PARKING SLOT DETECTION AND MAINTENANCE USING DEEP LEARNING

<u>Submitted By:</u>

PRANTO SAHA

192-35-2823

Department of Software Engineering

DAFFODIL INTERNATIONAL UNIVERSITY

<u>Supervised By:</u>

MD. SHOHEL ARMAN

Assistant Professor

Department of Software Engineering

DAFFODIL INTERNATIONAL UNIVERSITY

This Thesis report has been submitted in fulfilment of the requirements for the Degree of Bachelor of Science in Software Engineering

Spring-2023

APPROVAL

APPROVAL

This thesis titled "**PARKING SLOT DETECTION AND MAINTENANCE USING DEEP LEARNING**", submitted by **Pranto Saha (ID: 192-35-2823)** to the Department of Software Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfilment of the requirements for the degree of Bachelor of Science in Software Engineering and approval as to its style and contents.

BOARD OF EXAMINERS

--- **Chairman**

Afsana Begum
Assistant Professor
Department of Software Engineering
Faculty of Science and Information Technology
Daffodil International University

--- **Internal Examiner 1**

Md Shohel Arman
Assistant Professor
Department of Software Engineering
Faculty of Science and Information Technology
Daffodil International University

--- **Internal Examiner 2**

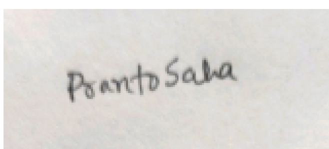
Md. Rajib Mia
Lecturer
Department of Software Engineering
Faculty of Science and Information Technology
Daffodil International University

--- **External Examiner**

Dr. Md. Sazzadur Rahman
Associate Professor
Institute of Information Technology, Jahangirnagar University

DECLARATION

This statement states that **Pranto Saha** completed the thesis titled **“PARKING SLOT DETECTION AND MAINTENANCE USING DEEP LEARNING”** under the guidance of **Mr. Md Shohel Arman**, Assistant Professor, Department of Software Engineering, Daffodil International University. Additionally, it declares that neither this paper nor any component of it has been submitted to another institution for the conferment of a degree.



Pranto Saha
ID: 192-35-2823
Batch: 29
Department of Software Engineering
Daffodil International University

Certified By:

Mr. Md. Shohel Arman
Assistant Professor
Department of Software Engineering
Daffodil International University

ACKNOWLEDGEMENT

First, I want to express my sincere gratitude and thanks to Almighty God for giving me the opportunity to complete the thesis with His help successfully.

I am grateful and wish our profound indebtedness to **Md. Shohel Arman**, **Assistant Professor**, Department of Software Engineering, Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of “Deep Learning” to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts, and correcting them at all stages have made it possible to complete this project. This project was made possible thanks to his never-ending tolerance, academic leadership, persistent encouragement, constant and energetic supervision, constructive criticism, insightful counsel, reading numerous subpar versions, and fixing them at every level. I would like to extend my sincere gratitude to **Dr. Imran Mahmud, Associate Professor** and **Head In-Charge**, Department of Software Engineering, Daffodil International University, Dhaka, for his kind assistance in finishing my thesis. I also want to thank the other professors and employees of the SWE department at Daffodil International University.

Last but not least, I must express my gratitude for my parents' unwavering support and patience.I also want to thank you for having faith in me.

ABSTRACT

Traffic is a major issue in Bangladesh, particularly in urban regions like Dhaka. The main issue with traffic in Bangladesh is parking by the wayside. Private transportation users spend the majority of their waking hours looking for parking spaces. I therefore made the decision to create a system that aids in the discovery of available parking spaces. In large cities, traffic and energy waste can be significantly reduced by the use of parking-management systems, including services that identify empty spaces. Since they may make use of the cameras that are already present in many parking lots, visual methods for spotting open places offer an affordable alternative. I created a system that is economical using a deep learning model. I have utilised three distinct deep-learning models. The three of them are Yolov7, Yolov8, and Mask-RCNN. Box loss, Class loss, Instances, Object loss, and mAp are the only outputs that the model produces. Yolov8 gives me the mAP of the models, at 96.8%. I have chosen the accuracy of YOLO v8 here because it is updated among all versions and gives very good and perfect accuracy. Here I have used the video footage of my university garage as a dataset. I have tried to give my best performance in every step of this thesis to use my own dataset. I'll try to make it so that authorised users can access the parking garage in the future. In order to achieve higher accuracy, and will expand the dataset.

TABLE OF CONTENTS

LIST OF FIGURE

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

People all throughout the world are getting better off while also giving birth to an increasing number of new individuals each day. The number of people who possess a car is increasing since transportation plays a significant role in how people live in the current era. As a result, there are more cars on the road. Finding a parking spot is getting more and more difficult everywhere since there are more and more cars on the road. Therefore, it's becoming increasingly difficult to locate a parking space that suits the needs of the owner or the motorist in a large city with a dense population. The amount of traffic that backs up can increase if you can't find a parking spot where you want to. However, if the motorist or user can determine if parking spots are available or not, he or she will be able to search for a parking spot elsewhere and won't have to enter a parking lot that is empty. To operate parking systems, a person utilises their hands. It takes a lot of time and is incorrect as a result. A lack of parking spaces also aggravates people. The majority of the parking lots, however, can feature open spaces that local drivers are unaware of. Therefore, the automatic parking system is a novel field in which computer vision researchers are keen to get involved.

The earlier methods were mostly built on the foundation of image segmentation or machine learning, particularly Support Vector Machines (SVM) and Neural Networks (NN) over spot patches. But because object detection algorithms have evolved over the past several years, it is conceivable to employ these algorithms for the accurate detection of autonomous parking management systems.

Traffic congestion, traffic pollution, and traffic surveillance have recently been discussed in TV and print articles and broadcasts. The odd-even rule for vehicles in Dhaka, traffic accidents, and fuel price increases have all been discussed. The creation of systems that allocate and remove parking spaces in real time is a goal of many academics. Because they don't need to be set up differently, sensor-based computer parking systems are less expensive than those that use security cameras to accomplish the same task.No additional setup is required for these vision-based solutions. Parking spaces must be distributed according to how they are being used for smart city parking systems to function. Drivers cannot reserve parking spaces the same way they would a movie ticket in real life. For real-time recorded video that is available, we have taken note of this issue and developed a method employing the statistical block matching algorithm (SBMA). The motivations for this work will be addressed. Different approaches to determining how blocks are moving are detailed in the literature review, along with any research gaps. It was discussed how to deliver real-time parking statuses and the block-matching mechanism. The suggested method's simulation results are shown, and its effectiveness is evaluated using recall, precision, and F1 scores.

1.2 MOTIVATION OF THE RESEARCH

In contrast to the homogenous implementation of such systems outside of Bangladesh, real-time traffic management system deployment in Bangladesh is diverse. The provision of users with the most recent information regarding the availability of parking spaces is one of the ITS's most crucial duties. We first created a simple module with a toy car and varied lighting conditions using circle Hough transforms, and then we created a smart parking system. Real-time movie theatre ticket booking systems served as the basis for the concept of finding parking spaces. The statistics for parking volume and capacity in big cities are very different from one another, especially in areas close to business centres, theatres, hospitals, and big malls. A reduction in traffic congestion, time savings, and fuel savings are all advantages for drivers who have access to parking information in advance. Nowadays, those who perform research, create jobs, and collect wealth have hopes of starting a business and being an entrepreneur. As a result, it is becoming increasingly clear that patents must be registered. The automatic parking module is one of these patent-protected uses. The Tezcan campus case study explains the parking fee module, which was created as a traffic demand management technique to lessen the usage of private vehicles and to prevent traffic congestion for students and even locals. In order to meet the requirements of the entire community, this was done.

1.3 PROBLEM STATEMENT

Along with the growth of the economy and the movement of people from more rural to more urban areas, the number of people and vehicles entering cities has increased. The majority of automobiles are frustrated when trying to find a parking space in one of the biggest cities in the world. According to a survey conducted by IBM, finding a parking space in Dhaka City was classified as the second hardest city to find one in. This is due to the length of time needed to find a parking space, which is never guaranteed to be available. The amount of time spent driving around in search of a parking space is detrimental to both the individual and the city's overall traffic flow. Although several solutions to the parking issue have been put forth, none of them have proven to be effective. Increasing parking fees in cities and shopping centres is one of these recommendations. People believed that this was an effort to pressure them into giving up their cars and instead forcing them to use public transportation. The city's parking space issue might be helped by adding extra parking spaces, however as a city expands, this solution won't be viable and won't function any longer. In order to help solve the parking problems that afflict our cities, computer vision and deep learning technologies can be used to provide drivers with information about where to find free parking spaces in the city.

1.4 RESEARCH QUESTIONS

The research question was-

- Can we develop a parking slot detection system that can handle dynamic environments, where vehicles are constantly moving in and out of parking spaces?
- What techniques can be employed to detect parking slot occupancy in real-time using computer vision methods?
- How can we extend parking slot detection to include other parking-related tasks, such as parking violation detection or vehicle licence plate recognition?

1.5 RESEARCH OBJECTIVES

The Objective of this research are-

- Explore the use of deep learning techniques, such as convolutional neural networks (CNNs) or recurrent neural networks (RNNs), for improved parking slot detection.
- Develop a real-time parking slot detection system that can process video streams and provide timely and accurate results.
- Investigate the transferability of parking slot detection models across different parking lot environments and evaluate the need for domain adaptation techniques.
- Investigate the privacy and security implications of parking slot detection systems, proposing methods to anonymize or protect sensitive information captured by the system.

- Investigate the impact of human factors, such as driver behaviour or vehicle occlusion patterns, on the performance of parking slot detection systems and propose mitigation strategies.

1.6 RESEARCH SCOPE

The objective of this project was to develop a powerful machine-learning model that can recognize and distinguish between vehicles and other objects in a parking lot under a variety of lighting and environmental circumstances. These goals formed the only focus of this investigation.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A literature review is a study of earlier publications, books, articles, research, reports, and conference proceedings that are relevant to a subject. With it, a person can find out what prior study has been done on the topic, obtain a broad perspective of the industry, and spot any gaps in the body of knowledge. They may take active measures to address constraints after identifying them in an effort to improve performance.

2.2 PREVIOUS LITERATURE

A Smart Parking System: An IoT-Based Computer Vision Approach for Free Parking Spot Detection Using Faster R-CNN with YOLOv3 Method, R. Nithya1 · V. Priya2 · C. Sathiya Kumar3 · J. Dheeba4 · K. Chandraprabha[1] Utilising the YOLOv3 approach, Faster Recurrent Convolutional Neural Networks (Faster R-CNN) are used to accomplish parking lot detection. This plan develops a model using a dataset of automobile images to help the system identify cars in parking lots. This method is highly beneficial because the proposed system only detects parked cars in the parking lot, not any temporary objects that can cause confusion. This system is stronger, more energy-efficient, and capable of receiving additional advancements. Finding a free parking space was made much faster by utilising the Faster Convolution Neural Network with YOLOv3 suggested smart parking system. Additionally, a user can utilise an application to verify the status of parking lots from any other location. Online, they may determine whether parking is available when they arrive at a specific place. Since the system automatically detects the empty slot in every predetermined 1.9 ms time frame each second, it is more accurate than other models like ResNet, AlexNet, CarNet, etc. They give ResNet50 96.24%, AlexNet 96.34%, CarNet 97.32%, Yolov3 and Faster R-CNN 98.41 % accuracy.

A Systematic Review of Smart Parking Systems Based on Machine Vision, Ahmad Reza Pulungan and Muhammad Zainal Abidin[2] put in place a smart parking system based on CNN's classifier. Along with a smart camera, the PKLot and CNRPark databases are utilised. The PKLot dataset is used to train and test the parking lot occupancy detection, while CNRPark is used in two distinct locations and from two distinct angles. The proposed system provides a real-time parking occupancy detection method that is effective, scalable, and distributed.A real-time image processing-based smart parking system was introduced by Bin et al. using a video camera as the sensor for parking space recognition. The three modules that make up the system's structure are those for picture acquisition, image preprocessing, and image detection. The real-time photos with a resolution of at least 640480 are collected by image acquisition. The preprocessing module then calculates those images. The detection algorithm is used to process them, such as by making the photos grayscale. The detecting module is where the ultimate determination of the parking space occupancy status is determined in real-time. Although fairly outdated, this approach has an 81% accuracy rate.

Computer Vision Based Parking Optimization System, Siddharth Chandrasekaran, Jeffrey Matthew Reginald, Wei Wang, Ting Zhu [3] The suggested system is a web-based application that gives the user the choice to investigate the occupancies for each parking block without the assistance of an outside technical person. It makes utilising the application more comfortable for the user. Because the same solution can function differently for many users depending on their preferences, the proposed approach likewise emphasises a dynamic model rather than a general one for the problem at hand. As a result, it also handles the multiple user scenario. When a common solution is developed, security and a parallel use case for the solution are two of the main problems that come up. Because the authentication factor uses the built-in Django module for authentication and stores passwords in hashed formats rather than plain text, the proposed approach maintains security. The parallel use-case situation is handled by having solution executions depending on class schedules, meaning that the solution behaves differently for different class schedules, which implies that the solution behaves differently for various people. They classified vehicles using the PKLot and CNRPark datasets, and their total classification accuracy for images from these datasets was 99.5%.

Context-Based Parking Slot Detection With a Realistic Dataset, HOSEOK DO 1,2 AND JIN YOUNG CHOI 1[4] suggest a method for context-based parking slot recognition that is motivated by how a human motorist locates a parking space. Two deep network modules—a parking context recognizer and a parking space detector—make up their approach. The parking slot detector pinpoints the precise location of a parking slot using multiple type-based fine-tuned detectors with rotated anchor boxes and a rotated non-maximal suppression, as opposed to the parking context recognizer, which recognizes the parking environment (type, angle, and availability of a parking slot). In addition, we make available a collection of 22817 photos of parking spaces with diverse features and environmental circumstances. We also provide brand-new assessment criteria for parking slot recognition that takes into account whether a car can fit in the discovered parking space. The performance of their method was 98.70% precision and 97.88% recall.

The Need for a Robust Model in 2020: A Comprehensive Study of Real-Time Vacant Parking Space Detection, Dipta Gomes, Rifath Mahmud, and A.F.M. Saifuddin Saif [5] proposition Finding empty parking spaces and This study demonstrates the current approaches with a list of their benefits and drawbacks Roboflow and CNRpark can only function in indoor parking environments with a small number of vehicle support.CNN Parking Space Management, Neural Networks, Object Detection, Segmentation.

Utilising a statistical block matching approach, real-time parking space availability for Bhavnagar 2020 The real-time feedback loop (vehicle parking places) aids the model that is provided, according to Janak D. Trivedi, Sarada Devi Mandalapu, and Dhara H. Dave [6]uses the customers' cc camera from the Reliance Himalaya Mall in Bhavnagar, Gujarat, India to continuously improve the parking strategy and position.The suggested solution confirmed parking accessibility for a single camera (with a fixed angle) for only four parking spaces. Precision, Recall, F1, Parking, and Statistical Block Matching Method are the key features of this algorithm.

Deep learning-based vehicle occupancy detection in an open parking lot using thermal camera 2020 Vijay Paidi, Hasan Fleyeh, Roger G. Nyberg [7]Compared to other detectors like yolo, yolo-conv, googlenet, and Resnet50, the suggested ResNet18 outperformed them. Axis Q1942-E thermal camera data for vehicle occupancy detection was obtained. The thermal camera has a 19 mm focal length objective and was mounted on a two-story building. Due to the possibility of lines of parking places being obscured by snow, it is typical for a car to park between two spaces. In these situations, the two parking spaces would be marked as occupied by the current IoU value, which is true practically but inaccurately. Googlenet, Resnet18, Yolo, Yolo- Conv, Resnet50 Yolo,Resnet,Googlenet.

Real-time deep learning parking occupancy detection using images 2018 Debaditya Acharya, Weilin Yan, and Kourosh Khoshelham [8] worked Using a deep CNN and a binary Support Vector Machine (SVM) classifier to analyse pictures, this paper proposes a framework for a reliable parking occupancy identification system. PKLot, Barry Street, which the author photographed, building shadows on parking spots, intense vehicle solar reflection, vehicles parked outside or in between designated bays by the drivers, and bias of the training data used by CNN, SVM.

Deep Learning and Faster R-CNN for Image-Based Parking Occupancy Detection in 2022 Anja Jakovljevic, Tomo Popovic, Zoja Scekic, and Stevan Cakic [9] engage in This study demonstrates how parking spaces may be classified into two categories—empty or occupied—by using photographs of parking lots to identify them using deep learning and Detectron2. PKLot As expected, given that these photographs were captured using an entirely different camera type, angle, and position, only a few cars can be seen in these images. These photos ought to be enhanced, annotated, and included to the larger dataset that will be used to create the better prediction model. Faster R-CNN, Detectron Deep learning, Detectron2, Faster R-CNN, machine learning, and parking occupancy detection are all examples of convolutional neural networks.

Convolutional neural networks are used for automated parking space detection. 2017 LeNet network with the Nesterov Accelerated Gradient as solver and AlexNet network with the Stochastic Gradient Descent as solver were used to train the system, according to Julien

Nyambal and Richard Klein [10]. On the validation set, we were able to achieve 99% accuracy for both networks. University of the Witwatersrand parking lots, PKLot. the presence of noise brought on by the light, certain objects adhering to the ground (oil leaks, fissures, etc.), or people stepping on parking spaces. Utilising Convolutional Neural Networks (CNN) with Caffe and the Nvidia DiGITS framework, incorrect classifications caused by noise have been rectified by enhancing the dataset. Gradient descent on CNN. Gradient descent on CNN.

Deep convolutional neural networks are the basis of the parking-stall vacancy indicator system. 2016 Eleni Stroulia, Martin Jagersand, Mennatullah Siam, Sepehr Valipour By using a camera to monitor many stalls, [11] approach this research's vision-based detection method reduces the system's cost per stall. The modern AUC was enhanced by 8.13% using the detection method. Additionally, it demonstrated dependable performance in a variety of test conditions, including tests using open-air cameras. Large parking lots at the Pontifical Catholic University of Parana and the Federal University of Parana are relatively expensive. CNN Internet of things, deep learning, smart parking, smart cities.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

On data that I acquired from the Daffodil International University garage, I employed models called Mask RCNN, Faster RCNN, Yolov7, and Yolov8 for my research.

3.2 DATA COLLECTION

In order to use the data for analysis, research, or other purposes, it must be collected in a relevant and representative manner. It is methodically compiling data or observations from numerous sources, such as surveys, experiments, sensors, or existing datasets, with the aim of acquiring accurate and thorough data for analysis and decision-making.

Data collection in computer vision and object detection often entails gathering and creating a dataset of picture or video frames containing the desired items. For instance, to collect data for the detection of parking slots, photos or videos of parking lots or street scenes with parked cars would need to be taken.

Here are some key steps involved in the data collection process:

1. Define the Objectives: The goals of the data collection activity should be made very clear. Make a list of the precise data or traits you'll need to gather to achieve your research or analytic objectives.
2. Plan the Data Collection Process: Create a data collection plan that specifies the procedures, approaches, and equipment to be employed. Take into account elements including the target population, sample size, length of data collection, and potential bias sources.

3. Identify Data Sources: The sources from which you will gather the data should be decided. This could involve conducting surveys, using cameras to take pictures or videos, using sensors, accessing pre-existing datasets, or using any other pertinent data-collecting methods.
4. Design Data Collection Instruments: Create the devices, tools, or surveys required to gather the appropriate data, if applicable. Creating survey forms, coming up with data-gathering procedures, or putting in place data-capturing technology could all be part of this.
5. Conduct Data Collection: Execute the data collection process and the data collection plan. This can be carrying out surveys, taking photos or videos, making observations, or using any other technique particular to your data-gathering goals.
6. Ensure Data Quality: Keep an eye on the quality of the data as it is being collected. Put procedures in place to reduce mistakes, preserve consistency, and guarantee the accuracy and authenticity of the data gathered.
7. Organise and Store the Data: After it has been gathered, structure the data organisation and storage to allow for quick analysis and retrieval. Making sure that data management procedures are correct and taking data security and privacy concerns into account, is crucial.

Data collection is a crucial step in conducting research, developing models, or performing analysis tasks. High-quality and representative data play a significant role in generating reliable insights, making informed decisions, and training effective models in various domains, including computer vision and object detection.

Most of the papers I read for my work dealt with PKlot data sets. So I wanted the data I would work with to be around me. So I collect the data from the parking garage of my studying university, and I record the data with the camera of my mobile phone. Because the quality of the CCTV footage data was not very good, for the convenience of the work and for the quality of the data, I recorded the video of the garage at different times and completed the data collection.

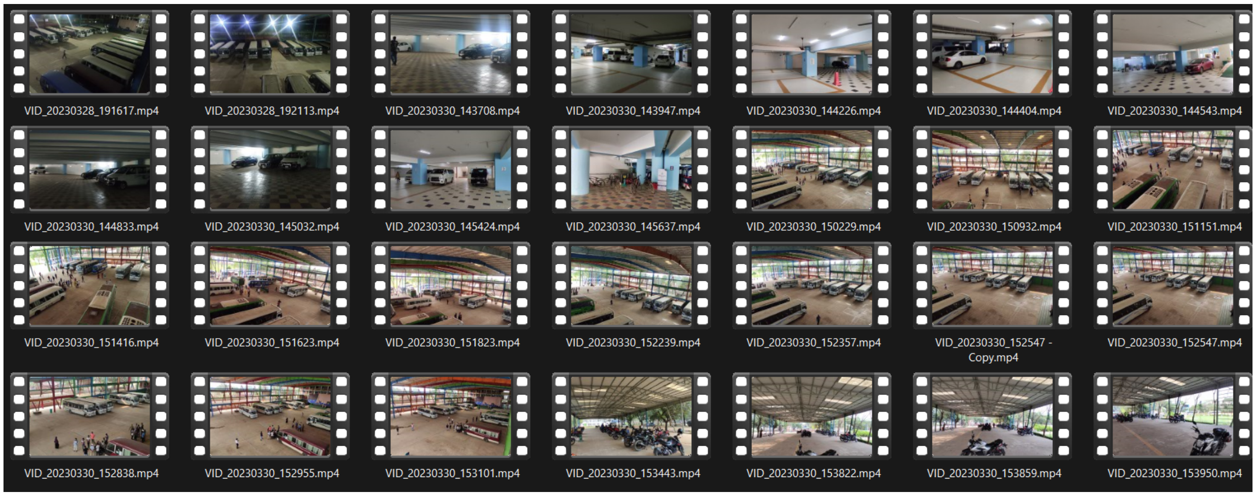


Figure 1: Garage video data

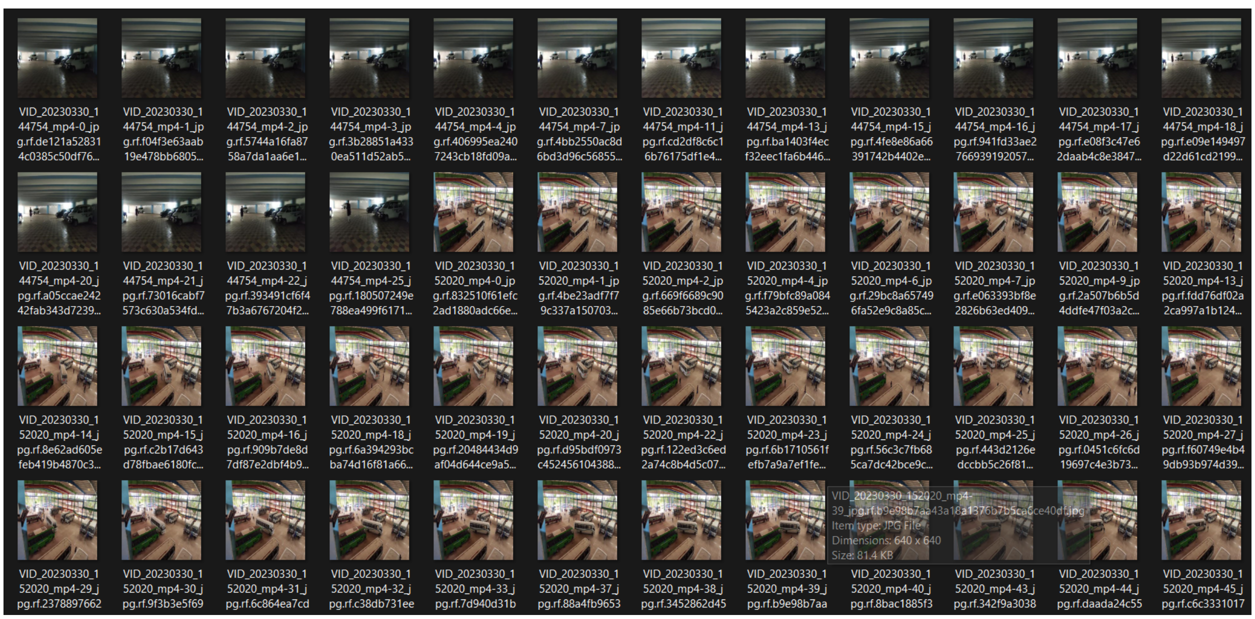


Figure 2: Garage picture data

3.3 DATA PREPROCESSING

Data preparation is an important stage in processes for data analysis and machine learning. It describes the process of preparing raw data for future analysis or modelling by cleaning, transforming, and normalising it. Data preparation aims to enhance data quality, eliminate errors, handle missing values, and get the data ready for efficient analysis or machine learning model training.

After data collection, we use the Roboflow web application for data cleaning, data transferring, featuring, reduction, integration and data sampling.

Here I describe all the steps of Roboflow data preprocessing:

- After logging into Roboflow I created a new project. My project type was object detection with a bounding box. After this, I added my collected data to the Adding Data section. Here, I have primarily worked with video data. Video Roboflow displays a dialog window where the frame rate can be selected after importing video data. I sample the video data in this case at a frame rate of 1 per second. The photos after being sampled from video will resemble those that I would have initially posted to Roboflow.

- Images obtained after sampling can be directly labelled with Roboflow. Here I have done multiclass classification. About 1075 images are obtained from my collected videos by sampling at a frame rate of 1 second. Smart polygon annotation on all images.

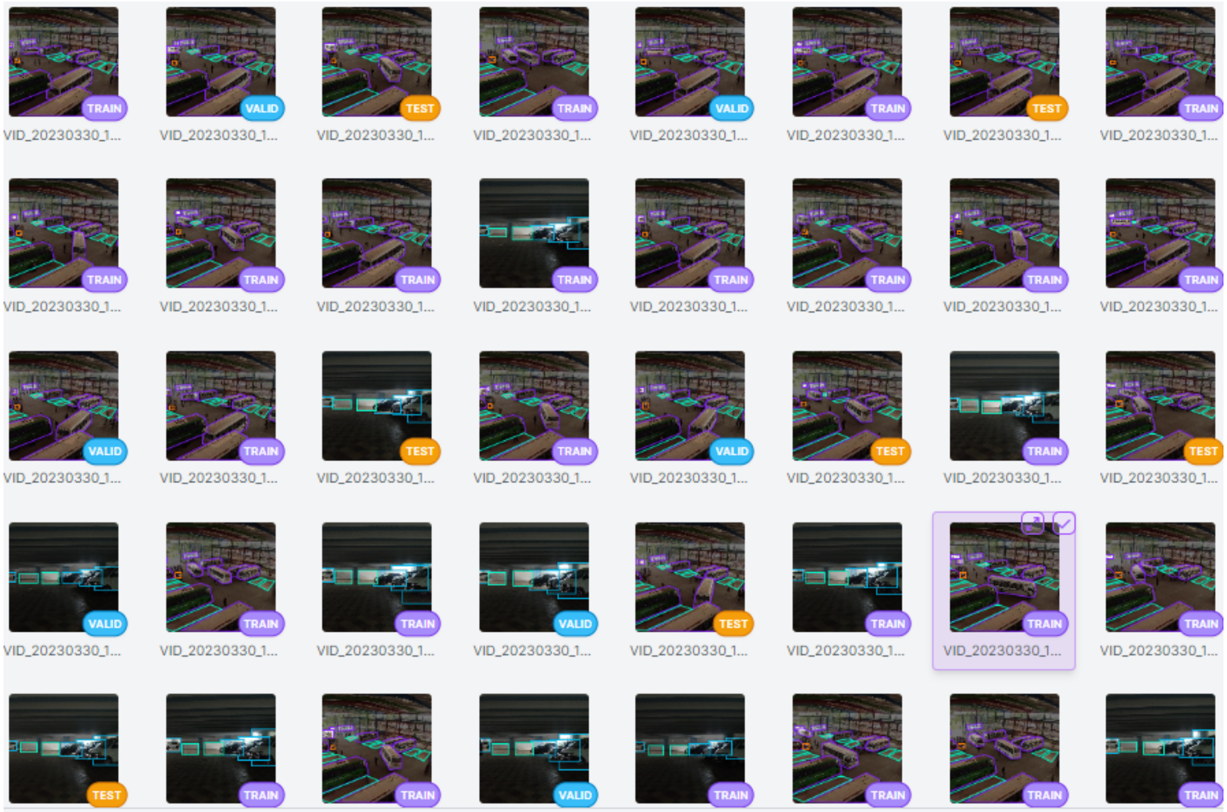


Figure 3: Annotated data

- Search for images using the train, valid, and test dataset split. Text-based queries may be used with search filters. Image tagging is now offered by Roboflow. Users now have the option to tag photographs when uploading, labelling them in batches, and using dataset searches. The addition of tags to my dataset gives search results more criteria to consider when narrowing the selection of photos in my dataset.
- All images go through preprocessing stages, which include resizing and grayscale conversion. Training, validation, and testing sets will all go through preprocessing stages.
- Image augmentation steps, such as randomly changing brightness or rotation, are image modifications made solely to expand dataset size for improved performance. Steps for image enhancement will only be used on training photos.

- Applying preprocessing to your training, validation, and testing sets will ensure that learning and inference takes place on the same picture characteristics. Roboflow Train is a product for AutoML that the company sells. It is the simplest method for training and deploying a cutting-edge object identification model on a unique dataset.
- The length of time it takes to train a dataset increases with its size and with the size of the outputted (produced) images. Training from a checkpoint means you are employing transfer learning. Transfer Learning will start training the model from my selected model. This can help reduce training time and provide improved training scores. Training from scratch means I am not employing transfer learning. This will start training your model with random initial values for the model weights.
- After training, my model is ready to be used for estimation and embedded in a custom application. My model will be prepared for integration into your application following training.

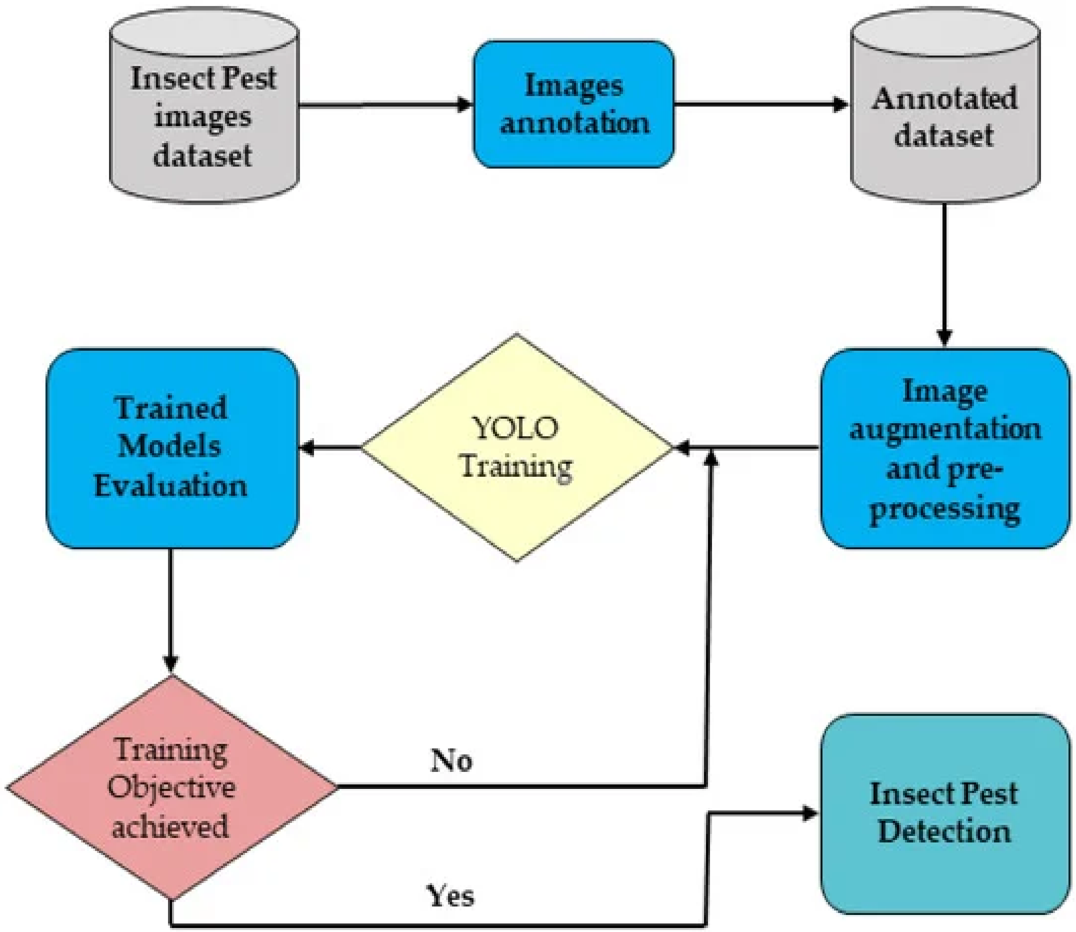


Figure 4: Data Processing Diagram

3.4 YOLO

A well-known object identification and picture segmentation model called YOLO (You Only Look Once) was created by Joseph Redmon and Ali Farhadi at the University of Washington. YOLO was introduced in 2015 and rapidly became well-known for its fast speed and precision. Here I used YOLOv8 for Detection, segmentation and classification.

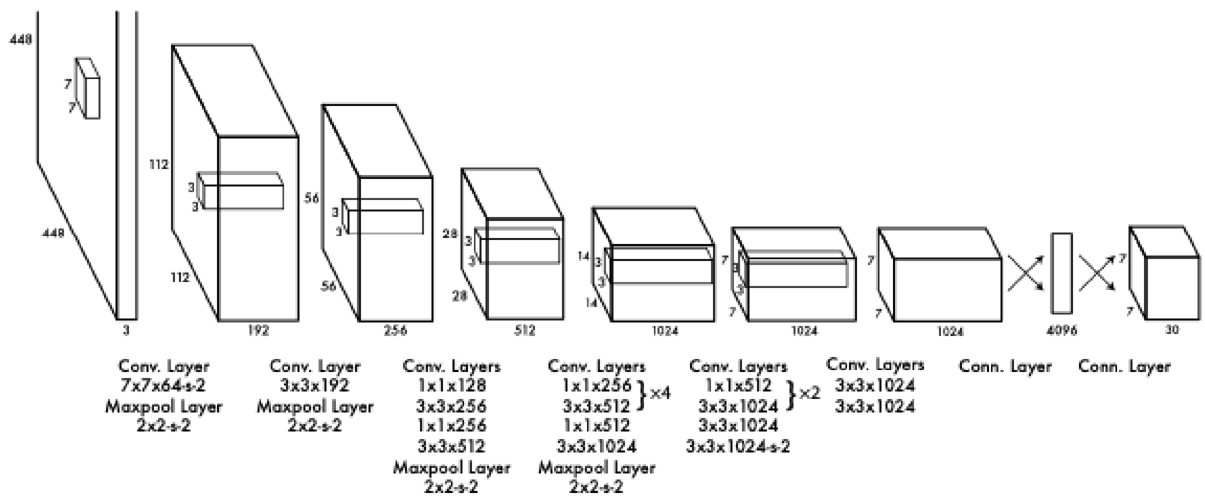


Figure 5: YOLO model architecture

The YOLO model's most current iteration, referred to as YOLOv8, is capable of carrying out tasks like object detection, image categorization, and instance segmentation. Ultralytics also produced the YOLOv8 model in addition to the substantial and industry-redefining YOLOv5 model. YOLOv8 contains various architectural upgrades and modifications over YOLOv5, which improve the developer experience. The YOLO series of models have become well-known in the computer vision community. YOLO has gained a lot of popularity due to its great accuracy and small model size. A number of developers can use YOLO models because they can be trained on a single GPU. Machine learning practitioners may quickly and inexpensively install it on edge hardware or in the cloud.

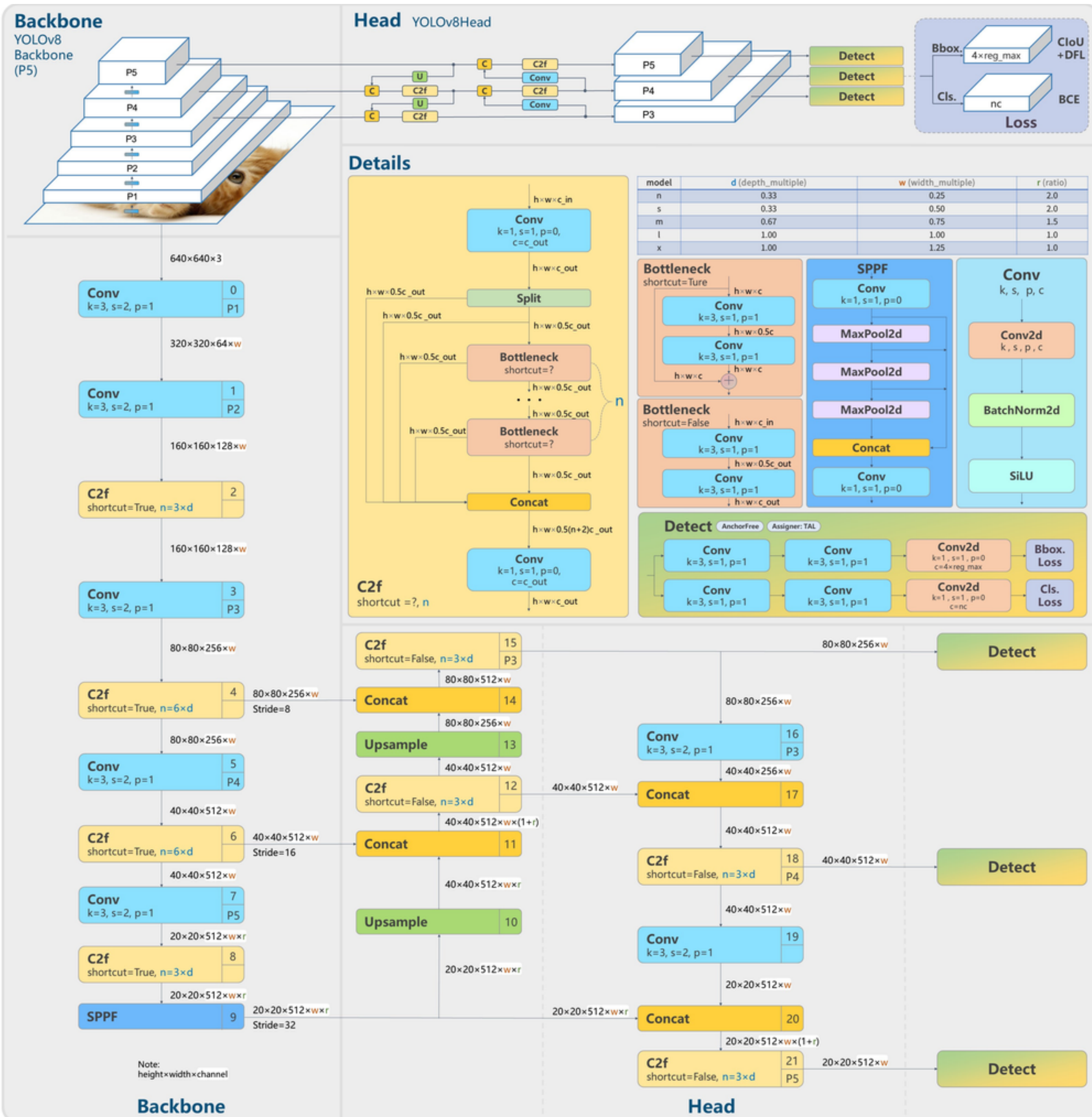


Figure 6: Yolov8 model deep architectures

The YOLOv8 object detection model predicts bounding boxes and class probabilities for items in an image using a single neural network. The input image is divided into a grid of cells by the model, which then forecasts the bounding boxes and class probabilities for each cell. By enabling the algorithm to forecast more precise bounding boxes for objects of various sizes, anchor boxes are used by YOLOv8 to increase the accuracy of object detection. .Through the use of anchor boxes, object detection models like YOLOv8 can more accurately anticipate bounding boxes for objects of various sizes, increasing the accuracy of object recognition. The location and size of items in a picture can be predicted using anchor boxes, which are pre-defined bounding boxes with various sizes and aspect ratios. For objects with various sizes and aspect ratios, YOLOv8 can anticipate more precise bounding boxes by employing anchor boxes.

3.5 Mask RCNN

Convolutional Neural Networks (CNNs) such as Mask R-CNN are cutting edge when it comes to segmenting images. This particular Deep Neural Network variation recognizes items in a picture and creates a superior segmentation mask for every one of them. Faster R-CNN was utilised to create Mask R-CNN. While Faster R-CNN produces a class label and a bounding-box offset for each candidate item, Mask R-CNN adds a third branch that produces the object mask. The additional mask output is different from the class and box outputs, necessitating the extraction of a considerably more precise spatial arrangement of an item. Faster R-CNN's expansion, Mask R-CNN, operates by simultaneously adding a branch for predicting an object mask (Region of Interest) and the branch already in place for bounding box detection. Pixel-to-pixel alignment, which is the main component lacking from Fast/Faster R-CNN, is the essential component of Mask R-CNN. The same two-stage method, with an RPN-based first stage, is used by Mask R-CNN. In the second stage, Mask R-CNN additionally generates a binary mask for each RoI in addition to forecasting the class and box offset. Contrary to most modern systems, which rely on mask predictions for classification. Given the Faster R-CNN framework's ability to support a variety of customizable architecture designs, Mask R-CNN is also easy to develop and train. A quick system and quick experimentation are also made possible by the mask branch, which only adds a minor amount of computational overhead.

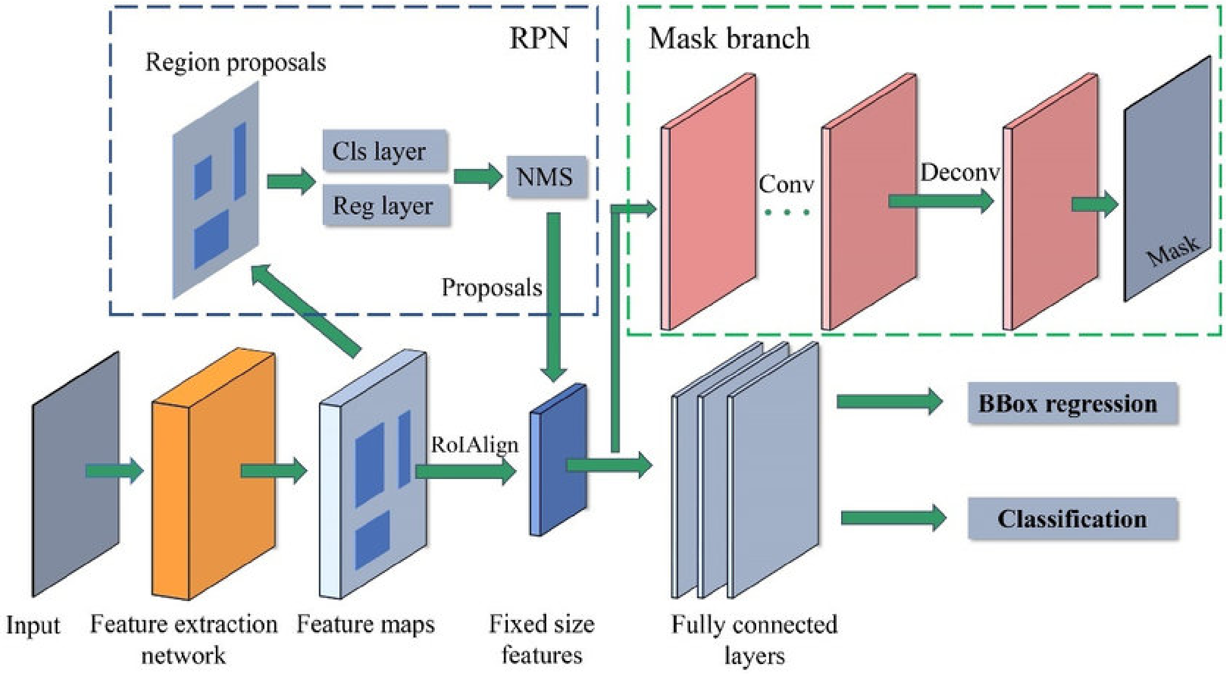


Figure 7: Mask R CNN

3.6 EVALUATION METHODS

The evaluation technique in the context of machine learning and computer vision refers to the procedure of evaluating the effectiveness and quality of a model or algorithm. It entails evaluating the model's performance on a specific job, such as object detection, image classification, or segmentation.

Evaluation methods typically involve the following steps:

- A dataset is split into two or more subsets. The validation set is used to adjust hyperparameters and keep track of the model's performance while the training set is used to train the model.
- During training or hyperparameter tuning, a distinct subset is known as the test set is held out and not used. The test set is utilised to gauge how well the trained model ultimately

performed. It functions as a neutral indicator of how well the model generalises to new inputs.

- The performance of the model is measured using a variety of measures. The particular task will determine which metrics are used. Metrics like mean Average Precision (mAP), Intersection over Union (IoU), precision, and recall are employed often in the field of object detection, for instance.
- Predictions from the training model are applied to the test set and contrasted with the ground truth annotations. Based on the ground truth and projections, performance metrics are calculated. These metrics reveal information about the model's precision, recall, and other pertinent properties.
- To evaluate relative performance, the model's performance measures are contrasted with those of other models or baselines. The results are analysed to determine the model's advantages and disadvantages, spot potential problem areas, and provide direction for future improvement.

To provide fair comparisons across various models or algorithms, a uniform evaluation technique must be established. As part of this, proper datasets must be used, data must be divided into training, validation, and test sets, and results must be reported using uniform performance measures.

3.6.1 CONFUSION MATRIX

The matrix form of the prediction summary is represented by a confusion matrix. It displays the percentage of right and wrong predictions made for each class. It aids in the comprehension of classes that are mistaken for other classes by models. For the binary classification task, Fig. 8 displays a sample confusion matrix.

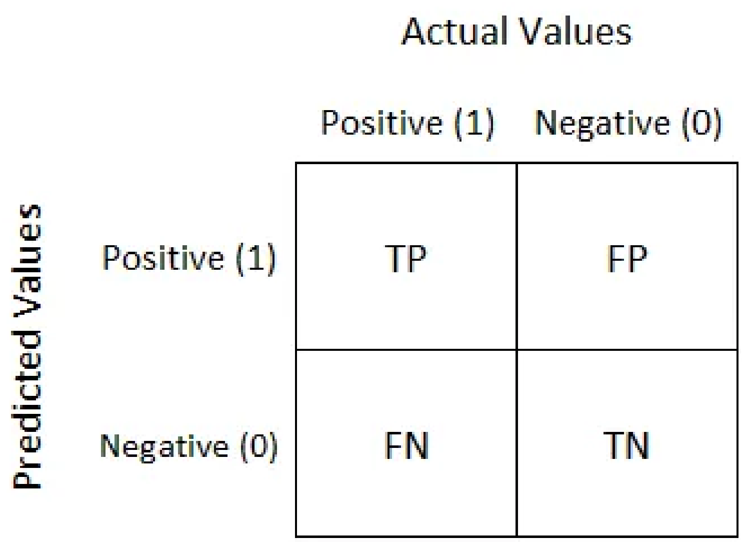


Figure 8: Confusion matrix representation

True Positive(TP): A result where the parameter optimization predicted the positive class is referred to as a “True Positive”.

True Negative(TN): True negative results are those for which the model accurately predicted the negative category.

False Positive(FP): An outcome when the analysis prior to the positive class inaccurately is known as a false positive.

False Negative(FN): False-negative results occur when the model predicts the negative category inaccurately.

3.6.2 ACCURACY

The quality of the model directly affects how well a machine predicts the outcomes. It will only be relevant when all of the courses are assigned the same weight. Each class has equal importance in the context of my work.

$$\text{Accuracy} = \frac{\textit{True positive value} + \textit{True Negative Value}}{\textit{True positive value} + \textit{True Negative value} + \textit{False positive value} + \textit{False Negative Value}} \quad \text{....(3.1)}$$

3.6.3 PRECISION

This expression is used in the field of machine learning to assess how effectively a model is performing its function. Divide the value that is actually positive by the value that is entirely positive to calculate the precision.

$$\text{Precision} = \frac{\textit{True Positive}}{\textit{True positive} + \textit{False Positive}} \quad \text{…………………...(3.2)}$$

3.6.4 RECALL

Recall is a measurement of the precise identified true positive. Divide the actual positive value by the total number of existing linked items to obtain an estimate of the recall.

$$\text{Recall} = \frac{\textit{True Positive}}{\textit{True Positive} + \textit{False Negative}} \quad \text{……………….(3.3)}$$

3.6.5 F1 SCORE

The F1 score measures test accuracy. To find the F1 value, recall and precision are both used.

$$\text{F1 Score} = 2 * \frac{Precision * Recall}{Precision + Recall} \quad \text{………………………………………..(3.4)}$$

The model and mAP for this methodology, the YOLOv8 method, have been demonstrated to be valid. Training consistency and efficiency are taken into consideration when calculating accuracy in the predictive performance mAP algorithm. In terms of training and testing productivity, the system costs are also taken into account.

3.6.6 MEAN AVERAGE PRECISION(MAP)

Mean Average Precision (mAP) is a popular metric for measuring how well object detection and segmentation systems perform. Measuring object detection models like Fast R-CNN, YOLO, Mask R-CNN, etc. using Mean Average Precision (mAP) is one method. Over recall levels between 0 and 1, the average accuracy (AP) values (mean) are computed.

$$\text{mAP} = \frac{1}{\text{n}} \sum_{k=1}^{k=n} AP_k \quad \text{……………………………………………………..(3.5)}$$

CHAPTER 4

RESULT AND DISCUSSION

4.1. INTRODUCTION

The performance outcomes of the constructed model under various testing scenarios are explained in this chapter. The model's performance was assessed in terms of detection speed, accuracy, and the effects of altering the edge detection approach on the model's ability to accurately detect cars and parking spaces.

4.2 RESULT

A final best accuracy of 0.968 or 96.8% was obtained after my collected data was processed through 25 epochs with Yolo version 8. I did 4 classes, and I used 336 pictures for object detection. Object identification and classification using the YOLO algorithm Below are the outcomes of testing a video and an image using the YOLO algorithm to categorise the cars, buses and bikes in the parking space.

Result with description:

```
Validating runs/detect/train/weights/best.pt...
Ultralytics YOLOv8.0.20 �� Python-3.10.12 torch-2.0.1+cu118 CUDA:0 (Tesla T4, 15102MiB)
Model summary (fused): 168 layers, 11127132 parameters, 0 gradients, 28.4 GFLOPs
       Class  Images  Instances  Box(P     R    mAP50    mAP50-95):100% 2/2[00:01<00:00, 1.21it/s]
         all     336        714     0.962  0.914  0.968       0.634
        bike     336         78     0.987  0.989  0.995       0.755
         bus     336        319     0.962  0.912  0.977       0.776
         car     336         24     0.922  0.958  0.936       0.499
       space     336        293     0.975  0.795  0.963       0.508
Speed: 0.3ms pre-process, 11.0ms inference, 0.0ms loss, 1.1ms post-process per image
Results saved to runs/detect/train
```

Figure 9: Result description

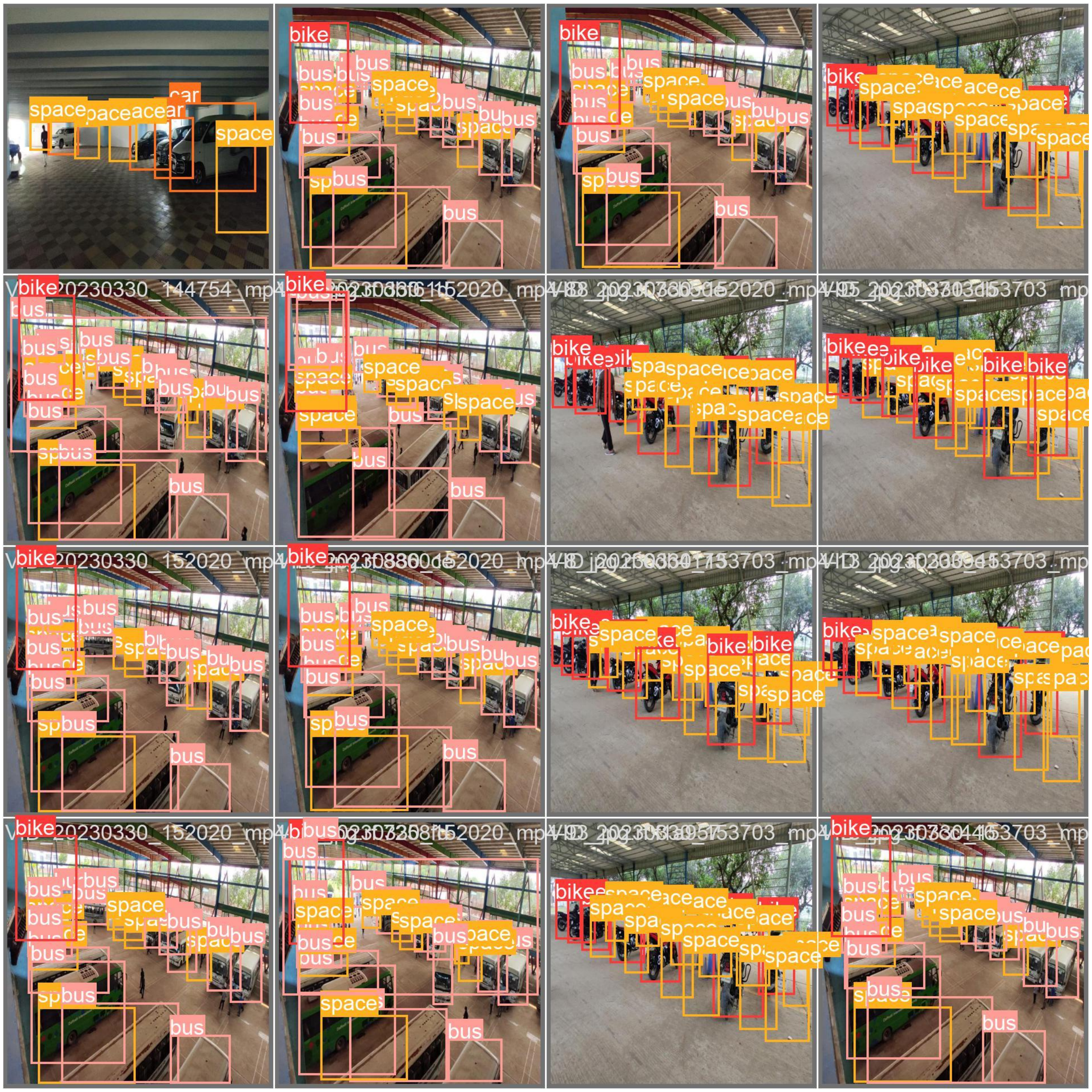


Figure 10: YoloV8 Object Detection Result 1

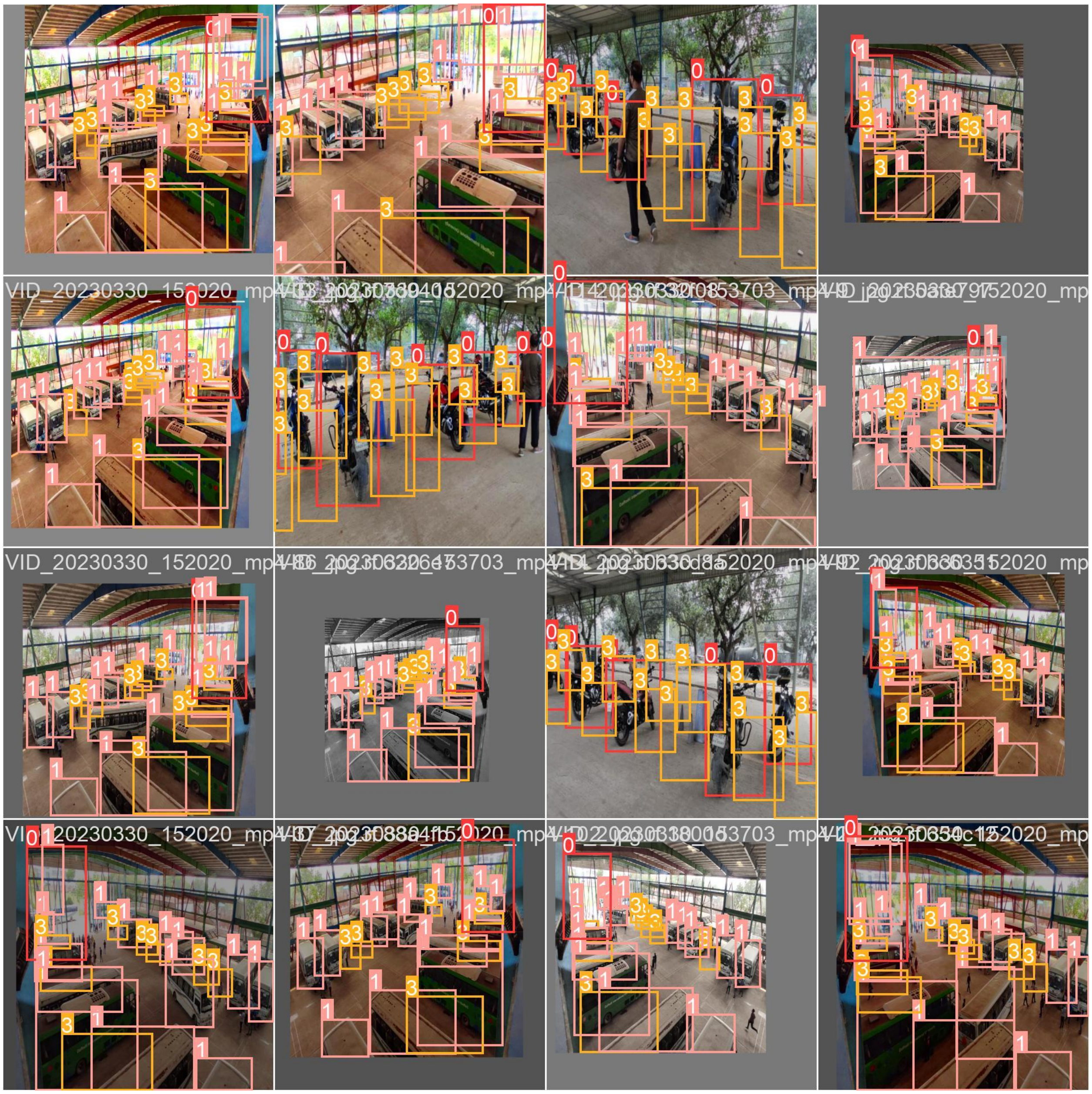


Figure 11:YoloV8 Object Detection Result 2

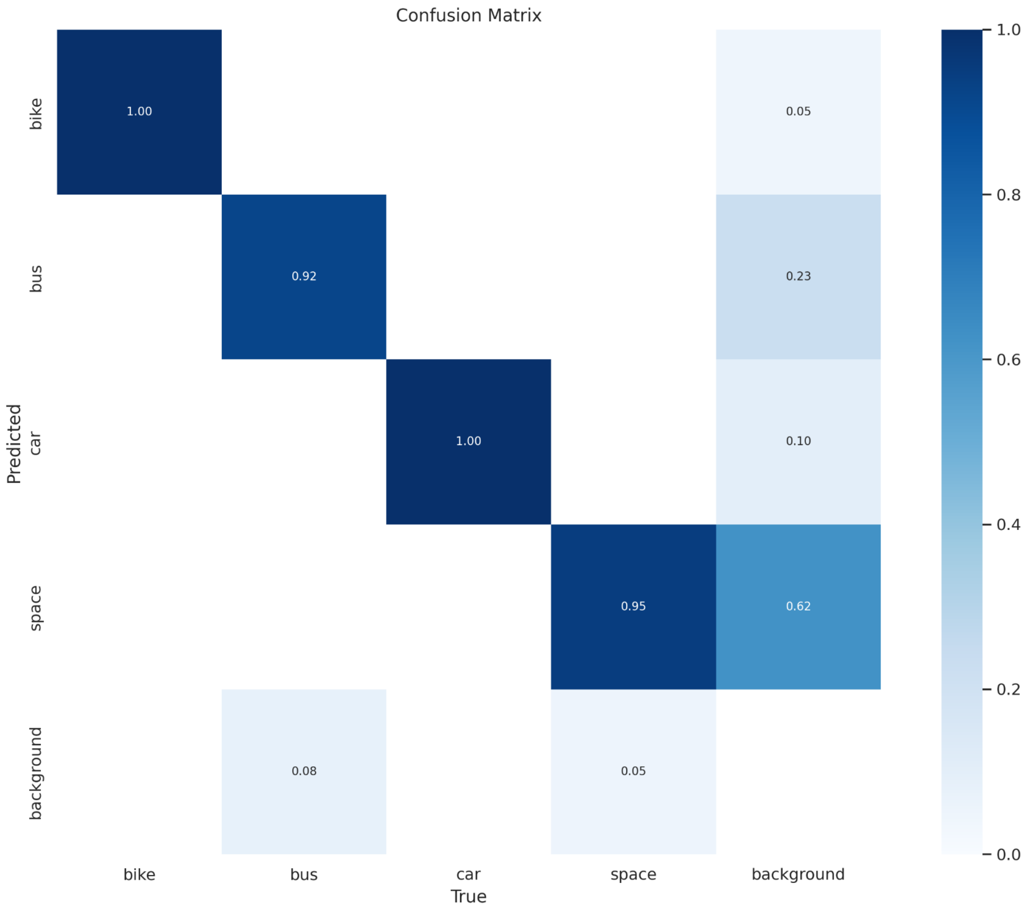


Figure 12: Confusion Matrix

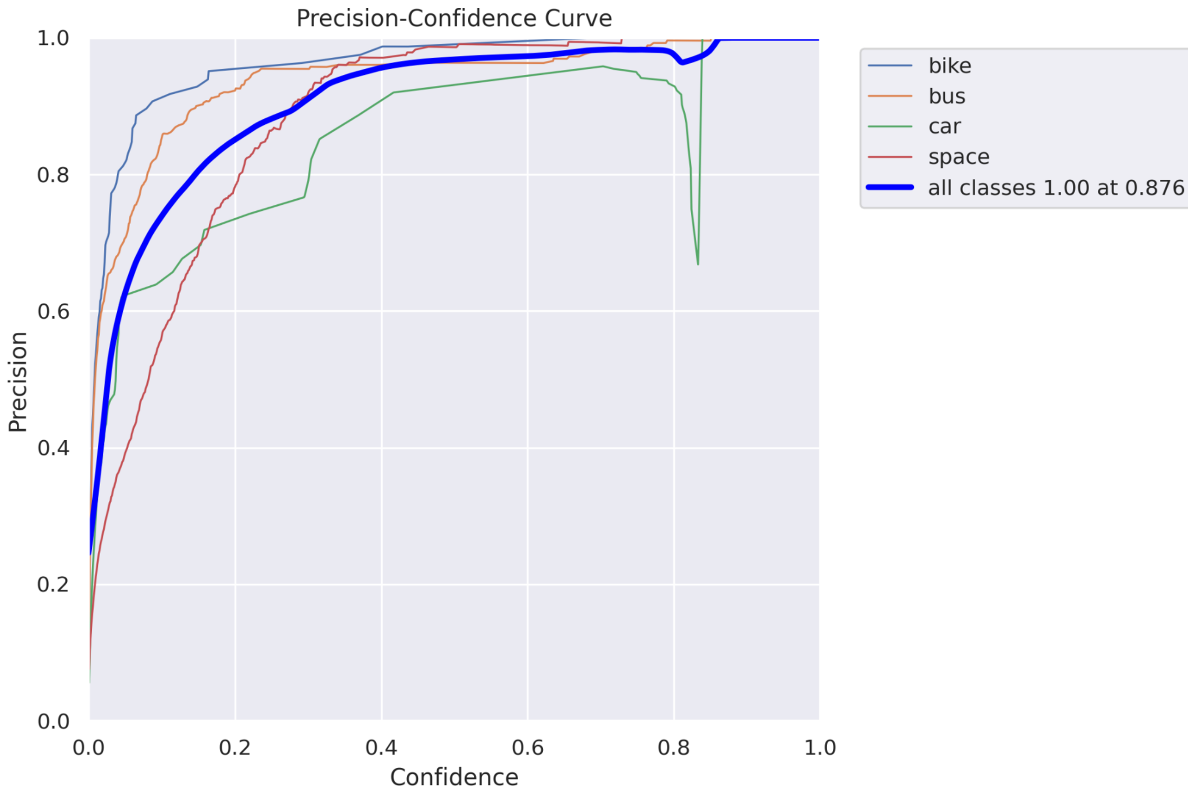


Figure 13: Precision Graph

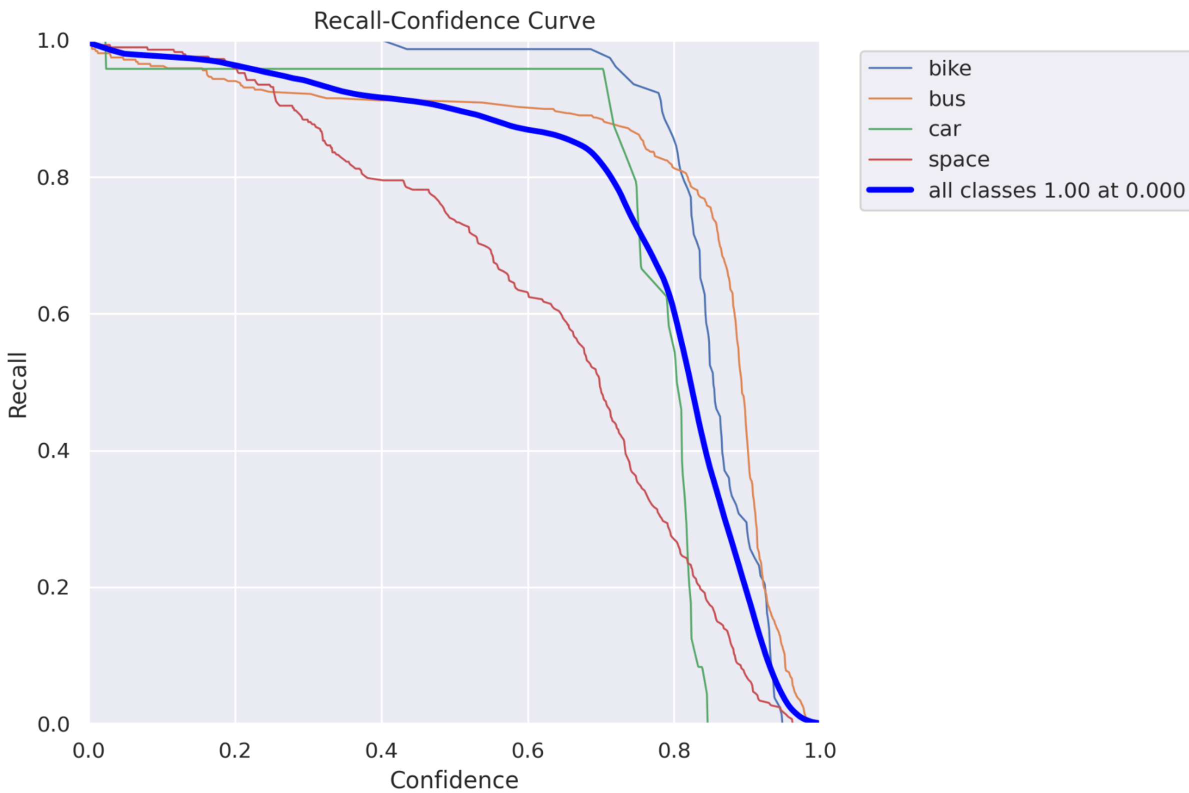


Figure 14: Recall Graph

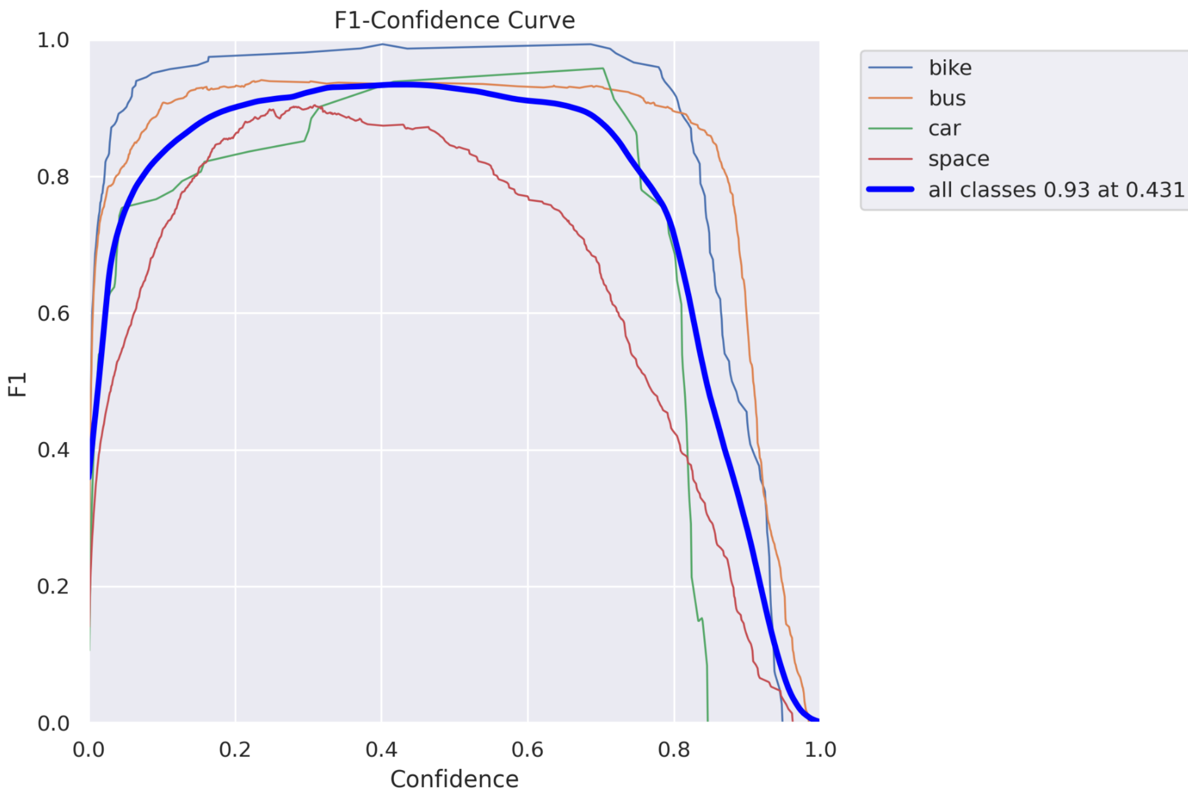


Figure 15: F1 Confidence Curve Graph

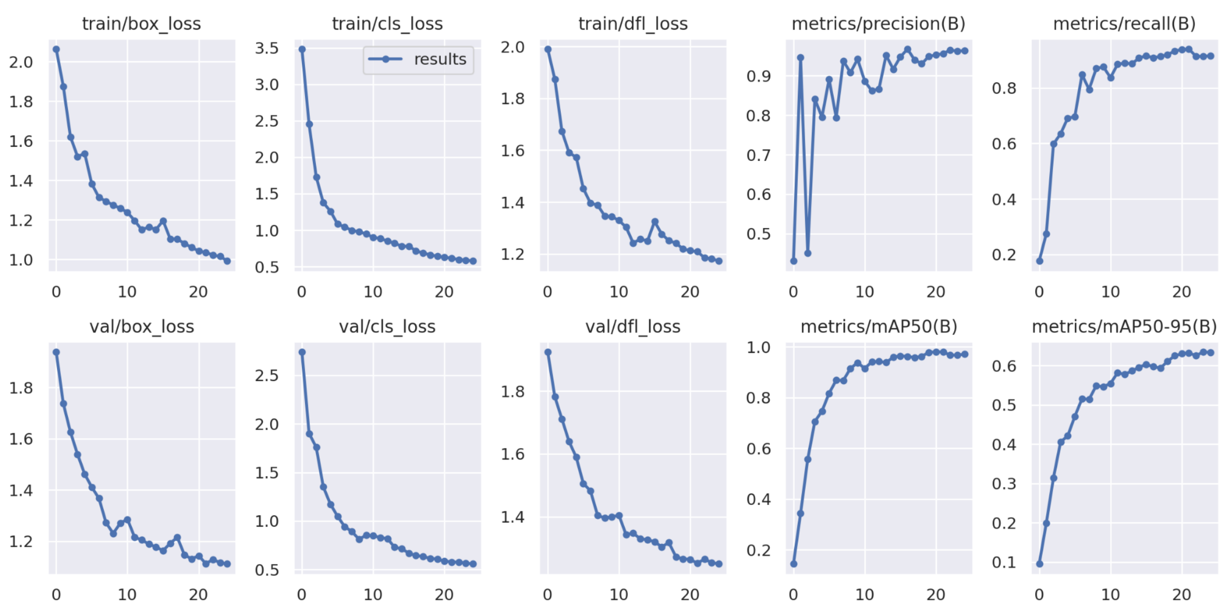


Figure 16: Total Results At A Glance

4.3 DISCUSSION

According to YOLOv8 documentation and their claims of greater object-detection accuracy, our specially trained 'YOLOv8 model' is displaying excellent outcomes in detecting different vehicles' movements. The categories are based on the different movements of the vehicles and the different conditions of the parking slots.YOLO was used for object detection on the prototype of our automated car parking system. Five video feeds displaying diverse parking places were used to assess the model's validity. The model was able to recognize cars and parking spaces in these video streams of vehicles entering and leaving the parking area. besides the status of the parking lots right now. There were two separate testing methods used: one in which the motion detection of cars entering the parking lot was turned on, and the other in which it was turned off.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

The main objectives of this study were to construct a model, assess the model's capability to predict parking spots with a high degree of accuracy and conduct an analysis of the methodologies currently used in the process of vehicle parking detection degree of accuracy. Our very own dataset, which is made up of standardised items, was used in the training process in order to train a YOLO model to recognize automotive objects in a parking lot. A simple piece of software was created throughout the course of this study to make it easier to register the coordinates of each parking space in the lot. Using this application, which was used to do so, the parking spaces in the lot were identified. Using a classifier, these coordinates were inputted, and the classifier was then used to determine whether or not there were any cars in the parking lot. The process started as soon as the image fed into the model from the video stream was done, with the first phase being object detection. After that, a checkup to assess the condition of the parking space was done. The parking slots whose status could not be established were subjected to a motion detection technique in order to improve the parking slot identification model's accuracy. This was carried out in an effort to improve the model's accuracy. This technique sought to evaluate the parking slot status after two seconds to see if anything had changed after detecting the motion of objects approaching the parking spaces. For parking spaces whose status was unknown, this motion detection method was employed. The model's performance was improved by using this technique. Because it made it simple to change the status of parking spaces. Daffodil International University was broadcast anytime a car entered or exited a parking space. This made it possible for the model to reflect the situation today more precisely.This technique can be used to locate parking spaces in real-world locations like shopping centres, cities, and airports, all of which see constant traffic of cars entering and exiting their respective parking lots. The situation right now.In reality, finding parking spaces necessitates driving around parking lots in search of openings. This adds to the traffic congestion that develops as a result of the more vehicles on the road and causes drivers to waste time. Drivers would have prior information on the condition of the parking zones if the created model were implemented in these areas, providing them with the capacity to choose whether to enter the parking lot or look for another parking space. Drivers would be aware of the state of the parking areas in advance, thus this would be achievable.

5.1. FINDINGS AND CONTRIBUTIONS

The acquisition of the data for this study is done with the utmost care. It was more difficult to gather real data for the entire project because it was taken from the university's parking garage. The study has some issues with their dataset, which is not ideal for our country, as I have observed and read in all the previous works I have seen and read. With the nearby data sets, work is done. In addition, the recent updates to Roboflow and the YOLO v8 model are employed for object recognition rather than the older works' usage of the most up-to-date tools or methodologies. The model's accuracy has consequently increased as a result. YOLO v8 accuracy was 96.8%.

5.2. RECOMMENDATIONS FOR FUTURE WORK

Here, different-sized car detection has been worked on; the number plates of those cars and their complete histories have not. This is anticipated to be carried out in the future. The footage is only being collected for a little period of time; eventually, it is decided to cover all the footage for the entire day.

CHAPTER 6

REFERENCES

1. Xu, C., & Hu, X. (2020, April). Real time detection algorithm of parking slot based on deep learning and fisheye image. In *Journal of Physics: Conference Series* (Vol. 1518, No. 1, p. 012037). IOP Publishing.

2. Jeong, S. H., Choi, C. G., Oh, J. N., Yoon, P. J., Kim, B. S., Kim, M., & Lee, K. H. (2010). Low cost design of parallel parking assist system based on an ultrasonic sensor. *International Journal of Automotive Technology*, *11*, 409-416.

3. Dubé, R., Hahn, M., Schütz, M., Dickmann, J., & Gingras, D. (2014, June). Detection of parked vehicles from a radar based occupancy grid. In *2014 IEEE Intelligent Vehicles Symposium Proceedings* (pp. 1415-1420). IEEE.

4. Shao, Y., Chen, P., & Cao, T. (2018, July). A grid projection method based on ultrasonic sensor for parking space detection. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 3378-3381). IEEE.
5. Wang, C., Zhang, H., Yang, M., Wang, X., Ye, L., & Guo, C. (2014). Automatic parking based on a bird's eye view vision system. *Advances in Mechanical Engineering*, *6*, 847406.

6. Suhr, J. K., & Jung, H. G. (2016). Automatic parking space detection and tracking for underground and indoor environments. *IEEE Transactions on Industrial Electronics*, *63*(9), 5687-5698.

7. Hamada, K., Hu, Z., Fan, M., & Chen, H. (2015, June). Surround view based parking lot detection and tracking. In *2015 IEEE Intelligent Vehicles Symposium (IV)* (pp. 1106-1111). IEEE.

8. Lee, S., & Seo, S. W. (2016). Available parking slot recognition based on slot context analysis. *IET Intelligent Transport Systems*, *10*(9), 594-604.

9. Li, L., Zhang, L., Li, X., Liu, X., Shen, Y., & Xiong, L. (2017, July). Vision-based parking-slot detection: A benchmark and a learning-based approach. In *2017 IEEE International Conference on Multimedia and Expo (ICME)* (pp. 649-654). IEEE.

10. Ding, X., & Yang, R. (2019, October). Vehicle and parking space detection based on improved yolo network model. In *Journal of physics: conference series* (Vol. 1325, No. 1, p. 012084). IOP Publishing.

11. Huang, J., Zhang, L., Shen, Y., Zhang, H., Zhao, S., & Yang, Y. (2019, July). DMPR-PS: A novel approach for parking-slot detection using directional marking-point regression. In *2019 IEEE International Conference on Multimedia and Expo (ICME)* (pp. 212-217). IEEE.

12. Zhang, L., Huang, J., Li, X., & Xiong, L. (2018). Vision-based parking-slot detection: A DCNN-based approach and a large-scale benchmark dataset. *IEEE Transactions on Image Processing*, *27*(11), 5350-5364.

13. Farhadi, A., & Redmon, J. (2018, June). Yolov3: An incremental improvement. In *Computer vision and pattern recognition* (Vol. 1804, pp. 1-6). Berlin/Heidelberg, Germany: Springer.

14. D. Trivedi, J., Mandalapu, S. D., & Dave, D. H. (2020). Real-time parking slot availability for Bhavnagar, using statistical block matching approach. *World Journal of Engineering*, *17*(6),

811-821.

15. Valipour, S., Siam, M., Stroulia, E., & Jagersand, M. (2016, December). Parking-stall vacancy indicator system, based on deep convolutional neural networks. In *2016 IEEE 3rd World Forum on Internet of Things (WF-IoT)* (pp. 655-660). IEEE.

16. Paidi, V., Fleyeh, H., & Nyberg, R. G. (2020). Deep learning‐based vehicle occupancy detection in an open parking lot using thermal camera. *IET Intelligent Transport Systems*, *14*(10), 1295-1302.

17. Mahmud, R., Saif, A. S., & Gomes, D. (2020). A Comprehensive Study of Real-Time Vacant Parking Space Detection Towards the need of a Robust Model. *AIUB Journal of Science and Engineering (AJSE)*, *19*(3), 99-106.

18. Amato, G., Carrara, F., Falchi, F., Gennaro, C., Meghini, C., & Vairo, C. (2017). Deep learning for decentralized parking lot occupancy detection. *Expert Systems with Applications*, *72*, 327-334.

19. Acharya, D., Yan, W., & Khoshelham, K. (2018). Real-time image-based parking occupancy detection using deep learning. *Research@ Locate*, *4*, 33-40.

20. Šćekić, Z., Čakić, S., Popović, T., & Jakovljević, A. (2022, February). Image-based parking occupancy detection using deep learning and faster r-cnn. In *2022 26th international conference on information technology (IT)* (pp. 1-5). IEEE.

21. Nyambal, J., & Klein, R. (2017, November). Automated parking space detection using convolutional neural networks. In *2017 Pattern Recognition Association of South Africa and Robotics and Mechatronics (PRASA-RobMech)* (pp. 1-6). IEEE.

22. Jiang, S., Jiang, H., Ma, S., & Jiang, Z. (2020). Detection of parking slots based on mask R-CNN.

Applied Sciences, *10*(12), 4295.

23. Ibisch, A., Stümper, S., Altinger, H., Neuhausen, M., Tschentscher, M., Schlipsing, M., ... & Knoll, A. (2013, June). Towards autonomous driving in a parking garage: Vehicle localization and tracking using environment-embedded lidar sensors. In *2013 IEEE intelligent vehicles symposium (IV)* (pp. 829-834). IEEE.

24. .Tong, L., Cheng, L., Li, M., Wang, J., & Du, P. (2013). Integration of LiDAR data and orthophoto for automatic extraction of parking lot structure. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *7*(2), 503-514.

25. . Yu, L., Jiang, H., & Hua, L. (2019). Anti-congestion route planning scheme based on Dijkstra algorithm for automatic valet parking system. *Applied Sciences*, *9*(23), 5016.

26. Jeong, S. H., Choi, C. G., Oh, J. N., Yoon, P. J., Kim, B. S., Kim, M., & Lee, K. H. (2010). Low cost design of parallel parking assist system based on an ultrasonic sensor. *International Journal of Automotive Technology*, *11*, 409-416.

27. Jiang, S., Jiang, H., Ma, S., & Jiang, Z. (2020). Detection of parking slots based on mask R-CNN. *Applied Sciences*, *10*(12), 4295.

28. Jiang, S., Jiang, H., Ma, S., & Jiang, Z. (2020). Detection of parking slots based on mask R-CNN. *Applied Sciences*, *10*(12), 4295.

29. Sun, B., Zhu, J., Yang, L., Yang, S., & Niu, Z. (2016). Calibration of line-scan cameras for precision measurement. *Applied optics*, *55*(25), 6836-6843.

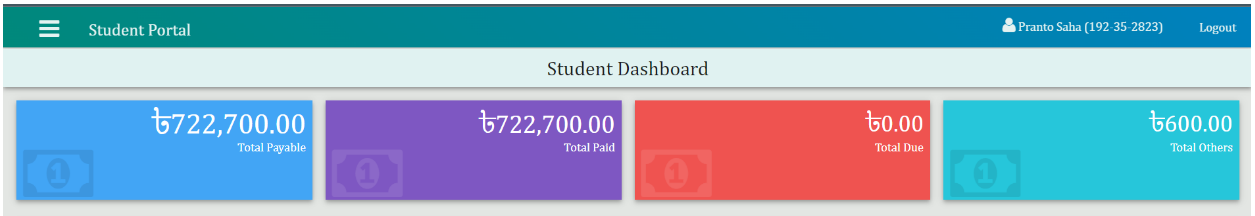
30. Li, Z., Gong, W., Nee, A. Y. C., & Ong, S. K. (2009). Region-restricted rapid keypoint registration. *Optics Express*, *17*(24), 22096-22101.

31. Schou, J., Scherrer, P. H., Bush, R. I., Wachter, R., Couvidat, S., Rabello-Soares, M. C., ... & Tomczyk, S. (2012). Design and ground calibration of the Helioseismic and Magnetic Imager (HMI) instrument on the Solar Dynamics Observatory (SDO). *Solar Physics*, *275*, 229-259.

32. Brook, A., & Ben-Dor, E. (2011). Automatic registration of airborne and spaceborne images by topology map matching with SURF processor algorithm. *Remote Sensing*, *3*(1), 65-82.

33. Sedaghat, A., & Ebadi, H. (2015). Remote sensing image matching based on adaptive binning SIFT descriptor. *IEEE transactions on geoscience and remote sensing*, *53*(10), 5283-5293.

ACCOUNTS CLEARANCE



LIBRARY CLEARANCE

PLAGIARISM REPORT

7/24/23, 5:17 PM Turnitin - Originality Report - 192-35-2823

Turnitin Originality Report

Processed on: 24-Jul-2023 17:17 +06
ID: 2136041433
Word Count: 7978
Submitted: 1

192-35-2823 By Pranto Saha

Similarity Index	Similarity by Source	
27%	Internet Sources:	22%
	Publications:	11%
	Student Papers:	14%

2% match (Internet from 29-Jun-2023)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/9625/22178.pdf?isAllowed=y&sequence=1

2% match (Internet from 23-Jul-2023)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/9589/22117.pdf?isAllowed=y&sequence=1

2% match (student papers from 31-Mar-2018)
Class: Article 2018
Assignment: Journal Article
Paper ID: 939036910

1% match (Internet from 22-Jul-2023)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/9286/21614.pdf?isAllowed=y&sequence=1

1% match (Internet from 22-Feb-2023)
https://www.researchgate.net/publication/346894718_Context-Based_Parking_Slot_Detection_With_a_Realistic_Dataset

1% match (Internet from 19-Feb-2023)
https://www.researchgate.net/publication/344649190_Real-time_parking_slot_availability_for_Bhavnagar_using_statistical_block_matching_approach

1% match (Internet from 19-Feb-2023)
https://www.researchgate.net/publication/346588094_A_Systematic_Review_of_Machine-vision-based_Smart_Parking_Systems

1% match (student papers from 21-Oct-2022)
Submitted to Liverpool John Moores University on 2022-10-21

1% match (Internet from 06-Jan-2022)
https://arxiv.org/pdf/2201.00095.pdf

1% match (Internet from 23-Feb-2023)
http://erepository.uonbi.ac.ke/bitstream/handle/11295/155870/Samuel%20Ndiva%20Murani%20%20Project.pdf?isAllowed=y&sequence=1

1% match (Janak D. Trivedi, Sarada Devi Mandalapu, Dhara H. Dave. "Real-time parking slot availability for Bhavnagar, using statistical block matching approach", World Journal of Engineering, 2020)
Janak D. Trivedi, Sarada Devi Mandalapu, Dhara H. Dave. "Real-time parking slot availability for Bhavnagar, using statistical block matching approach", World Journal of Engineering, 2020

1% match (student papers from 05-Oct-2022)
Submitted to Cranfield University on 2022-10-05

1% match (Internet from 04-Dec-2022)
https://link.springer.com/article/10.1007/s11277-022-09705-y?code=669abf90-37b7-4d95-99a7-aab2f89827fd&error=cookies_not_supported

1% match (Internet from 09-Apr-2021)
http://ajse.aiub.edu/index.php/ajse/article/download/80/75/

1% match (student papers from 08-Mar-2022)
Submitted to Universiti Teknologi Petronas on 2022-03-08

1% match (student papers from 20-Jul-2023)
Submitted to Sunway Education Group on 2023-07-20

< 1% match (Internet from 29-Jun-2023)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/9280/21604.pdf?isAllowed=y&sequence=1

< 1% match (Internet from 21-Nov-2022)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/7544/173-35-2248%20%2823%25%29clearance.pdf?isAllowed=y&sequence=1

< 1% match (Internet from 23-Jul-2023)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/9651/22232.pdf?isAllowed=y&sequence=1

< 1% match (Internet from 29-Jun-2023)
http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/123456789/9628/22182.pdf?isAllowed=y&sequence=1

https://www.turnitin.com/newreport_printview.asp?eq=1&eb=1&esm=10&oid=2136041433&sid=0&n=0&m=2&svr=21&r=58.26333453941097&lang=en... 1/8