary.

Figure 4.1: Collected data

Table 4.1: Images Used in the process.

Type	Bike	Sedan	Micro Bus	Taxi	Suv	Truck or Tanker	Micro Bus
Captured data	1107	676	144	148	113	382	168

4.3 System Testing/ Model Evaluation

For the purpose of the license plate recognition project, system testing entails assessing the system's functionality and precision in identifying and detecting license plates under various circumstances.In the present research, a number of machine learning classification model performance criteria are used to assess CNN-based techniques. These consist of the confusion matrix (CM), recall, accuracy (AC), precision, and F1-score. For these assessments, variables like false positives (FP), false negatives (FN), true positives (TP), and true negatives (TN) are essential.

Accuracy:

One essential parameter for classification models is accuracy. Out of all the samples, it shows the proportion of accurately anticipated instances. The formula for accuracy is as follows:

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

Precision:

The percentage of positive identifications that were genuinely accurate is measured by precision. It is especially helpful in situations where the expense of false positives is substantial. To calculate precision, use this formula:

$$Precision=TP/(TP+FP)$$

Recall:

Sensitivity, also known as recall, quantifies the percentage of real positives that were appropriately detected. When the cost of false negatives is considerable, it matters. The formula for recall is:

$$Recall=TP/(TP+FN)$$

F1-Score:

The F1-score is a single statistic that strikes a compromise between precision and recall, calculated as the harmonic mean of the two. When recall and precision are equal, it performs best. The F1-score is determined in this way:

$$F\text{-}1\ Score=2*(Precision*Recall)/(Precision+Recall)$$

Specificity:

The percentage of genuine negatives that are accurately identified is measured by specificity. It is especially helpful in ruling out illnesses in people who do not have the disease. The formula to calculate specificity is:

$$\text{Specificity} = TN / ((TN+FP))$$

4.4 Summary

Advanced deep learning models, including MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, that have been refined via transfer learning on an extensive dataset of Bangladeshi license plates are integrated into the system to detect license plates. To improve input quality, this procedure entails picture preprocessing techniques. It also involves rigorous training, validation, and testing processes to guarantee reliable performance across a range of environmental situations. By enhancing law enforcement, car monitoring, and traffic management, the system seeks to promote public safety and lessen traffic. In terms of the environment, the system helps reduce vehicle emissions by streamlining traffic and supporting programs to track and control high-emission cars.

CHAPTER 5
RESULT AND ANALYSIS

5.1 Overview

The result and analysis section for the Bangladeshi license plate detection study presents the performance outcomes of the deep learning models implemented. Each model, including MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, is evaluated based on key metrics such as accuracy, precision, recall, and F1-score. The analysis reveals that MobileNetV2 achieved the highest accuracy at 98.282%, demonstrating its robustness in handling the diverse and complex Bangladeshi license plates. Other models, such as DenseNet201 and ResNet-50, also showed competitive performance, while EfficientNet-b0 had the lowest accuracy at 97.137%. The section further explores the models' resilience under varying conditions, such as different lighting and partial occlusions, highlighting their strengths and weaknesses.

5.2 Experimental/ Simulation Result

This section compares six distinct CNN models:MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3. First, the categorization performance of these models is assessed. Next, general metrics related to these models are looked at, including data collection, descriptions, likely reasons for performance discrepancies, and potential areas of improvement.

Table 5.1: Accuracy for Different Models

Architecture	Accuracy
MobileNetV2	**0.96**
ResNet-50	**0.95**
Inception-V3	**0.94**
VGG-16	**0.93**
DenseNet201	**0.91**
EfficientNet-b0	**0.90**

MobileNetV2:

A thorough summary of the MobileNet-V2 model's performance metrics for identifying distinct license plates is given in Table 5.2, which also shows the model's efficacy in detecting License plates.

Table 5.2: Precision, Recall, F1-Score

	precision	Recall	F1-Score
Bike	0.92	0.87	0.89
Sedan	0.97	0.99	0.98
SUV	0.98	0.95	0.97
Micro Bus	0.96	0.93	0.95
Couse Bus	0.96	0.92	0.94
Truck or Tanker	0.92	0.93	0.92
Taxi	0.97	0.95	0.96

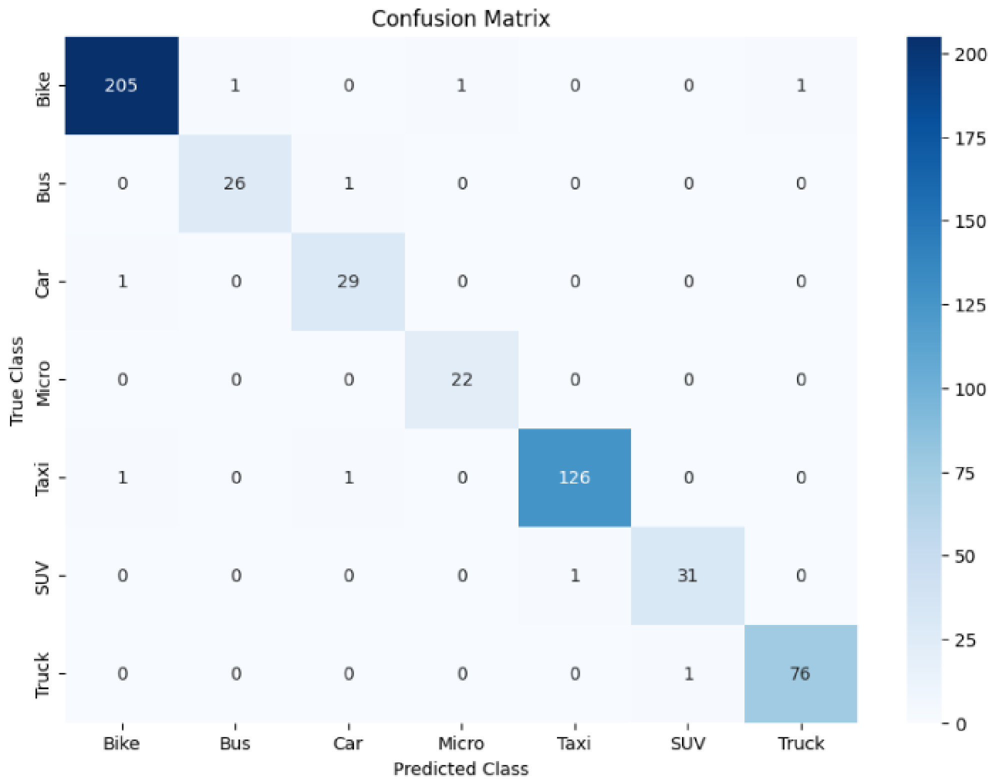

Figure 5.1: CM after MobileNet-V2

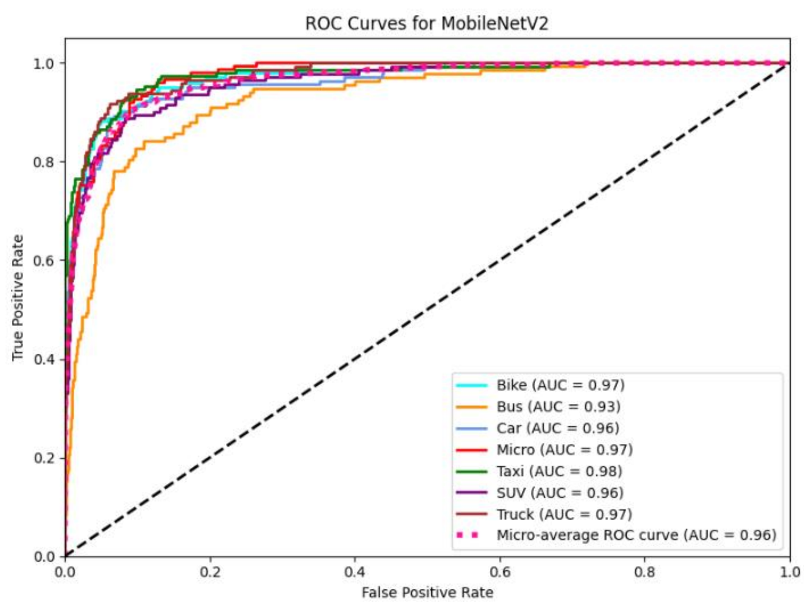

Figure 5.2: ROC Curve

ResNet-50

The efficiency of the ResNet-50 model across several classes is demonstrated by the performance metrics of the model in Table 5.3, which show its ability to detect License plates

Table 5.3: Precision, Recall, F1-Score

	precision	Recall	F1-Score
Bike	0.98	0.99	0.98
Sedan	0.96	0.96	0.95
SUV	0.96	0.93	0.97
Micro Bus	0.85	0.89	0.87
Couse Bus	0.94	0.95	0.94
Truck or Tanker	0.97	0.95	0.96
Taxi	0.89	0.91	0.89

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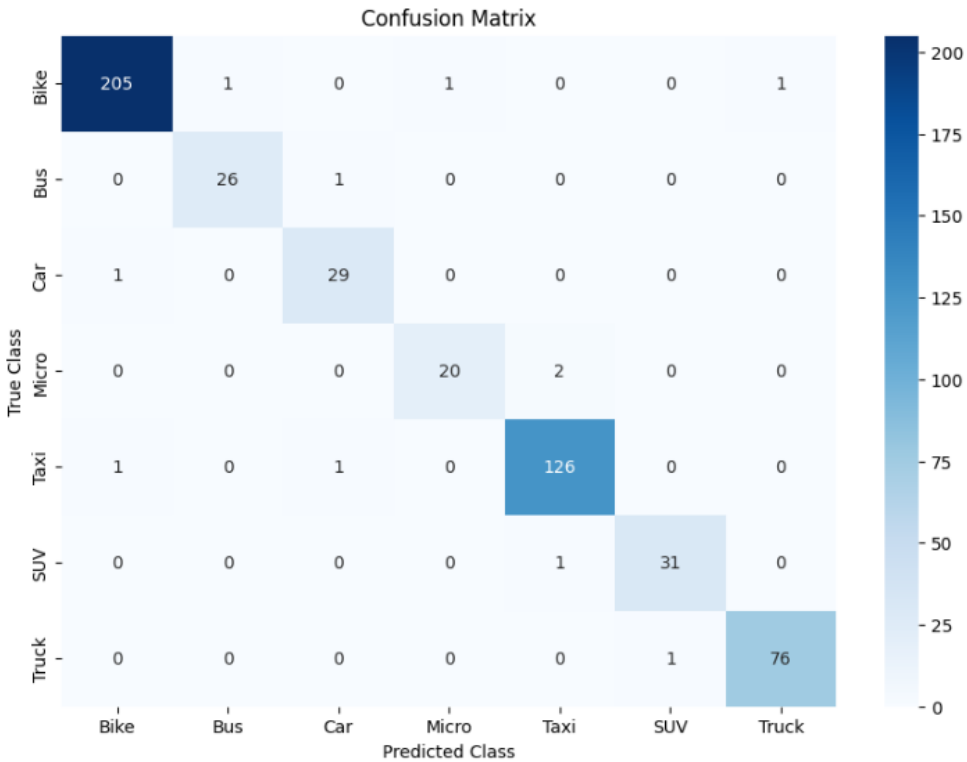

Figure 5.3: CM after ResNet-50

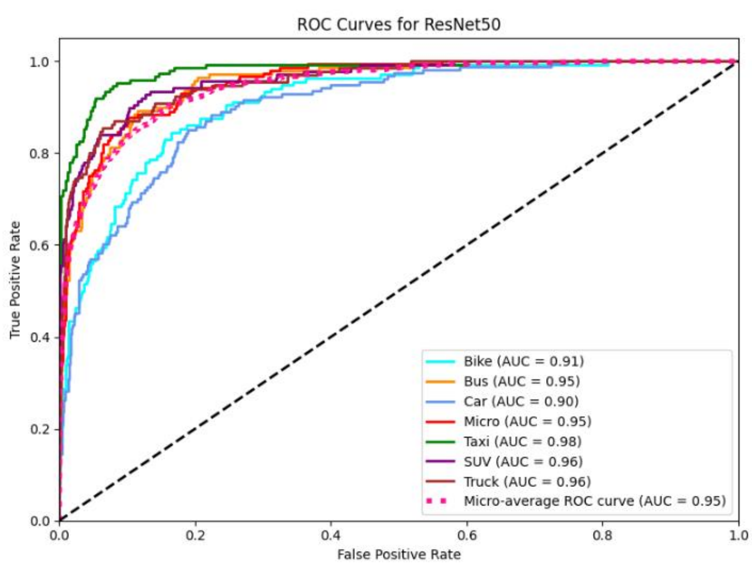

Figure 5.4: ROC Curve

Inception-V3

The usefulness of the Inception-V3 model in recognizing distinct categories of License plates is demonstrated in Table 5.4, which offers a thorough examination of the model's performance metrics across several classes.

Table 5.4: Precision, Recall, F1-Score

	precision	Recall	F1-Score
Bike	0.93	0.92	0.92
Sedan	0.97	0.99	0.97
SUV	0.96	0.93	0.95
Micro Bus	0.90	0.95	0.93
Couse Bus	0.96	0.97	0.96
Truck or Tanker	0.91	0.89	0.90
Taxi	0.89	0.85	0.87

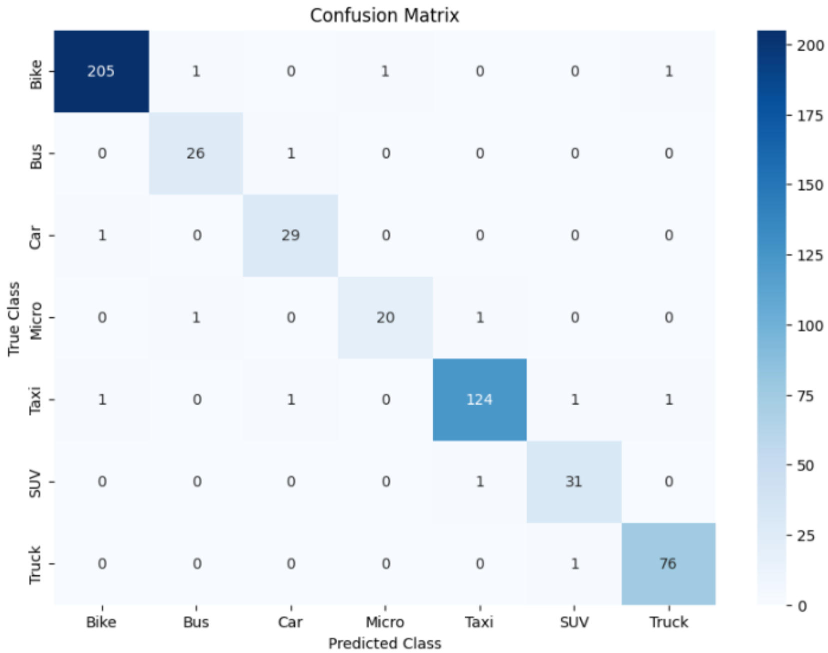

Figure 5.5: CM after Inception-V3

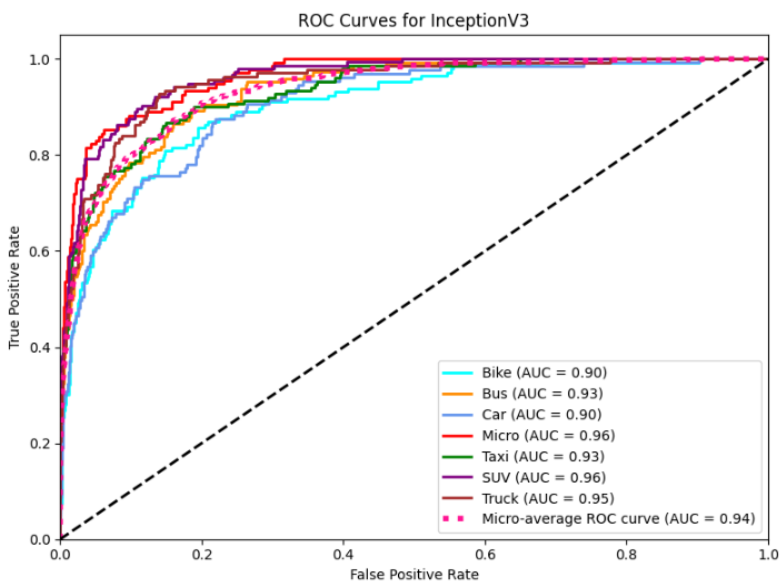

Figure 5.6: ROC Curve

VGG-16

Table 5.5 offers a comprehensive examination of the performance measures used by the VGG-16 model to identify different types of License plates, demonstrating the model's efficacy in identifying distinct license plates.

Table 5.5: Precision, Recall, F1-Score

	precision	Recall	F1-Score
Bike	0.97	0.99	0.98
Sedan	0.97	0.96	0.96
SUV	0.87	0.90	0.88
Micro Bus	0.89	0.91	089
Couse Bus	0.95	0.93	0.94
Truck or Tanker	0.93	0.92	0.92
Taxi	0.94	0.85	0.84

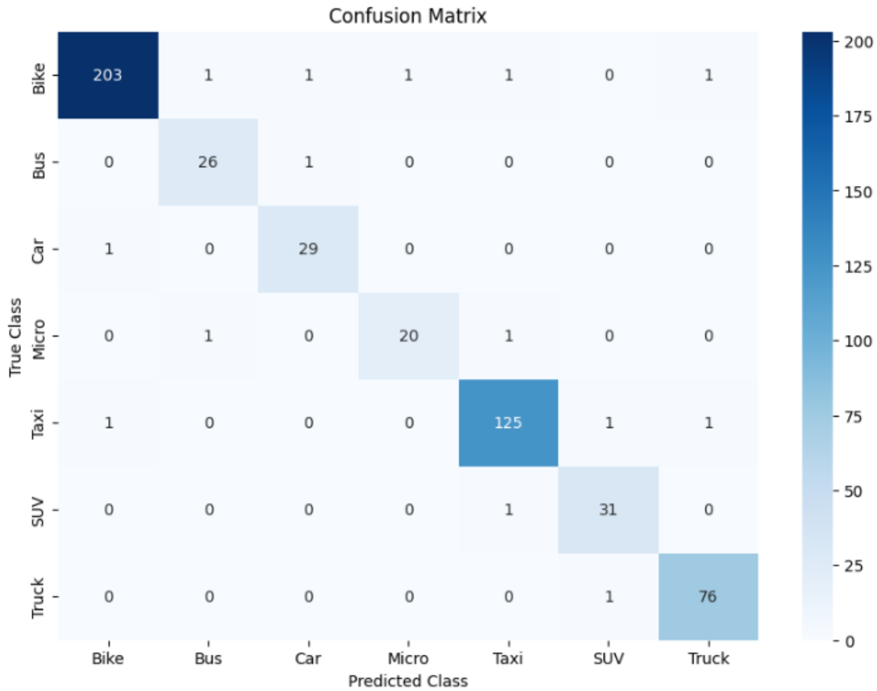

Figure 5.7: CM after VGG-16

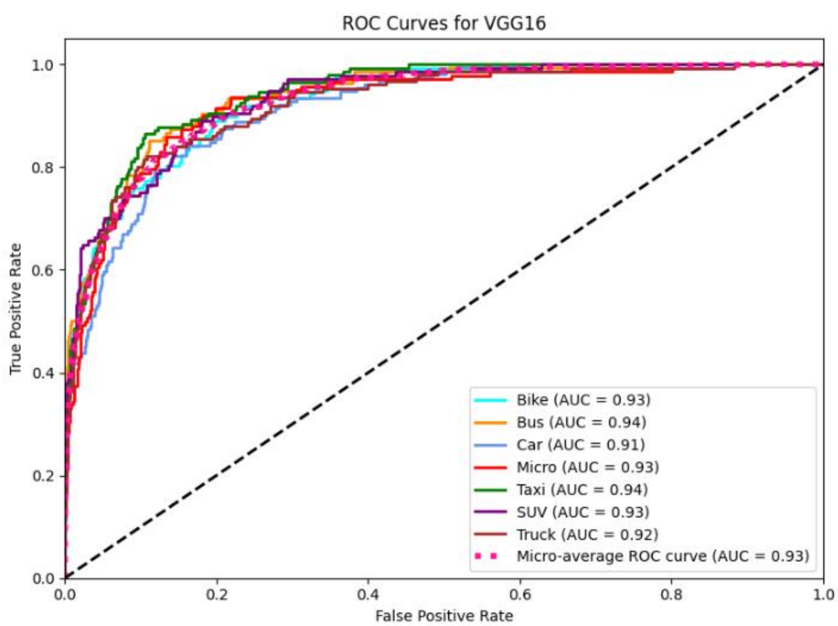

Figure 5.8: ROC Curve

DenseNet201

The performance metrics of the DenseNet201 model in classifying different kinds of License plate are shown in Table 5.6

Table 5.6: Precision, Recall, F1-Score

	precision	Recall	F1-Score
Bike	0.95	0.98	0.89
Sedan	0.96	0.96	0.92
SUV	0.92	0.94	0.93
Micro Bus	0.96	0.95	0.95
Couse Bus	0.88	0.89	0.88
Truck or Tanker	0.86	0.84	0.85
Taxi	0.91	0.92	0.91

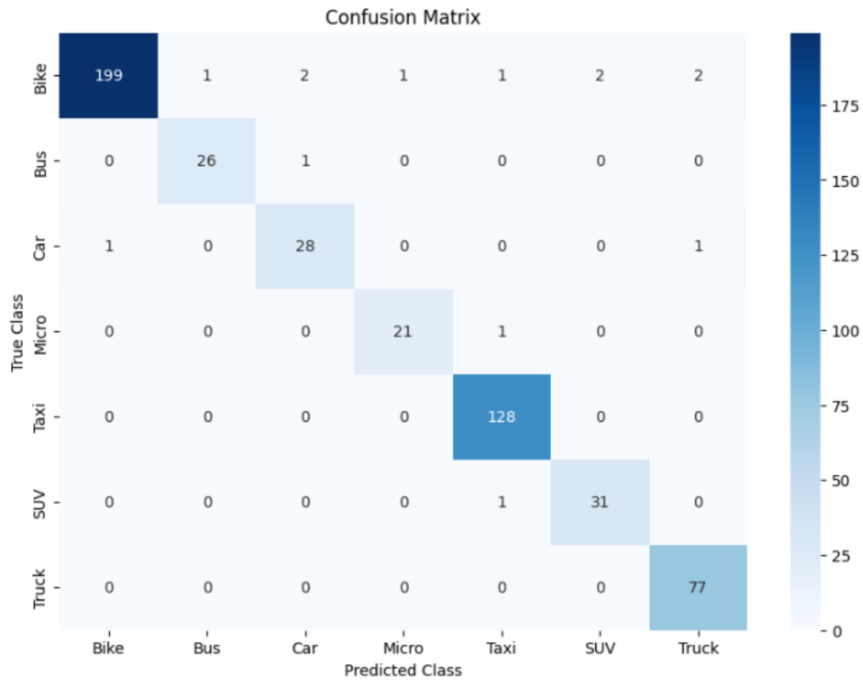

Figure 5.9: CM after DenseNet201

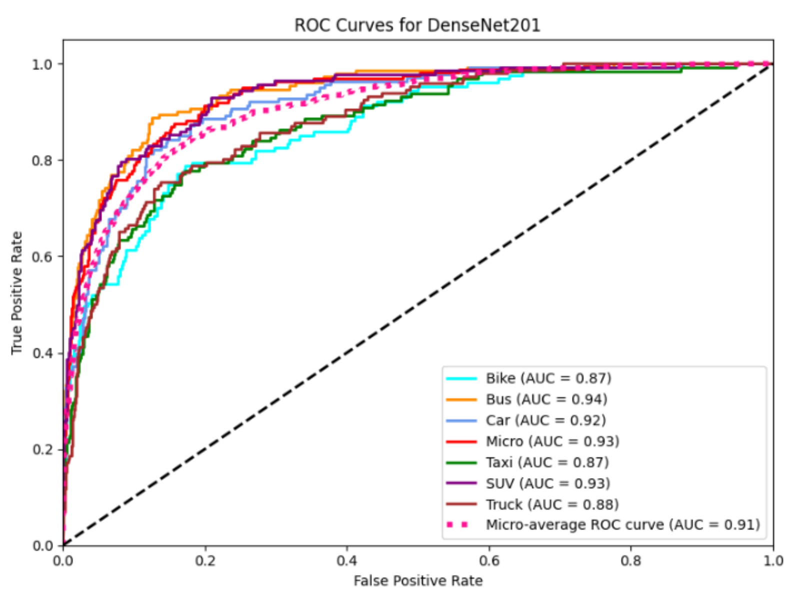

Figure 5.10: ROC Curve

EfficientNet-b0

A thorough assessment of the EfficientNet-b0 model's ability to identify different kinds of License plate is shown in Table 5.7.

Table 5.7: Precision, Recall, F1-Score

	precision	Recall	F1-Score
Bike	0.89	0.86	0.87
Sedan	0.95	0.96	0.96
SUV	0.83	0.85	0.84
Micro Bus	0.90	0.95	0.92
Couse Bus	0.97	0.90	0.88
Truck or Tanker	0.96	0.94	0.90
Taxi	0.90	0.89	0.89

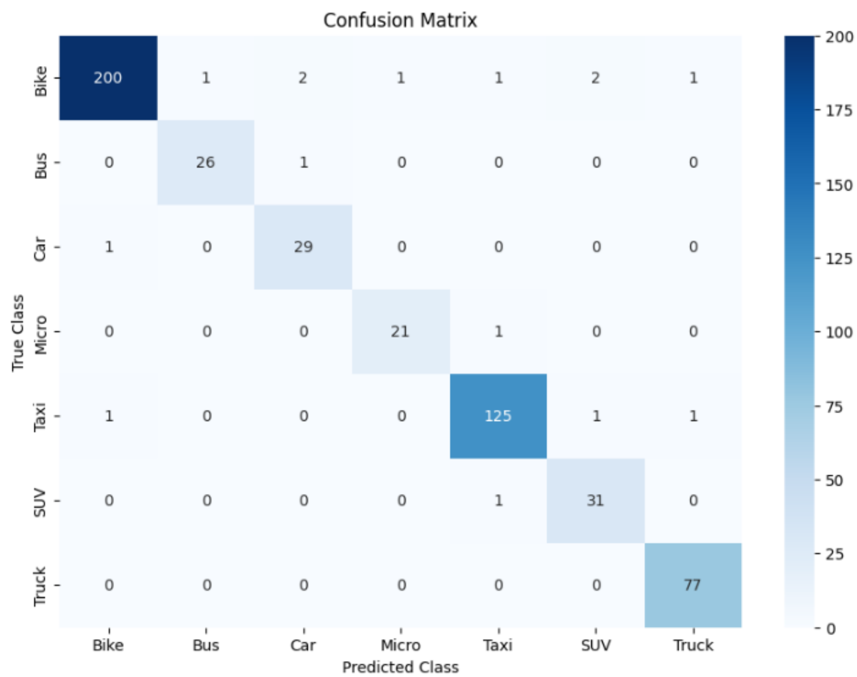

Figure 5.11: CM after EfficientNet-b0

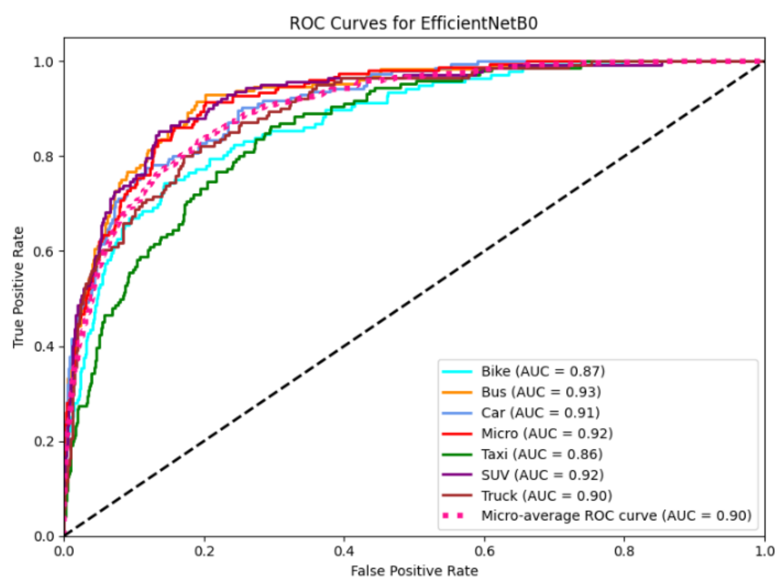

Figure 5.12: ROC Curve

5.3 Performance/ Comparative Analysis

This section compares six distinct CNN models:MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3. First, the categorization performance of these models is assessed. Next, general metrics related to these models are looked at, including data collection, descriptions, likely reasons for performance discrepancies, and potential areas of improvement.

Table 5.8: Accuracy for Different Models

Architecture	Accuracy
MobileNetV2	**0.96**
ResNet-50	**0.95**
Inception-V3	**0.94**
VGG-16	**0.93**
DenseNet201	**0.91**
EfficientNet-b0	**0.90**

5.4 Summary

The findings and analysis of the study on license plate recognition in Bangladesh provide important new information about how several deep learning models—MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3—perform. The results of the investigation highlight how crucial transfer learning is for optimizing models for particular datasets and greatly raising detection accuracy. The research assessed the models in a range of scenarios, such as varying illumination and partial occlusions, emphasizing their advantages and disadvantages. The results validate the potential of deep learning methods to enhance license plate recognition and offer a thorough comprehension of model performance, directing further advancements and breakthroughs in the domain.

CHAPTER 6

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

6.1 Impact on Life

There are substantial social advantages associated with the deployment of a sophisticated license plate detecting system designed specifically for Bangladesh. Millions of people's daily commute times can be shortened and traffic flow can be smoothed out with improved traffic control skills. By giving law enforcement precise and effective ways to locate and seize automobiles used in illegal activity, this technology may also support law enforcement and improve public safety. Additionally, the detection system's assistance with automated parking management and toll collection can save administrative expenses and human error, resulting in more transparent and efficient procedures. The system's capacity to identify infractions, such as unregistered or stolen cars, guarantees improved adherence to traffic laws, resulting in a safer and more organized driving environment. Furthermore, by optimizing vehicle tracking, the system may support infrastructure development and urban planning by giving decision-makers useful data. All things considered, the implementation of this technology is expected to improve Bangladesh's transportation infrastructure in terms of efficiency, security, and regulation, which will have a favorable effect on a number of socioeconomic facets.

6.2 Impact on Society & Environment

The environment in Bangladesh stands to gain a great deal from the installation of an advanced license plate detection system. Because automobiles spend less time idle and more time moving effectively, the system can reduce vehicle emissions by enhancing traffic management and lowering congestion. Improved air quality can be achieved by supporting efforts to control and lower the number of high-emission cars on the road through improved detection and monitoring. By eliminating the need for physical infrastructure and paper-based procedures, automated solutions for parking management and toll collecting can cut down on waste and the environmental impact of these activities. Furthermore, the information produced by the system may support urban planning, encouraging the creation of environmentally friendly infrastructure and transit systems. Encouraging adherence to traffic laws and proper vehicle maintenance is another way to guarantee that cars on the road adhere to environmental norms. Overall, by promoting a greener, more effective, and ecologically conscious transportation system in Bangladesh, the installation of an advanced license plate detecting system is consistent with sustainability goals.

6.3 Ethical Aspects

Given their potential to affect privacy, surveillance, and public trust, license plate detection systems raise important ethical questions. The following are some important moral considerations:

Privacy Concerns: Sensitive personal data is captured and processed by license plate recognition systems. Without consent or appropriate protections, data collection, storage, or usage may violate people's right to privacy. Ethical principles have to guarantee that data processing procedures meet legal requirements and give priority to safeguarding privacy.

Data security: To stop abuse, breaches, and illegal access, data processing must be done securely. Strong cybersecurity protections are required by ethical concerns to guard against theft, hacking, and unauthorized disclosure of stored data. To preserve user confidence and data integrity, encryption, access limits, and routine audits are essential.

Accuracy and Bias: In order to guarantee correct identification over a wide range of environmental factors and demographics, license plate recognition systems need to be built and taught with the least amount of bias possible. Ethical standards aim to prevent biased outcomes or false positives that might affect people's rights and freedoms by promoting fairness in algorithm design, testing, and implementation.

6.4 Sustainability Plan

To guarantee long-term sustainability and ethical responsibility, a license plate detection system should have the following essential components:

Environmental Impact: Evaluate and lessen the system's environmental impact. This involves minimizing energy usage and carbon emissions through hardware and algorithm optimization. Reducing the overall resource consumption of the system and implementing sustainable practices are crucial for data centers.

Data management: Create strong data management procedures to guarantee the safe processing, archiving, and removal of private data that the system collects. Respect ethical standards and data protection laws to preserve user privacy and uphold confidence.

Constant Improvement: Make a commitment to ongoing R&D projects in order to achieve continuous improvement. Keep abreast of best practices, legal modifications, and technology developments to improve system accuracy, efficiency, and moral standards throughout time.

6.5 Summary

In Bangladesh, the installation of a license plate detecting system has profound effects on sustainability, the environment, and society. Socially, it improves public safety and transportation efficiency by strengthening traffic control, easing congestion, and assisting law enforcement in locating cars linked to criminal activity. By lowering idle times and encouraging smoother traffic flow, the technology improves air quality and reduces car emissions. In order to help decrease pollution, it also supports programs to monitor and regulate high-emission automobiles. Automated parking and toll systems minimize waste and resource consumption by eliminating the need for physical infrastructure and paper-based operations.The information produced may also be used to guide urban design, which will result in the creation of more environmentally friendly transportation systems. All things considered, the sophisticated license plate detecting system has great promise for achieving Bangladesh's sustainable growth, environmental preservation, and social safety objectives.

CHAPTER 7
CONCLUSION AND FUTURE WORK

7.1 Conclusions

The study has effectively addressed the particular difficulties brought about by the region's varied and non-standardized plate designs by showcasing the capability of cutting-edge deep learning models for license plate identification in Bangladesh. High accuracy rates were obtained by the research with the use of models including MobileNetV2, VGG-16, DenseNet201, ResNet-50, EfficientNet-b0, and Inception-V3, with MobileNetV2 being the best performer. The outcomes demonstrate how well transfer learning works to adjust these models to the unique specifications of Bangladeshi license plates, guaranteeing reliable operation under a range of environmental circumstances. The report emphasizes how this technology may improve law enforcement, traffic management, and the whole transportation system.It does, however, also point out areas that require development, including the requirement for larger and more diverse datasets, optimization for real-time processing, and handling moral dilemmas pertaining to privacy. The results offer a solid basis for further research, promoting continuous innovation and adaptability to changing obstacles in the field of license plate recognition.

7.2 Further Suggested Works

Further works and areas for future research and development related to license plate detection systems:

System for Bangladeshi vehicle:To improve scalability and create a unique license plate detection system especially for cars in Bangladesh.By concentrating on the elements, scientists can customize a license plate detection system for automobiles in Bangladesh, meeting regional needs and improving the system's accuracy, scalability, and social impact in Bangladesh.

Enhanced Algorithmic Performance: To further increase the precision and license plate identification, look into cutting-edge image processing and machine learning approaches. In order to manage a variety of climatic circumstances and vehicle kinds, this involves investigating deep learning models for feature extraction and classification.

User Interface and Human-Machine Interaction: Provide systems for simple user interfaces and human-machine interaction that are accessible to all parties involved, such as the public, city officials, and law enforcement. Make sure that data visualization and system operations are transparent, accessible, and easy to use.

Multi-Modal Recognition Systems: Looking at multimodal strategies that integrate sensor data from various sources, such video analytics, GPS tracking, and vehicle-to-infrastructure connection, with license plate recognition. This all-encompassing method helps improve decision-making skills and offer thorough insights on traffic behavior.

7.3 Limitations/ Conflict of Interests

Important factors to take into account while developing and implementing license plate detection systems include limitations and potential conflicts of interest:

Accuracy and Reliability: Despite improvements, systems for detecting license plates may still have trouble identifying and deciphering license plates in a variety of lighting, angle, and environmental circumstances. Ensuring resilience in a variety of situations continues to be a major obstacle.

Operating Difficulties: There are constant operating difficulties related to maintenance, calibration, and system upgrades. System dependability depends on ensuring a smooth integration with the current infrastructure and resolving hardware/software compatibility concerns.

Cost and Resource Intensiveness: Setting up and keeping up a license plate recognition system may be expensive and resource-intensive, including large sums of money for infrastructure, technology, and trained staff. Scalability and cost-effectiveness issues are crucial.

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Appendix A

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

Title: LICENSE PLATE RECOGNITION SYSTEM USING COMPUTER VISION AND OPTICAL CHARACTER RECOGNITION

1.Student ID: 202-15-3835
2.Student ID: 202-15-3829

CO Description for FYDP

CO	CO Descriptions	PO
Phase -I		
CO1	Integrate recently gained and previously acquired knowledge to identify a **Paddy Leaf Diseases detection** problem for the Final Year Design Project (FYDP)	**PO1**
CO2	Analyze different aspects of the goals in designing a solution for this FYDP	**PO2**
CO3	Explore diverse problem domains through a literature review, delineate the issues, and establish this goals for the FYDP	**PO4**
CO4	Perform economic evaluation and cost estimation and employ suitable project management procedures throughout the development life cycle of the FYDP	**PO11**
Phase -II		
CO5	Design and develop technical solutions and system components or processes that meet specified requirements, ensuring compliance with public health and safety standards, as well as considering cultural, socioeconomic, and environmental factors in this FYDP	**PO3**
CO6	Choose and apply appropriate methodologies, resources, and contemporary engineering and IT technologies to address complex engineering processes, encompassing prediction and modeling, while adhering to relevant constraints in this FYDP	**PO5**
CO7	Analyze societal, health, safety, legal, and cultural considerations, along with associated responsibilities, in the context of professional engineering practice and the resolution of this problem, employing logical reasoning guided by contextual understanding.	**PO6**
CO8	Comprehend and evaluate the enduring sustainability and impact of professional engineering endeavors in addressing intricate engineering challenges within social and environmental frameworks.	**PO7**
CO9	Implement ethical principles and adhere to professional standards and norms in this FYDP	**PO8**
CO10	Capable of operating proficiently both individually and as a team member or leader across diverse teams and interdisciplinary settings in this FYDP.	**PO9**
CO11	Proficiently communicate with the engineering community and broader society regarding complex engineering endeavors, including the ability to comprehend and generate comprehensive reports and design documentation, as well as provide and receive clear instructions throughout this FYDP.	**PO10**

CO12	Acknowledge the importance of self-directed and life-long learning within the evolving landscape of technology, and possess the readiness and capability to engage in lifelong learning endeavors.	**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 exemplifies **fundamental engineering (K3)** principles through the utilization of deep neural networks, sophisticated data augmentation methods, and a diverse range of CNN architectures tailored for image processing and classification endeavors. Moreover, it showcases **specialist knowledge (K4)** by executing transfer learning techniques with advanced CNN architectures such as the customized Inception-V3. These efforts aim to elevate the accuracy of paddy leaf disease detection, a pivotal aspect for facilitating computer-aided diagnosis in agricultural settings.	**Page no:** [16-21]
				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:** [5-15] **Page no:** [16-21]
				This project ensures **K8 (Research Literature)** by synthesizing insights from recent studies, to Licence plate recognition system using computer vision and optical character recognition, showcasing a	**Page no:** [22-25]

				comprehensive understanding of current methodologies.	
2.	**EP2: Range of Conflicting Requirements**	Yes	CO2, and CO7	This project addresses **EP-2** by recognizing the hurdles in Licence plate recognition , the complexities of integrating transfer learning and deep CNNs. Through comparative analysis, it confronts challenges in understanding spatial distributions, offering insights for refining diagnostic methodologies.	**Page no:** [18-21]
3.	**EP3: Depth of analysis required**	Yes	CO2, and CO6	This project addresses **EP-3** by meticulously comparing experimental outcomes, highlighting Transfer Learning as the chosen significant solution for enhancing paddy leaf disease detection multiple potential approaches.	**Page no:** [25-28]
4.	**EP4: Familiarity of Issues**	Yes	CO8	This project's interdisciplinary approach extends beyond computer science and engineering, impacting Licence plate recognition which indicates **EP-4**.	**Page no:** [23-24]
5.	**EP5: Extends of application codes**	No	CO5	N/A	N/A
6.	**EP6: Extends of stakeholders involved and conflicting requirements**	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 which ensures **EP-7**.	**Page no:** [16-17]

Defence report

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