VEHICLE PARKING VIOLATION DETECTION AND LANE VIOLATION DETECTION SYSTEM

Project Id: 2021-238

Project Final Report

Malith Manjalitha Charuka Ranasinghe (IT18097634)

B.Sc. (Hons) Degree in Information Technology

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Declaration

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Student IT number	Name	Signature
IT18097634	Ranasinghe M.M.C	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

……………………

Signature of the supervisor

(Ms. Chamari Silva)

………………………

Date

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ABSTRACT

Automatic identification of vehicles for video surveillance has been an area of important research in the past few years. We are proposing a system to identify and track violations of illegal vehicle parking and lane change violations. As being among the monitoring tasks for violations and traffic laws helps to avoid vehicle accidents. CCTV cameras are being used to take videos as a monitor to identify the traffic rules violated vehicles.

Traffic rules violation detection system based on video processing. Intelligent vehicle identification and lane change traffic rules violations has become extremely significant in the area of expressway. Lane change traffic rules violation is driving on the second lane, not vehicle overtake. Also detects illegal crossings of road lines. Lane change violations are a major cause of traffic conflicts and accidents in expressway. When drivers try to pass vehicles, many accidents happen.

The safety of other vehicles is directly challenged by illegally parked vehicles in the expressway. As a result, the number of vehicle accidents has been increasing annually. Illegal parking in expressway is also becoming increasingly, especially for commercial trucks. However, no approach to reducing or eliminating injuries caused by vehicles illegally parking on an expressway has been reported. The outcome of this research offers solutions to improve the protection in expressway, gathering data on the state of illegal parking and resolving critical issues.

The purpose of this research implementing a solution that satisfies a software application that views the information collected by the CCTV used to detect violations, expressway management will be able to monitor the behaviors that would outcome in the detection of traffic rules violated vehicles. Finally, the primary aim of this research is to implement a system that can detect traffic rules violated vehicles.

Keywords: Object detection, Video processing, Road Lane violations, Parking violations,Video Processing

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1. INTRODUCTION

1.1. Overview

This research represents a method for traffic rules violated vehicle process of automatic analysis, classification, and reporting of vehicle data to expressway management. The introduction chapter gives an outline for the automated vehicle detection method for the identify of vehicle parking violation vehicles and Lane violation vehicles using deep learning techniques. This is a decision support approach; it is never replacing traffic polices' valuable work. Firstly, the author discusses in detail the background of the problem. In addition to the research challenge, the significance of this project is discussed. Previously discovered research findings are discussed. The goals that must be met in order for the project to be completed are established. Furthermore, the project scope was identified as in and out of scope, which specifies the project's scope. Finally, the hardware, software, and data resource requirements will be discussed.

1.2. Background

The violation detection system is one of the most complicated processes within the Surveillance camera. With the ongoing increasing vehicle population, traffic accidents and on-road loss of lives have been a major concern in Sri Lanka over the last ten years. According to the latest WHO data published in 2018, road traffic accidents killed 3,590 people in Sri Lanka, accounting for 2.82 percent of all deaths. As an outcome, there is a growing market from both traffic and safety authorities and the general public to use cutting-edge technologies to facilitate increased safety, effective traffic control and monitoring, on-road guidance, and so on. Over the last ten years, the research in this field has paid close attention to automated vehicle identification, tracking, traffic surveillance, behavioral pattern recognition, and outlier detection [2]. This paper will concentrate on existing camera and deep learning techniques, as well as video processing for automated rule violation analysis, monitoring and vehicle tracking, lane detection, and urgent event detection etc.

1.3. Problem Definition

To improve parking violation detection, need a metric to monitor it. This is usually accomplished by manually recording procedures conducted in the traffic department from expressway. This documentation may be the only evidence of a complete process of expressway traffic rules violation detection. This is a crucial piece of information. Despite the introduction of various specifications.

Deep learning approaches have become increasingly popular in recent years, with excellent results in a variety of fields, including object detection. Automatic vehicle identification may be very useful in reducing traffic police work. Furthermore, automated identification of rules violated vehicle detection system finds, such as lane detection and overtake vehicle detection may be very useful inaccuracy documentation, as these observations include valuable detail to include in every traffic management study. Intending to achieve reliable and high-quality detection results expressway, the Road Safety - WHO advises using minimal standard language (MST) and minimal standard documentation (MSR). However, following these guidelines takes time, and views differ from one identify vehicle to the next, resulting in discrepancies in detection results all over the expressway.

Artificial intelligence (AI)-based approaches, such as neural network models, will automatically vehicle detection and tracking variations in vehicles' differing identification. But all are the vehicle capture images and number plate numbers. Its can understand to all of users. Although these methods have been shown to work effectively in the expressway management domain, sometimes outperforming conventional methods, there is one feature of deep learning that makes it possible to apply in real-world contexts. Since the internal mechanisms that contribute to a given outcome are easy to understand and perceive, neural networks are often referred to as "CNN." Because of this main object detection, there is confidence around these schemes, and detection models also favor the old practices. However, as the success of AI-based networks improves, they have a greater capacity to assist users in the expressway management process. To open this detection system, new interpretability approaches will help to create trust in the system. In addition, several recent studies are not used for overtaking vehicle detection applications based on AI-based vehicle tracking systems. Because of the problems of confidence and consistency. So, in the field of traffic rules violation detection research, a more precise analyzing method with an understandable report was still needed.

1.4. Problem Statement

There are several solutions for the automatic identification of traffic rules violated vehicles in expressway. All the research are not returning their final output to understandable for non-technical users. However, the complete analyzing system of CCTV testing with the automated detection, visualization the identified area and understandable reporting solutions which use AI in the final output are met with trustworthy and accurate traffic police expertise.

1.5. Research Motivation

In detecting in parking violations and lane rules violations, deep learning can play a critical role and thus help expressway management personnel. However, management must consider AI principles in order to address the lack of trust in the method. With deep learning neural networks' performance and complexity gradually improving, we can see that they have a lot of potential in assisting expressway management in detecting serious rules violated vehicles. The lack of understanding and confidence, on the other hand, is worrying. The use of modern interpretability methods to open this "black box" would not only help to create trust and understanding among traffic management experts but could also be used to generate high-quality vehicles capture videos. Consequently, the interpretability methods will help to build trust and deliver quality vehicles capture videos. The above open questions motivated the author to research in the field of vehicle detection with deep learning techniques to recognize abnormalities.

1.6. Existing Work

Features	Research [1]	Research [2]	Research [3]	Research [4]	Proposed System
Parking Violation Detection	✓	✓	X	✓	✓
Fast Moving vehicle detection	X	✓	✓	X	✓
Lane violation Detection	X	X	X	X	✓

Better Accuracy existing system	✓	✓	X	X	✓
Display Violated vehicle	✓	X	X	X	✓
Violated Vehicle Counting & Display	X	X	X	X	✓

1.7. Research Gap

After a deep research study, the author identified the main areas that have been overlooked.

1) Proposed system approach for parking violation detection lane violation detection.

After deep review, the author found in this domain hasn't introduced custom CNN model architecture or background subtraction approaches for vehicle detection. Lots of transfer learning approaches are there. So, author focused on this gap to introduce novel fast vehicle detection approach for vehicle parking violation detection and lane violation detection. System used ssd_mobilenet_v2_coco model, is a Single-Shot multibox Detection (SSD) network intended to perform vehicle detection.

2) Does not have accurate complete solution for violated vehicle detection system.

Most of the previous research are focused on only for vehicle detection. It means they were focused only for get good accuracy for identify vehicle. This research based on traffic rules violated vehicle detection for expressway management domain. So, in this domain users haven't technology of automated system of violation detection. They refused current all solutions due to it's not understandable for non-technical persons and carrying on their own manual testing process. So, in deep research, the author identified expressway management domain users don't know about AI in the real-time scenario, they don't know the procedure to produce the results. That's why still, those approaches are therefore not successful in the automated perspective. The author focused on this primary gap to resolve this issue focus on the use of explicable AI techniques and create complete solution for get understandable. For understandable purpose, the author implemented explainable deep learning techniques for visualization.

1.8. Contribution to Research

The research's main contribution is the development of a novel method that allows expressway management experts to gain a deeper identify of automated violation vehicle detection system. This included more accurate models for the two most common vehicle detection, as well as output video save using various visualization techniques. This is an innovative open-source system that is publicly available for future traffic rules violated vehicle detection research.

1.9. Research Challenge

A balanced dataset is the key challenge. To achieve a high level of classification accuracy and generalizability, deep neural networks usually need to train on large amounts of data. When it comes to vehicle detection applications, this is one of the most important roadblocks. Furthermore, the data must be annotated by a qualified expert in each area, especially a label vehicle using label-Img-master tool and draw bounding boxes in the case of expressway CCTV data. This is mostly because specialists in the field have not been ready to carry out the traffic management task of recording thousands of CCTV videos automatically. However, when managing some kind of CCTV data there is still a challenge with fundamental ethical and privacy issues.

Also, Detecting and clarifying the traffic rules violated vehicles in automatically is very challenging due the following reasons: complex background, poor quality due light limitations, poor focus, low resolution, shadows caused by rainy days and fast-moving vehicles. Background color variations in evening time. Also, the research generation part is the major challenge in this research. Because the final output video must be understandable and need to show more accurate decisions and explaining how the result came and why it’s interesting. Also, it will be understandable for non-technical people.

1.10. Questions for Research

- ❖ What's the most recent advances in software development that can be used to improve the accuracy of violation detection, and more readable output violation detection video generation in CCTV video testing?

- ❖ RQ2: How to gain the expert trust and improve the quality of final decision using the automated process of detecting rules violated vehicles and generating understandable output video?
- ❖ RQ3: Can knowledge of previous models built for more accurate traffic rules violation detection system utilized to speed up and automate explainable final output video generation?

1.11. Aim of this Research

The study's goal is to create, test, and review accurate model of CCTV video analyzing systems that will generate a traffic rules violated vehicles include video which can be easily understandable by non-technical users. This detection is proposed based on deep learning approach. Initially, the author aimed to give this valuable system to traffic police in expressway, expressway management and need all users. But after questionnaire findings and advice of vehicle detection experts, this system restricted to only expressway management.

1.12. Research Objectives

The following objectives were set during the Project and Research stages, depending on the study objective and research questions.

Objective	Description	Learning Outcomes
Literature Survey	● Review the current traffic rules violation detection research and different machine learning models with techniques. ● Review the current best working and existing algorithms. ● Identifying databases of CCTV video datasets from reputable detection institutions and analyzing the composition of the CCTV dataset. ● Research for different technologies to support	● L04 ● L05 ● L07 ● L08

	automated development systems.	
Requirement Analysis	● Consult the expressway management head for advice on the real-life practicality of automated rules violated vehicle detection systems with understandable video generation. ● Learn insight into the functionality that a current automated system should provide in order to meet the needs of expressway traffic police .	● L02
Development	● Develop prototypes, including data entry component, ML-model, classification of an ML algorithm, and generate an understandable visualization video	● L01 ● L03 ● L06
Testing	● Prototypes should be tested on a unit and a functional. ● Accuracy evaluation of both functional and non-functional criteria.	● L08 ● L09

1.13. Scope of the Research

Determined on the basis research and its goals, the scope of this thesis is researching and developing more accurate abnormality finder based on traditional identify rules violated vehicles testing with a focus on deep neural network understanding and transparency for use in the expressway management domain.

1.13.1. In scope

- Identify main abnormalities in the vehicle detection based on traditional system testing.
- Highlight the identified sections using novel visualization techniques for non-technical understanding.
- Show the output with more understandable ways to get accurate decisions.

- Generate a more readable final output vehicle detected video with identified abnormalities.
- After many interviews, the author restricted this application for only expressway management.

1.13.2. Out scope

- Further rules violated vehicle identification identifications are out of the scope of this research.
- Wireless vehicle detection testing is out of scope in this research work.

1.13.3. Prototype Feature Diagram

Figure 1-Prototype Feature Diagram

1.14. Requirements for Research Resources

The following are standard specifications for achieving the project's objectives, as well as the hardware, software, and data resource requirements.

1.14.1. Requirements for Hardware Resources

- Core i7 or high-performance GPU – Carry out ML tasks that necessitate a large number of resources.
- 8 GB or higher RAM – Manage huge amounts of data for deep learning research.
- Hard Disk 40 GB or above Space – Store all the data relevant to the research.

1.14.2. Software Resource Requirements

- Operating-System - A 64-bit OS which is related to latest version is required since it has a large computational process of ML.
- Scikit learn python package – This is where the algorithm resides.
- Zotero – Assistant tool to manage research papers and also to back up them.
- MS Office and Google Doc – For create safe documentations.
- Google Drive – For Backup necessary files which are relevant to the project.
- Google Colab and pycharm - For training and testing the proposed model.

1.14.3. Data Requirements

- Expressway CCTV video 2TB dataset

1.14.4. Skill Requirement

The skills mentioned below are both built and needed during the study because a reliable system cannot be anticipated without them, and the system must be configured to accommodate the usage case of the issue being discussed. (5 Skills to become an engineer for machine learning, 2016)

- Data Structures and Algorithms – Knowledge of data structures and algorithms is required specifically to build an ML Model and classification algorithm based on an appropriate data framework.
- Probability and Statistics – It is necessary for development and validating models based on the dataset. Since certain machine learning algorithms are drawn from numbers, which is the starting point.
- Information Modeling and Evaluation – needed for determining the dataset's underlying data structure as well as identifying trends.
- Using Machine Learning Libraries and Algorithms – Knowledge of how hyper-parameters influence the learning process is needed when using machine learning algorithms from libraries, as well as knowing the benefits and drawbacks of each solution when selecting the best match model.
- Software engineering and system design - After the testing process is completed, software engineering and system design are used to construct the solution. Rather than the tiny test datasets used previously, the device architecture must now accept huge

chunks of data. It is essential to know how to extend the structure using expanding algorithms.

2. LITERATURE SURVEY

2.1. Research Overview

This section describes the background and related work in the domain of detection of traffic rules violated vehicles. The most modern methods for vehicle detection were then examined with a detailed understanding of deep learning by various forms of CCTV dataset. Furthermore, various approaches for the implementation of deep neural networks in the vehicle detection field were explored. Consideration has also been given to the current state of traffic rules violation detection, existing research work in these fields, and the strengthening of this sector.

2.2. Problem Domain

2.2.1. 2.3.1 Vehicle Parking Violation Detection

Figure 2 Vehicle Parking Violation Detection

A serious concern related to traffic jams and road accidents. This may occur given the limited allocation of the traffic police to the expressway. There is a significant increase in vehicle use with the expressway. Consequently, there seems to be an increase in violations of traffic rules. All these violations lead to much more road accidents.

Road traffic accidents (RTAs) are widely recognized as an increasing public health problem. The rate of death and disabled road accidents occurring is increasing and each day is an actual public health challenge for all the authorities involved to prevent them. The way to implement the laws and regulations help to control road accidents is often unsuccessful and partially. The creation of awareness, the strict implementation of traffic rules and the measures of scientific software development are a matter of time to prevent this public health disaster.

Though this number of lives lost in road accidents in high-income countries has shown a downtrend in recent years, for most of the global population, the responsibility of road traffic injuries—in terms of social and economic cost savings rising significantly [1]. Damage and road traffic accidents (RTA) are a massive public health problem in developing countries, where more than 85 percent of all deaths and 90 percent of disability-adjusted lifespans have been lost due to road traffic injuries [2].
More details of vehicle detection testing are mentioned below.

2.2.2. Types of vehicle detection Testing

As an initial stage for research, the author has looked at the diverse methodologies of current vehicle detection system worldwide. The system records the location, speed, and shapes of passing vehicles in images and videos. Road traffic images contain a wealth of information over a wide area. Techniques for detecting vehicle images can be used in multiple lanes and zones. Weather conditions and the transition from day to night may have a significant impact on performance. Street lighting is required for nighttime video image recording in order to obtain reliable signals. Vehicle parameters such as length, height, and width dimensions were extracted from the literature and used to classify vehicle types.

2.2.3. Computer vision technology is using for traffic monitoring

Figure 3 Computer vision technology is using for traffic monitoring

Many countries use computer vision technology for traffic monitoring. The advancement of computer vision technology over video-based traffic monitoring for detecting moving vehicles in video streams has become a critical component of ITS. A substantial amount of research has been conducted on vehicle tracking and detection using computer vision technology. Hasegawa and Kanade introduced a system for detecting and classifying moving objects based on their type and color in 2005. During this process, a series of images of a specific location were provided, and vehicles were identified using these images. Nilesh et al. (2013) designed and developed a system for detecting and counting moving vehicles using visual C++ and OpenCV. It can automatically detect and count moving objects as vehicles in real-time or from recorded videos, primarily through the use of background subtraction, image filtering, image binary, and segmentation techniques.

2.2.4. MOTION VEHICLE DETECTION AND SEGMENTATION APPROACHES

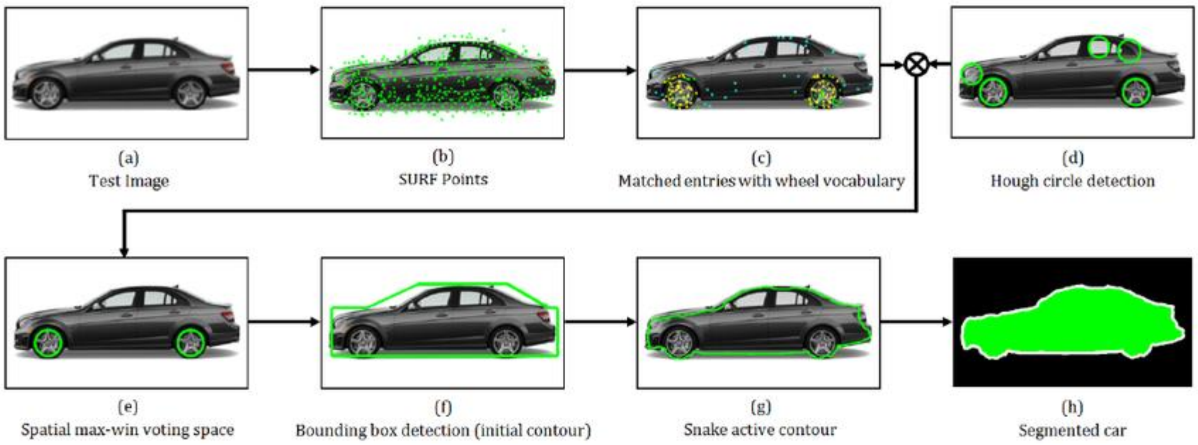


Figure 4 The side-view car detection and segmentation process.

One of the most interesting fields in computer vision is the detection of moving object regions of change in the same image sequence captured at different intervals. The change detection technique is used in a wide range of applications, including video surveillance, medical testing and treatment, object tracking, underwater detecting, and civil infrastructure [16]. Traffic image analysis, which includes moving/motion vehicle detection and segmentation approaches, is one of the video **surveillances** branches. Despite the fact that numerous research papers have been presented for moving vehicle detection (background subtraction, frame differencing [17-22], and motion-based methods), it remains a difficult task to detect and segment vehicles in dynamic scenes. It consists of three major approaches to detecting and segmenting the vehicle, as listed below:

1. Background Subtraction Methods.

2. Feature Based Methods.

3. Frame Differencing and Motion Based methods.

2.2.5. Background Subtraction Methods

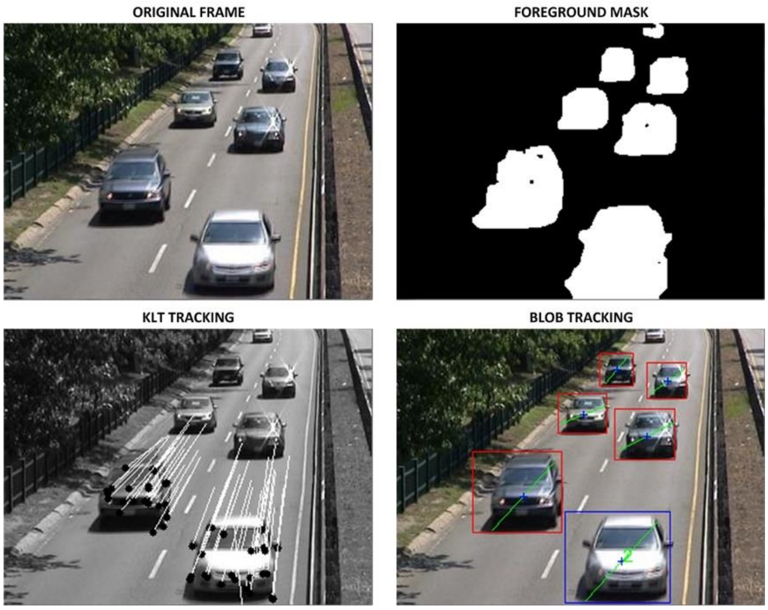


Figure 5 Vehicle Detection, Tracking and Counting on Behance

Background subtraction is the process of extracting moving foreground objects (input image) from a stored background image (static image) or a generated background frame from an image series (video), and the extracted information (moving objects) is then used as the image differencing threshold. This method is one of the most widely used detection methods in vehicle regions detection. The inability to adapt is a disadvantage that has arisen as a result of changes in lighting and climate [23]. As a result, several researchers are working to address this issue through methods proposed in this field.

2.2.6. Feature Based Methods.

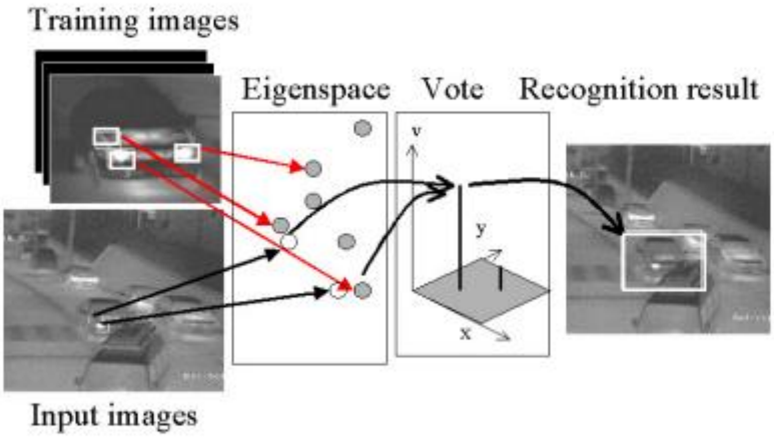


Figure 6 Eigen-window method.

Another trend that the researchers investigate and motivate is the collection and analysis of sub-features such as the edges and corners of vehicles, moving objects segmented from background images by collecting and analyzing the set of these functionalities from the motion between subsequent frames. Moreover, the feature-based method handles occlusions between overlapping vehicles and, when compared to the background subtraction method, represents a lower level of computational problems [33].

Several approaches that use features to distinguish the object from the background have been proposed, including a trainable object detection approach proposed by [34]. This learning-based approach employs a set of labeled training data for labeling the extracted object features. Furthermore, it employs a Haar wavelets technique for feature extraction and a support vector machine classifier for classification. Furthermore, this approach has been tested on static image datasets of faces, persons, and vehicles.

2.2.7. Frame Differencing and Motion Based methods.

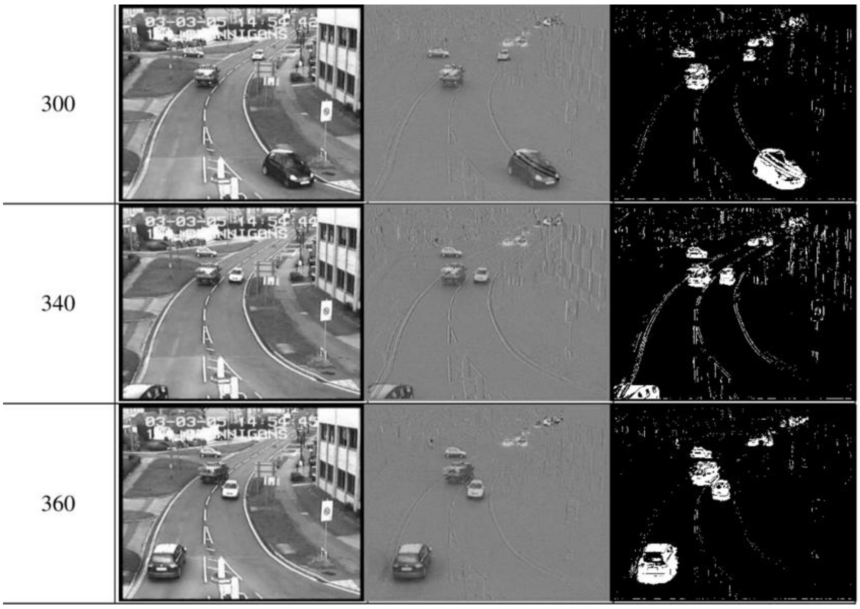


Figure 7 Cumulative frame differencing

The method of subtracting two subsequent frames in an image series to segment the objects (moving object) from the background frame image is known as frame differencing. Furthermore, the motion segmentation technique is another important step in detecting vehicles in image sequences, which is accomplished by isolating moving objects (blobs) through analysis and assigning sets of pixels to different classes of objects based on directions and speed of their movements from the background of the motion scene video frame [1,2,3,4].

To identify and manipulate compression vehicles, a framework with intraframe, interframe, and tracking levels is suggested. This paper demonstrated quantitatively that the interframe and interframe could be used to effectively manage and manipulate partial occlusions images, while the tracking level could be used to effectively manage and manipulate full occlusions images [2].

2.4. EXISTING WORK

2.3. Flexible Video-Based Vehicle Detection, Classification, Counting, and Speed-Measuring System for Real-Time Traffic Monitoring

2.3.1. Digitization of images and background removal

Background subtraction is a widely used technique for detecting moving objects in video captured by static cameras. For object extraction from video, the proposed system employs the background subtraction technique. It is faster, more dynamic, and yields better results than other pattern-based [17] detection methods. Pattern-based detection is useful for detecting one-of-a-kind objects. However, when there is a wide range of vehicle types, pattern-based detection cannot produce a better result. The moving foreground is extracted from a static background using the background subtraction technique. Background subtraction computes the foreground mask by subtracting the current frame from the background model.

2.3.2. Counting Vehicles and Measuring Speed

When counting vehicles, it is critical to count each vehicle only once. A count line has been added to the system for this purpose. Vehicles detected crossing the count line will only be counted; otherwise, they will not be counted. A speed line is also included in the proposed system to measure the speed of moving vehicles. It is necessary to draw both the count line and the speed line while configuring the system. The distance between the count line and the speed line will be predetermined when the camera is set up. Because the distance between the speed line and the count line is known, our developed system can calculate the time required to cross the speed line to the count line.

2.3.3. Identification and Removal of Shadows

When there is a moving shadow of a vehicle, the background subtraction considers it to be a moving foreground, and thus the shadow may be detected as a moving vehicle. Because simple background subtraction cannot detect moving vehicle shadows, some good algorithms, such as BackgroundSubtractorMOG2, are introduced to deal with the shadow problem. The BackgroundSubtractorMOG2 [18] algorithm allows you to specify whether or not a shadow should be detected. When detectShadows = True, shadows are detected, and BackgroundSubtractorMOG2 marks shadows in gray color.

2.4. A Platform for Detecting Illegal Parking Based on Deep Learning

Efficiently detecting illegal parking has piqued the interest of researchers from a variety of fields. Significant effort has gone into the development of new algorithms aimed at improving detection performance [6, 7, 9, 13]. The majority of these attempts have relied on videos captured by fixed cameras [7, 9]. Recent studies used alternative data sources, such as biking trajectories, to detect illegal parking to overcome the limitation of fixed camera coverage [6]. Our research differs from previous studies in that we use cameras that can be deployed on moving objects (e.g. patrolling vehicles, robots). As a result, the detection system's spatial coverage will not be limited to fixed locations.

2.5. Detecting Illegal Parking Using the Gaussian Mixture Model and the Kalman Filter

In a video scene, segmenting a moving foreground object typically entails modeling the background without the moving object and then computing the error between the modeled background and the current sequence image. Among the various existing methods for background model construction and foreground extraction, the Gaussian mixture model (GMM) has emerged as one of the most dependable and computationally efficient approaches. The GMM approach, first proposed by [22], [23], models each pixel of an image as a mixture of Gaussian distributions.

Kalman filtering can also be used to create an image's background model, with each pixel of the image sequence modeled using an individual Kalman filter [20].

2.6. Lane line detection methods based on image processing

SDAS relies heavily on the LDWS module. It is a type of safety system that can warn the driver if the vehicle is about to deviate from the lane or has already deviated from the lane. LDWS cannot actively control the driving vehicles in order to prevent lane departure events from occurring in the near future. The primary goal of LDWS, as illustrated is to warn drivers to reduce or avoid lane departure events. LDWS collects road information near the driving vehicle using relevant sensors, then analyzes the driving vehicle's situation, the warning threshold and warning time set in the structure and evaluates whether the vehicle has a tendency to deviate from the current driving lane.

2.6.1. Algorithms Review

It is vital to select the most suitable algorithm when implementing a system related to deep learning. The criteria that need to focus on as time taken for the training, the size of the dataset, number of features.

2.6.2. Deep learning

Deep learning is a subset of Artificial Intelligence (AI) that enables systems to learn from their experiences without the need for programming. Machine learning is the scientific study of algorithms and statistics used to perform a specific task. Nowadays machine learning is used most of the fields like image classification, vehicle detection etc. The train dataset represents training data for get experience for create machine learning model to resolve the problem.

Types of learning patterns in machine learning.

- Supervised learning
- Transfer Learning
- Unsupervised Learning
- Reinforcement Learning

2.6.3. Supervised Learning

In supervised learning labeled data set is used. In labeled data, both the input and output parameters are machine readable which requires huge manpower to label the data. High accuracy level of the labeled data leads to high accuracy of output. Very little amount of data set is given to the algorithm for the training. This small data set needs to represent the whole data set which includes the problem of the domain. Once the algorithm is trained based on the small data set, it has the ability to identify the patterns and relationship between the input and output. Then the learned solution is provided with the final data set to get the real output. Supervised learning divides into groups called classification and regression.

Classification refers to predicting the correct class label for the given input dataset. There are different types of classification algorithms like,

- Artificial neural network models
- Support vector machine (SVM)
- K-nearest Neighbor (KNN)
- logistic regression

2.6.4. Deep Learning

Deep learning is an Artificial neural networks and machine learning subset that usually has three or more layers of a neural network. It also trains computers to do what naturally comes to human. it is a learning approach. During in-depth learning, a computer model learns to classify tasks directly from images, text, or sound. Deep learning models can approach cutting-edge accuracy, which can sometimes exceed the human level. Models are trained with a wide array of labeled and multi-layered data and neural network architectures.

- Convolutional Neural Networks (CNN)

- Recurrent Neural Networks (RNN)
- Artificial Neural Networks (ANN)

2.6.5. Convolutional Neural Networks (CNN)

Machine learning makes use of neural networks. Deep learning algorithms rely heavily on neural networks. CNN is a popular deep learning algorithm that reads input images and assigns significance to specific features in order to distinguish them. Convolution is a direct scientific action between matrices, and this term derives from it. The coevolutionary layers serve as building blocks in coevolutionary neural networks. In a tensor computational function or application, a convolutional layer generates a feature map that visualizes the input. CNN is a small neural network that specializes in two-dimensional or three-dimensional image recognition. This network includes a linear operation for increasing the weights of the inputs.

- Each kernel contains data transmission neurons, and the Convolutional Layer contains filters and parameters. It also depends on whether the project calls for 2D or 3D convolutional layers.
- Pooling layer might decrease the Convolved Include spatial measurement. This layer can decrease the computer power used to feed data. Max pools and average pools are available.
- The output of a network is determined by activation functions, which are numerical expressions. Each neuron has a function that is linked to it. “Relu”, “Softmax”, “Sigmoid”, and “tanh” are a few examples of activation functions. Relu is the most widely used activation function for improving layer performances.
- The output produced under the last max pooling layer is connected to the fully connected layer.

2.6.6. Recurrent Neural Networks (RNN)

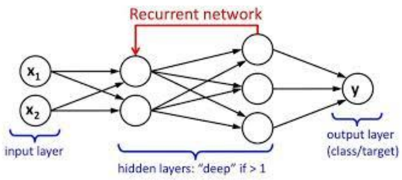


Figure 8-RNN Workflow

RNNs are a type of neural network that is both powerful and sturdy. They are one of the most exciting algorithms in use because they are the only ones that have internal memory. Recurrent neural networks, like many other deep learning techniques, are still in their infancy. They were first developed in the 1980s, but we didn't realize their full potential until recently. RNNs have gained popularity as a result of increased computer power, massive amounts of data we now have to deal with, and the introduction of long short-term memory (LSTM) in the 1990s. RNN can memorize crucial things because of its internal memory, which helps them to forecast precisely what will occur. That's why it's the favorite algorithm for sequential data such as time series, voice, text, accounting records, audio, video, weather, etc.

Artificial Neural Networks (ANN)

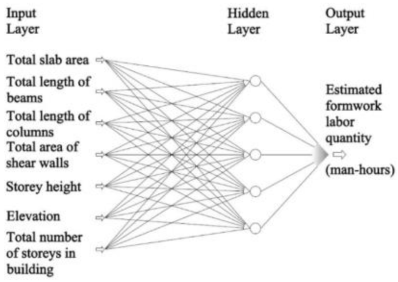


Figure 9-ANN Workflow

An artificial neural network is a model that includes neuronal biology and mathematical functions. This includes neurons and collects information using a connectivity form. ANN adapts its architecture to the dataset that runs onerous neurons during the training phase. ANN's learning can be monitored or unattended. The neural network generates a couple of test data together with the expected outcomes of each of these tests if it is supervised training.

2.6.7. Visualization Techniques

In order to establish confidence among those using neural network systems, we need to design transparent models that explain why they produce results. Those descriptions must be clear to see because most users are unable to follow certain procedures fundamentally, technically or mathematically. A typical approach among profound learners uses visualizations like heat maps and saliency maps to get a deeper understanding of a model's defects, therefore boosting the intuition to correct those problems through further training.

- Saliency maps

One basic drawback of the earliest CNN visualization approaches was the fact that the projections had mainly restricted to the initial layers in which the input image pixel spaces could be transferred. Interpreting that last layer is difficult, since features are usually more complex and a coupled with low features corresponds to them.

- Generating Class Discriminate Activation Maps (Grad-Cam)

2.7. Chapter Summary

The domain, current work, and innovations were all examined. The introduction to the vehicle detection was the first step in the domain analysis. The domain's Types of detection Testing, moving object detection, simple machine learning, and easily understood video generation strategies were addressed. The analysis of previous work was then discussed. The work was split into two sections: narrowly identifying vehicle and producing understandable video, all of which were described. Each current study was reviewed for similarities, benefits, weaknesses, and breakthroughs. The design of parking violation detection and lane detection systems and their applications is discussed. Having followed that, a tech audit was performed. For processioning, computation selection, feature selection, ultra-optimization, and evaluation techniques, the literature was reviewed. Their significance, advantages, disadvantages, application in programs, and alternatives were investigated. The level of automation attained by these systems and modules was evaluated. The multiple conclusions and appropriateness for this project, and the authors' evaluation, are interspersed throughout the chapter.

3. RESEARCH METHODOLOGY

3.1. System Overview

The project management and development methodologies used during the research are covered in this chapter. Comparisons are presented of the different options investigated and the final methods chosen. In addition, justifications are given for the methodologies and diagrams used to chart the implementation of the project.

3.2. Parking Violation Detection

If vehicle not moving in 30 s system detect that vehicle illegal parked vehicle. Author can change the time period. And another benefit is illegal vehicle parking counting and show the top of the display.

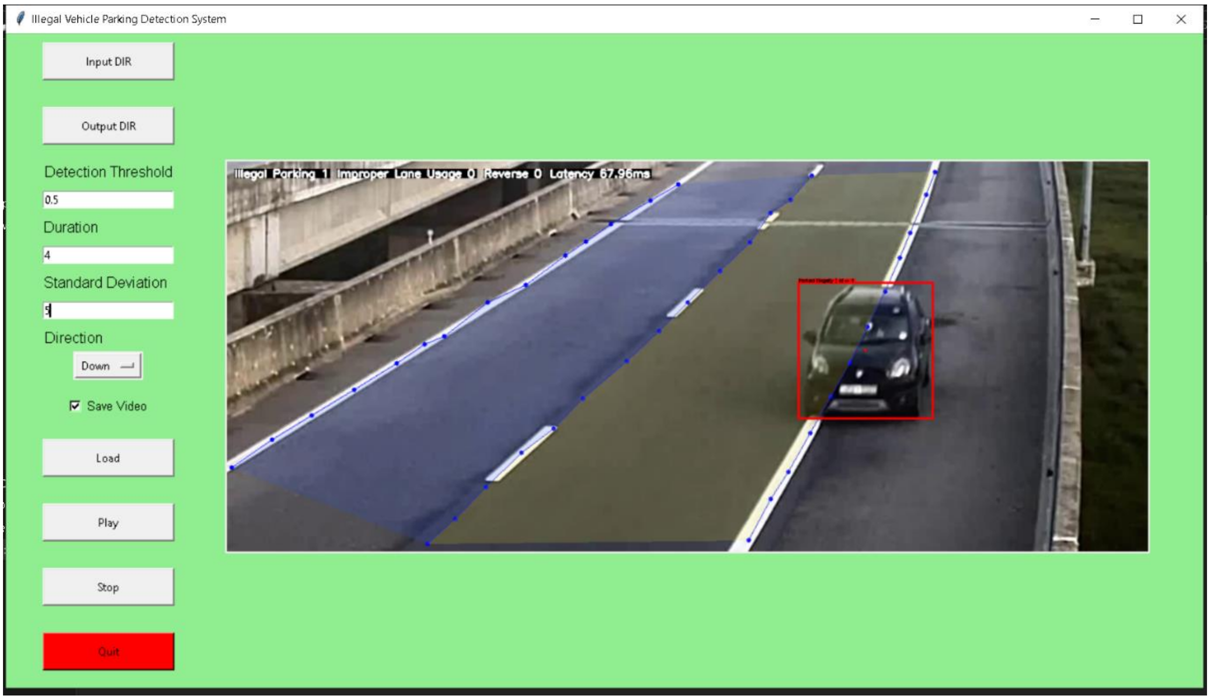


Figure 10 Parking Violation Detection

3.3. Lane Violation detection

If vehicle drive on the second lane (not vehicle overtaking time) System identify that vehicle lane violated vehicle and display on red box. Another benefit is lane violation vehicle counting and showing top of the display.

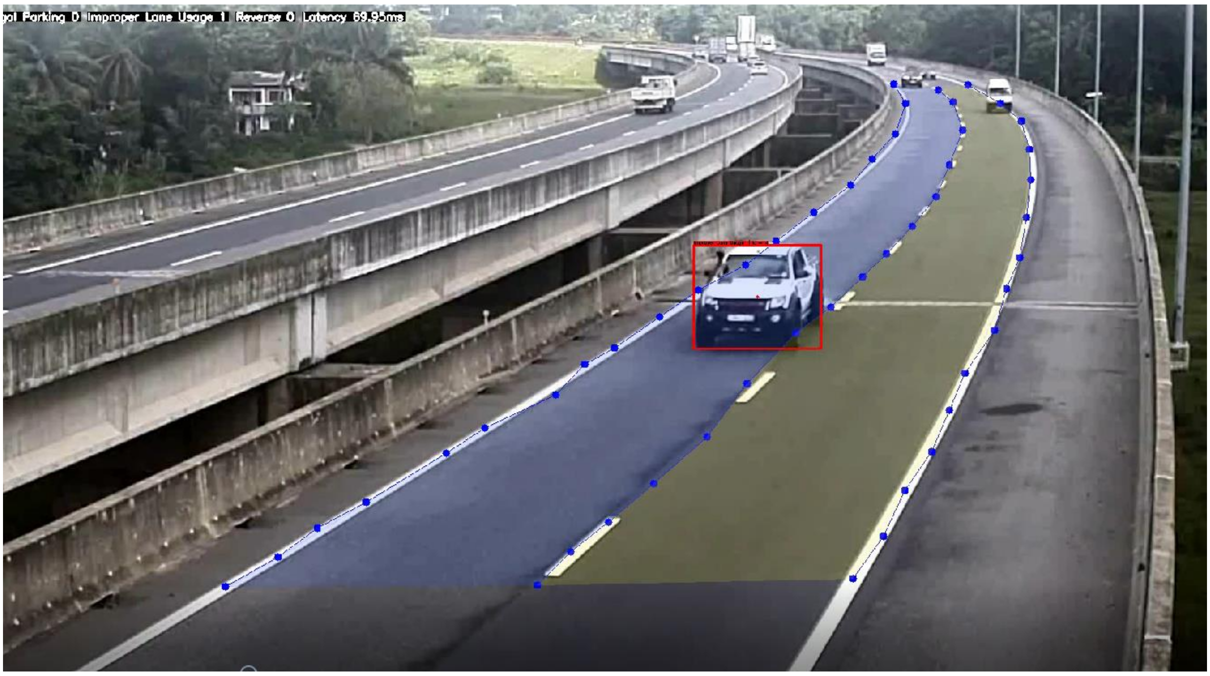


Figure 11 Lane Violation detection

If Vehicle overtaking another vehicle system does not detect lane violated vehicle. Every time system checks if the vehicle on the second lane then system check 1st lane on another vehicle driving or not. Vehicle Overtaking time system show only detection and vehicle counting and show green color box.

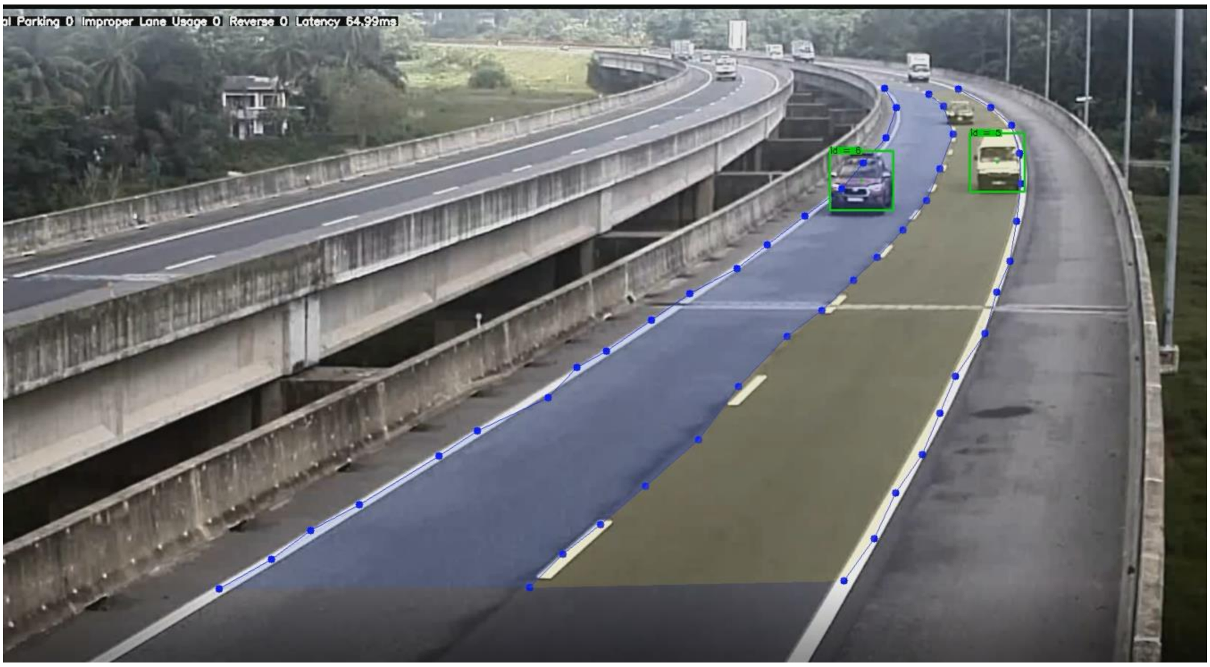


Figure 12 not lane violation time

3.4. Selected Methodologies

There are three key aspects to the quality of every project. In order to ensure a good project, scope, time and cost must be effectively handled during the project. Due to the existence of research projects, methodologies are essential because requirements and scope can change continuously. The need for methodologies is therefore increasing. The table below lists the methodologies chosen for this research.

Research Methodology	Philosophy	Upon pragmatism, interpretivism, realism and, positivism. Positivism is selected since the project will undergo full testing and also will be compared with the quantifiable existing factors such as performance scores, benchmarks etc. The project is not dependent on the user, but it will be judged based on the factual data.
	Approach	This is based on the data collection and how it is interpreted. Inductive and deductive are two main methods of data collection. The deductive method is chosen because this project is supposed to undergo a full testing and proving. As the data analyzing technique is quantitatively selected upon qualitative due to high amount of testing.
	Strategy	This stands for the approach chosen when dealing with the project. Surveys seem to be the best strategy upon experiments and interviews because of the quantitative tactic. Other methods will also be used later but not at the beginning. Choice- Though as the analyzing method quantitative is selected, the interview will provide qualitative data. However, since at the beginning surveys will take place. Therefore, a mixed method is selected.
	Choice	The mixed-method approach was selected. Since the quantitative approach was selected, interviews would yield qualitative data, but surveys will be used in the beginning. As a result, both quantitative and qualitative information will be used. The approach is, therefore 'mixed method.' The main data

		obtained by quantitative methods will be tested using qualitative methods.
	Time Horizon	The data is collected before and after the project. Therefore, longitudinal method seems the best method upon cross sectional.
	Techniques and Procedures	To collect data and analyze the data below methods will be used. Documents, surveys, medical databases, interviews etc.
Project management / Software Development Methodology		Among various types of methodologies Agile will be chosen due to the high tendency of changing requirements, and the ability to provide small parts to the user and receive the feedback from the user.

The methodologies mentioned above were used to describe the project's aspects listed below.

Research Hypothesis: The manual procedure used by expressway management when examining and detection of parking violation can be automated using deep learning. The expressway management would benefit from the final classification result and the probabilities of the abnormality observed, which are shown as a more readable virtualizing process and understandable final video generation by the system.

Prototype Input: Expressway CCTV video dataset

Research Output: Detecting the CCTV data of a given expressway based on abnormality and generating an understandable video with their certainty in a way that would be useful to the expressway management and traffic police.

Prototype Features:

- One platform for automated parking violation detection and lane violation detection testing.

- Accurate model which is automated identify main two traffic rules violation testing CCTV videos
- User friendly GUI with showing the output results with more understandable visualizing methods (python GUI)
- The user can generate a final customize video with adding identified vehicles.

3.5. Methodology of Project Management

3.5.1. Gantt chart

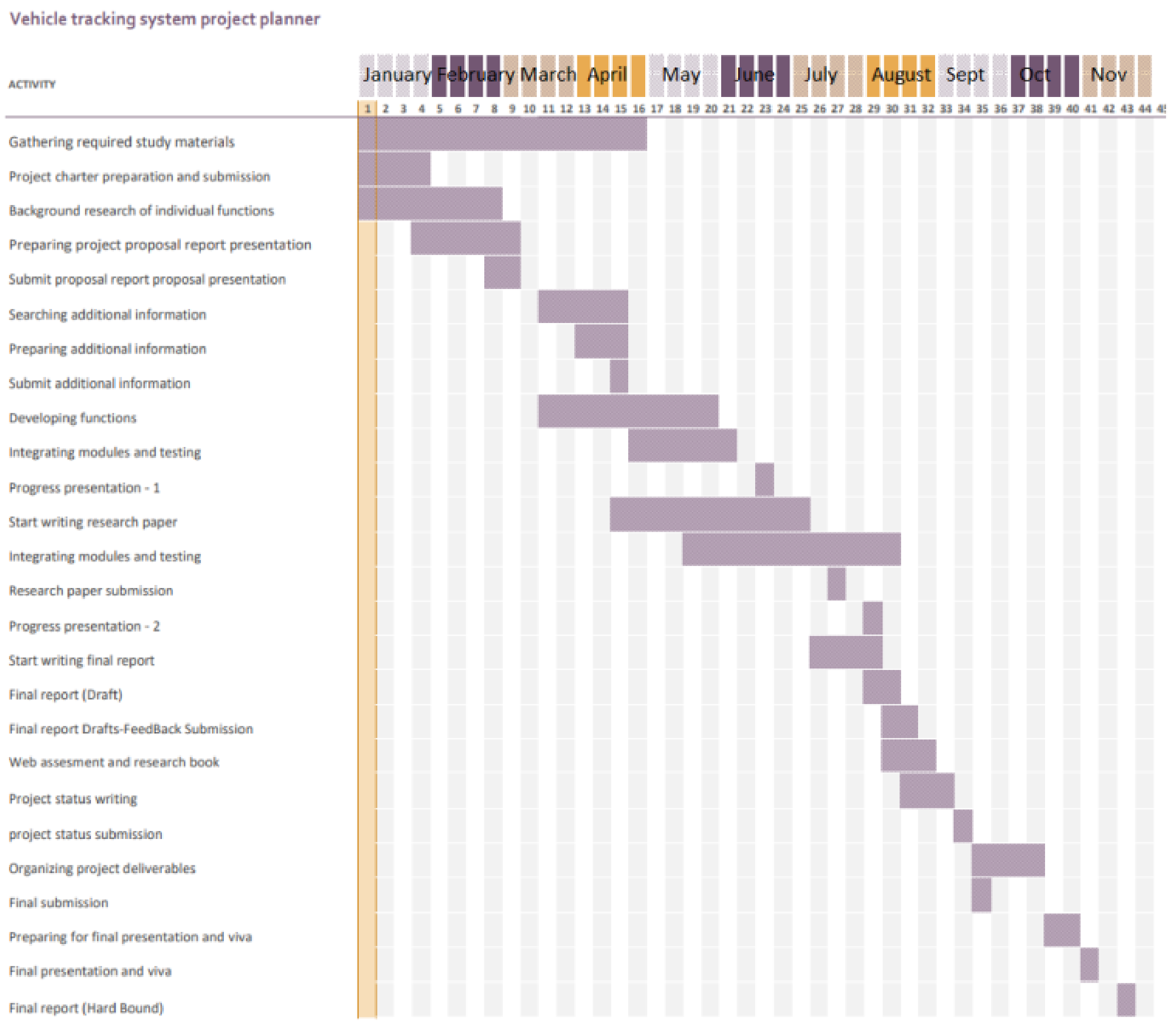


Figure 13 Gantt chart

3.5.2. Deliverables

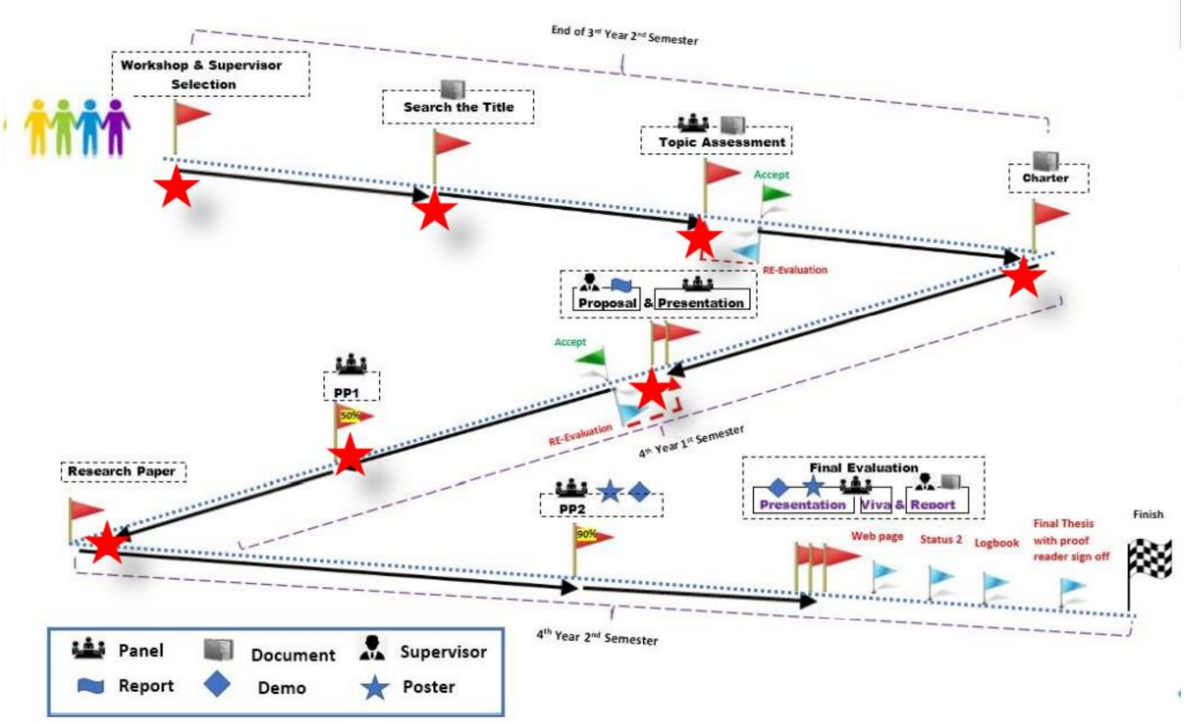


Figure 14 research submission workflow

3.5.3. Important Dates

Progress Presentation-II (90%)	**14, 15, 18 – October-2021**
Final Report (draft) Individual and Group Submit to the Supervisor	**08– October-2021**
Website	**05-November-2021**
Project status document II, Student Logbook, Research paper registration notification	**24-November-2021**

Figure 15 Important Dates

3.5.4. 3.4.3. Risks and Mitigation

When working on a project for a long period of time, risks are inevitable. As a result, it's critical to recognize and analyze potential threats, as well as develop mitigating strategies. The table below lists the project's threats as well as the risk reduction programs in place to address them.

Risk	**Level**	**Frequency**	**Mitigation**
The specifications for the system will vary during the production period, and these modifications must be accommodated for each new prototype design.	High	High	Iterative programming approach can help with framework requirement updates and new function implementation. To have the least amount of complication as requirements change, it is beneficial to create a framework module.
It would be beneficial to have an understanding of the term associated with machine learning if you need to accumulate a vast volume of information on the domain.	High	Low	In order to research and develop a new philosophy, time management is essential. It would also aid in the completion of literature reviews. As a result, The context should be set to a scope that can be completed within the given timeframe defined.
Data set shortages and unavailability, as well as other license restrictions, will stymie the production of machinery leaning parts.	Low	Low	Until deciding on a research subject, find out if there are any open-source data sets that can be used; if so, the data can be downloaded right away to avoid having to rely on other resources.

Insufficient hardware capital One of the more common problems with machine learning projects is that most hardware is incapable of performing high computation.	High	High	Google, Amazon, and Microsoft have developed a high-performance cloud-based Virtual Machine solution. These can be used to carry out complex calculations.
Due to a lack of viable technologies, the required tool or application may not be produced or may be prohibitively costly.	Low	High	In software engineering projects, this is a normal phenomenon. If the criteria is basic, the tool may be built as part of the project. If that is not the case, other solutions should be considered. In addition, the unavailable part will be built at a later point in the development process.
This page has not been changed. Owing to the newness of this domain, a variety of academic and commercial research has been undertaken. As a result, the implementation of emerging technologies would have an effect on the project's novelty.	Medium	Medium	It is important to stay informed of emerging systems and technology as they become accessible. After that, the latest introduction should be examined to see if it impacts the structure. After that, it may be added to the system, modified, or fitted into the system with slight modifications.

3.6. Methodology Summary

The chapter started with the selection of suitable research and management methodologies. Agile was chosen as the software process to meet the changing requirements. The subtasks are established. In addition, the Appendix contained supporting graphs, diagrams, and other documents. These methodologies are followed accordingly by the rest of the project.

4. SPECIFICATION OF SOFTWARE REQUIREMENTS

4.1. Overview

The focus of this chapter is the collection of software system and the analysis of those prerequisites. It begins by identifying and describing the system's stakeholders. The approaches to requirement collection, how they are used, and the results of different methods will be mentioned. At the requirement review point, the use case diagram and its definitions are presented. Finally, the system's functional and non-functional specifications are scoped and their importance to the system determined.

4.2. System Overview

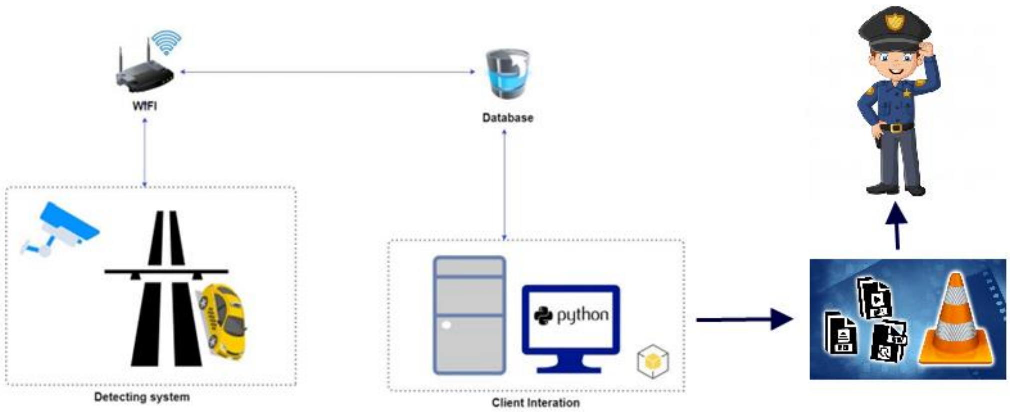
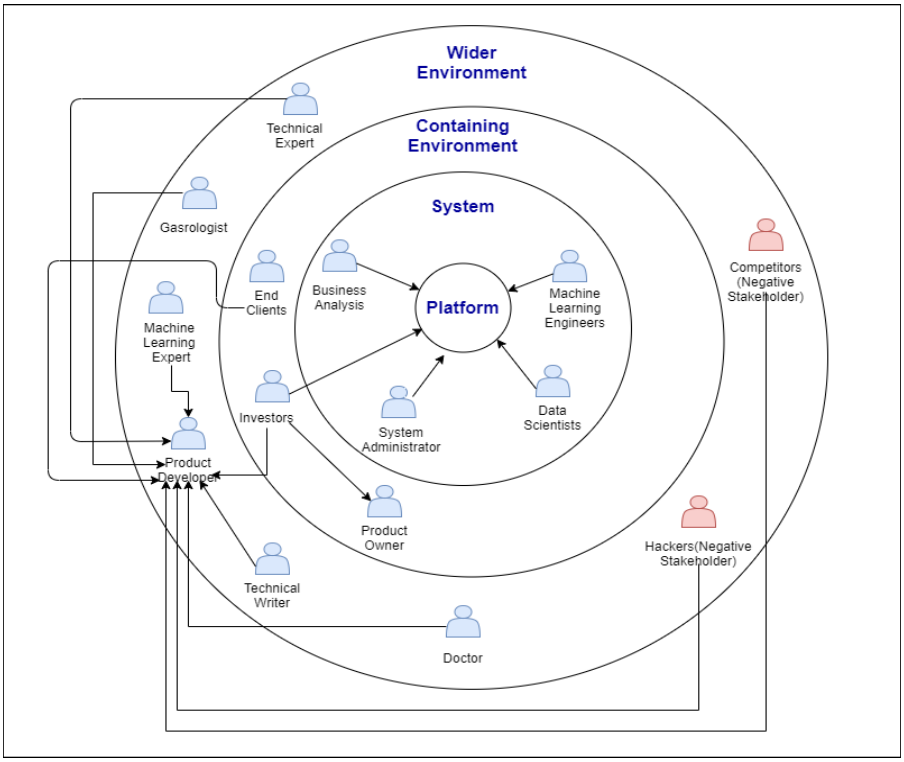


Figure 16 System Overview

4.3. Analysis

An onion diagram represents the identified stakeholders who are associated with the system and a description of an overview of each actor's function in the system.

4.3.1. Understanding the Research Onion Model



4.3.2. Stakeholder Viewpoints

Stakeholders	Funtion	Advantages/disadvantages
Scientists of statistics, machine learning engineers, and business analysts are all examples of data scientists.	Maintenance of all operations	Develop main machine learning models for the system
System Administrator	System and operations administration	Monitor the system implementation, operation and final performance.
Technical Writer	Assistance for the system	Creating understandable necessary documents which support the system
Product Owner		The creator of the system

End Clients	Functional Beneficiary	Users of the system
Product Developer	Financial beneficiary	The architecture of the system
Investor		Invest for the product to get profits
Expressway Management	Providing Professional Advice	Providing knowledge and experience on violation detection testing to create a better method.
Traffic police		Providing expert knowledge and experience on violation detection testing and sharing data to create a better method.
Machine Learning Expert		Providing technology expertise and key principles for the creation of a better method.
Technical Expert		Analysis on whether the platform will meet the requirements.
Hackers	Negative Stakeholders	Malicious intention to interrupt the working system.
Competitors		Creates the same features as a similar system.

4.3.3. Examining existing systems and conducting a literature review

The very first step in the demand analysis stage is a review of the literature on existing systems. This is done in order to review and identify knowledge gaps. This will help to identify the project's new requirements specifications.

Advantages	Disadvantages
● Easy to Identify private available datasets based on parking violation detection testing. ● Easy to Identify private available datasets based on lane violation detection testing. ● Easy to identify core components in existing machine learning approaches.	● Very challenging task to get more accuracy due to different datasets of different cameras.
Findings- Despite the fact that there have been many studies in this area and that their models have had a significant amount of training performance, the majority of them have high accuracy rate but not testing accuracies that have been attained during field testing. In addition, a general knowledge of the parking & lane violation detection research processes that accompany it was gained, which was helpful in identifying specifications.	

4.3.4. Interviews

Domain experts interviewed to identify requirements in the system criteria. Interviews were conducted with traffic police professionals and other technology experts.

Advantages	Disadvantages
● Ability to comprehend the system's specifications in greater depth ● The ability to ask complex and	● It was impossible to perform interviews with a large number of people.

ambiguous questions.	
Findings- To get system's specifications and feedbacks.	

4.3.5. Brainstorming

During several stages of the project, the author carried out brainstorming.

Advantages	Disadvantages
• Can find major research gaps in previous work.	• It's important to separate the important and relevant ideas from your own.
Findings-Brainstorming led to the identification of many system requirements, general characteristics, and functionalities.	

4.3.6. Questionnaires distribution

To gather requirements, a questionnaire was distributed online through Google Forms to domain experts and other individuals in related fields.

Advantages	Disadvantages
• Easy to use google form functions to evaluate the responses. • Save valuable time. • Capacity to reach a wider audience.	• Identify the domain experts.

4.4. Workflow Diagram

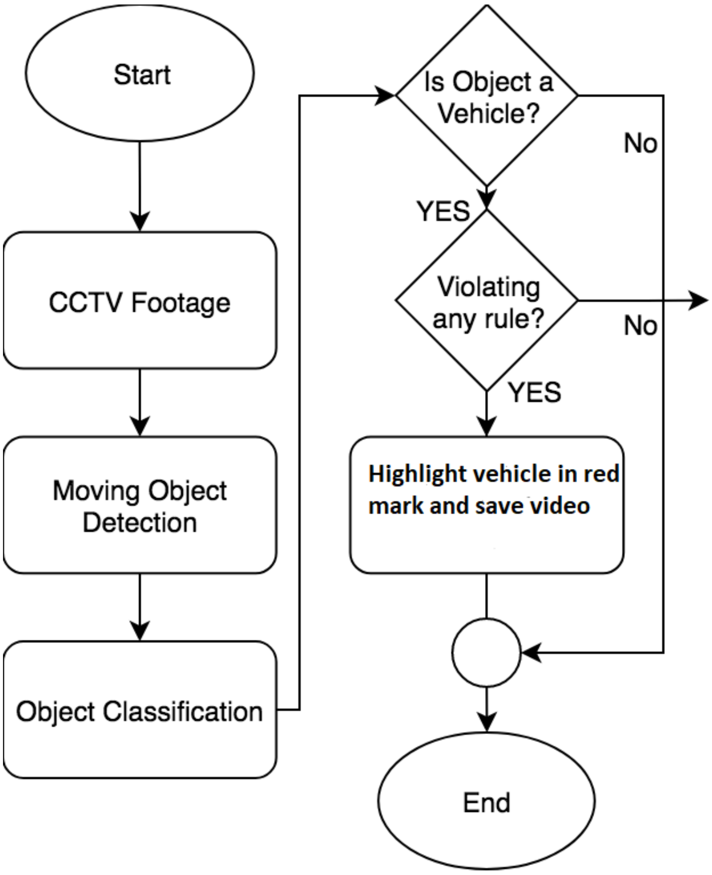


Figure 17 Context Diagram

4.5. System Use-Case Diagram

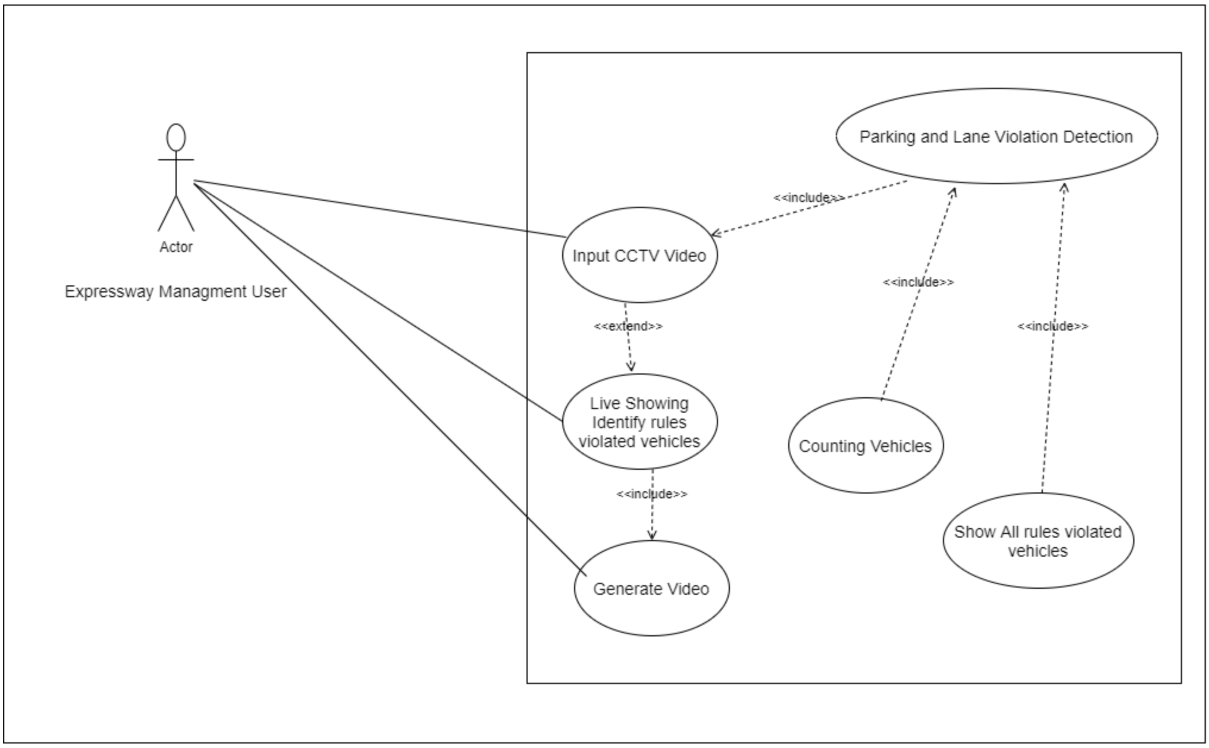


Figure 18 Use Case Diagram parking & lane violation detction

4.6. The use case's description

4.6.1. Use case of Classification

Use-Case	Classification
Definition	Classify and provide classification scores of endoscopic images based on their anomalies.
Participating Actors	Expressway Management User
Preconditions	• Good knowledge of the system
Main Flow	A clear CCTV Video should be uploaded in the dashboard.
Alternative Flow	None
Exceptional Flow	If the system crashes in the middle of the

	operation, the use case will end with a failure.

Use case of create-visualization.

Use Case Name	Create Visualization
Description	Highlight the mismatch in the image using the novel visualization method
Preconditions	● A clear video should be uploaded in the dashboard. ● End of the video process should be finished.
Main Flow	1. Upload an CCTV Video. 2. Add video details of system
Alternative Flow	None
Exceptional Flow	If the system crashes in the middle of the operation, the use case will end with a failure.

Use case of generate-video.

Use Case Name	Generate Video
Description	This is the final output in the system. It is an understandable video for non-technical people. This is an non-editable video. So, it contains to type on vehicle details.
Preconditions	● A clear video should be uploaded in the dashboard. ● End of the video process should be finished.
Main Flow	1. Upload a CCTV Video

	2. Go to home section. 3. Users can add camera details, recommendations and detection threshold.
Alternative Flow	None
Exceptional Flow	If the system crashes in the middle of the operation, the use case will end with a failure.

4.7. Functional Requirements

Priority Levels	Description
High	Core functions in the system
Medium	These functions are not essential but considered necessary for the system.
Low	Requirements that are outside the project's scope.

<table>
<tr><td>No</td><td colspan="2">Requirement</td><td>Priority Level</td></tr>
<tr><td rowspan="2">FR1</td><td colspan="2">In order to upload the images, users need to have access to the local machine.</td><td rowspan="2">High</td></tr>
<tr><td>Description</td><td>To obtain the abnormality classification, A video file of the CCTV should be uploaded.</td></tr>
<tr><td rowspan="2">FR2</td><td colspan="2">The video that are uploaded have to be processed.</td><td rowspan="2">High</td></tr>
<tr><td>Description</td><td>To obtain the abnormality classification, A video file of the CCTV should be uploaded.</td></tr>
<tr><td rowspan="2">FR3</td><td colspan="2">System should display all the detection vehicles.</td><td rowspan="2">High</td></tr>
<tr><td>Description</td><td>The transparency is high when all the final</td></tr>
</table>

		scores are displayed	
FR4	System should generate visualized video		High
		By using new visualization techniques, the image that contains the mismatch due to the abnormality is highlighted.	
FR5	System should generate video that could be understood by the non-technical personnel.		High
		The final report includes all the identified abnormalities, detected vehicles, and vehicle details.	

4.8. Non-Functional Requirements

No	Requirement	Priority Level
NR1	**Accuracy**: When identifying the parking violation vehicles in the system test videos, the accuracy level needs to be high because the people who use this system do not have technical expertise. Further this finally affects the decision of the expressway management expertise.	High
NR2	**Performance:** The users need the results with minimum wait time. They do not want to wait many hours looking for the results. This system provides results within a real time.	High
NR3	**Usability:** The target audience of this system is non-technical personnel. Since they do not have technical knowledge and also since it's not their job, the system should be user friendly and easy to handle.	Medium
NR4	**Maintainability:**	High

	Due to the rapid changes in detection, code changes and other different changes would need to add to the system while going forward. In order to add or remove features from the system, the proposed solution needs high maintainability.	
NR5	**Extendibility:** The ability to extend the solution is easy to identify new violation detection.	Medium

4.9. System Architecture and Design

4.9.1. Design Objectives

Design Goals	**Description**
Adaptability	New functionality should be simple to integrate into the system. New extensions must be simple to integrate with the core. Furthermore, if a module is deleted, the device does not fail.
Re-usability	To make it easy to reuse in other programs or improvements, it should be a built-in module.
Scalability	Scalable by taking into account more abnormality data and increasing their human vulnerability and precision by obtaining more training data from various sources.
Correct	The system's goal is to define parking and lane violation detection testing according to abnormalities and offer a helpful recommendation as a result. In addition, the

	device should be simple to use. If it is unable to do so, the method cannot be deemed right.

4.10. Design of System Architecture

The architecture of the system is represented in the diagram below. The architectural style is three-tiered. Data, logic, and presentation are among them. The bulk of the research output is in the logic tier. The presentation and information tiers are largely driven by the program. In all possible situations, a modular solution is used. Coupling, cohesiveness, adaptability, scalability, re-usability, and division of concerns are all information architecture standards to adopt.

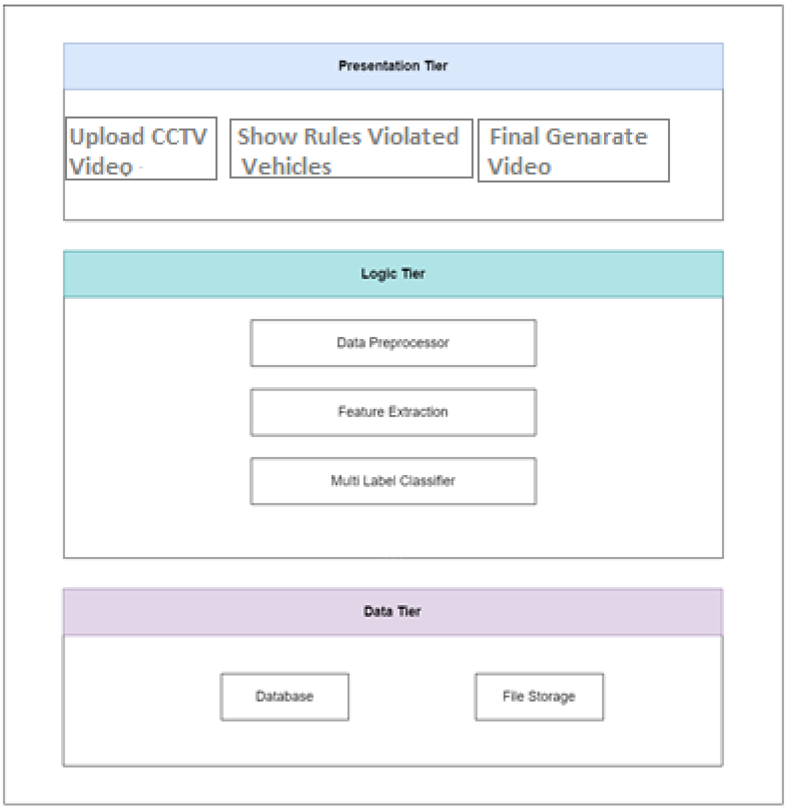


Figure 19 Design of System Architecture

1. Data Tier

- Database - Store all classification history, Saved CCTV videos and model details.
- File Storage- All the necessary data will store in this file storage.

2. Logic Tier
    - Data Preprocessing -Remove boarders, remove background and Resizing
    - Feature Extraction – Gray scale feature extraction.

3. Presentation Tier
    - Show all the classification details and generated items in a user-friendly GUI to get a better idea to non-technical persons.

4.11. Proposed System Design

4.11.1. Design Ideology Selection

Method	Advantages	Disadvantages
Structured System Analysis and Design Method	● Focus on top to bottom design. ● Easy to plan, execute and evaluate. ● Easy to deliver the result on time. ● Ensures high quality ● Low cost ● Since the focus is not on the data and data processing it is easy to understand	● Huge investment in training ● Have to wait till the end of the cycle to receive the output. ● Difficult to see the progress of the project ● Difficulty in changing the requirements time to time.
Object Oriented Design Method	● Focus on bottom to top design. ● High Reliability ● Maintenance cost is	● The tendency for incompleteness and less accuracy of the project may occur due

	less due to high reliability. ● The project can be delivered in several stages. ● Since the focus is objects and data structures. ● The reusability of the code is high. ● integration is easy.	to less knowledge on OOD concepts. ● Most of the vendors do not accept OOD methods. ● There may be bottlenecks in the development cycle due to identification problems in OOAD implications.

Based on the analysis of the two above methods in this project, Structured system analysis and design method is chosen due to limited time framework and main focus on process.

4.11.2. System Sequence Diagram

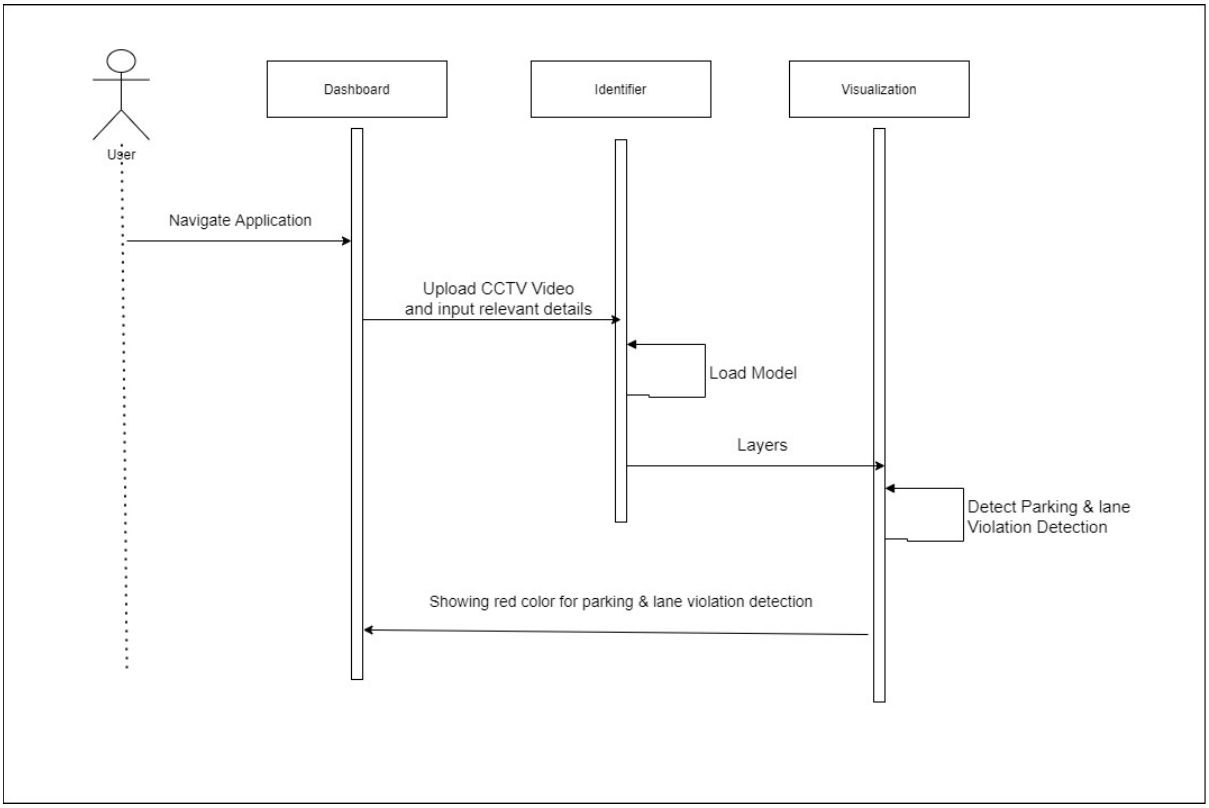
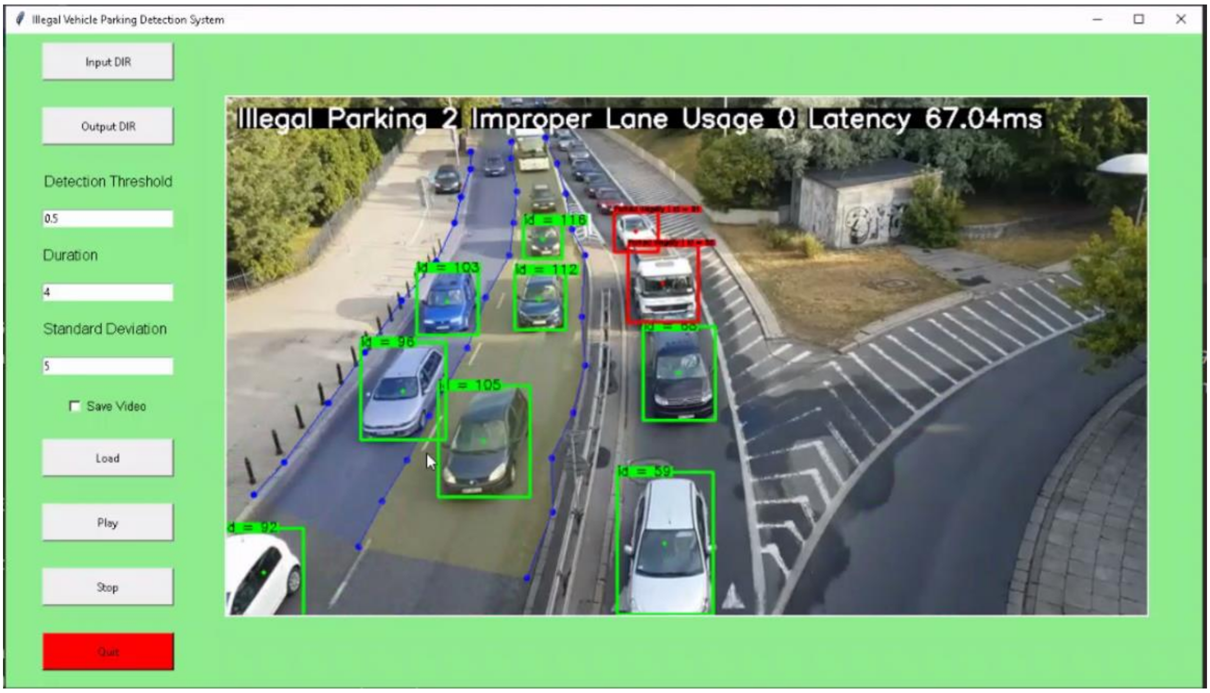


Figure 20 Sequence Diagram

4.11.3. System UI Design (Dashboard page)



4.11.4. User Experience

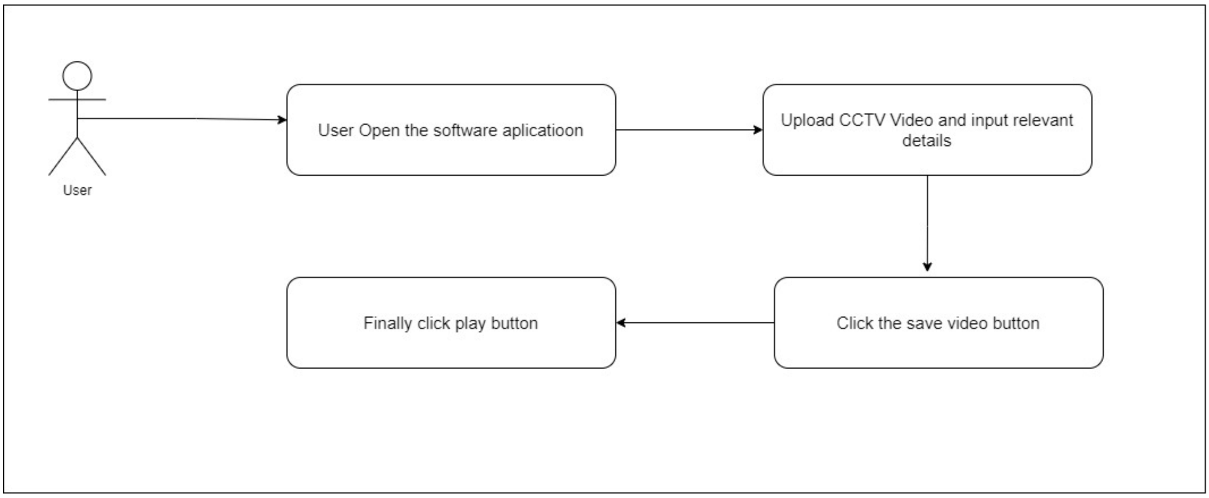


Figure 21 User Experience

5. SYSTEM IMPLEMENTATION

5.1. Choosing Advanced technologies

5.1.1. Selected Technology Stack

Figure 22 Selected Technology Stack

5.1.2. Data Extraction

The most important thing in the data science research project is a valid, balanced data set. Also, the final performance of the projects based on data size and quality of the data. Therefore, the author had to search suitable data set in the initial stage of the project. To find a dataset, the initial step was to visit the expressway management and request a valid dataset. After requesting a lot of times, the author found 2TB CCTV video datasets. This private dataset is recorded in expressway CCTV video, Sri Lanka. One of the balance datasets is Kottawa exit, It has 227 video files with day time and night time. It has 130GB size section. Three different areas such as Kottawa, Kahathuduwa, Kaduwela and entrance point CCTV footage in the dataset. It also offers two classes that deal with the method for 1st lane and 2nd lane(over take lane). Author is sorting and annotating the dataset. Other dataset is entrance footage, it has totally 70GB data resources related to Expressway entrance unit. But its need for number plate detection function implementation. It contains quality videos including clearly show vehicle number plate, and vehicle type findings. The concerning of 2000 of label image set divided into 7 classes. After analyzing the two datasets, the author expressway CCTV dataset regarding the vehicles and diseases which are classified in dataset.

5.1.3. Selection of Development Framework

The backend of this research project is built on python programming language. Frontend also used python GUI. For tracking moving objects, the system employs the Kalman filter, which estimates a state vector containing the target's parameters, such as position and velocity, based on a dynamic/measurement model. This chapter will focus on a typical second-order one-dimensional Kalman filter tracker, whose true state vector is identified as. System software application development for Windows. For fast moving vehicle detection, the system made use of the OpenVino toolkit. This is an object recognition network built on an SSD framework and using MobileNet v1 as a feature extractor that has been tuned. The OpenVINO toolkit (Open Visual Inference and Neural Network Optimization) is a free toolkit that allows for the optimization of a deep learning model from a framework and deployment onto Intel hardware using an inference engine. Intel is the creator of OpenVINO.

7.2.4. Programming Language

Python is used as the programming language among different languages like java , C++ in this implementation due to below reasons.

- When comparing with other programming languages like java, C++, Python is more robust, the level of complexity is low and also it is easy to maintain.
- Based on the analysis of different deep learning projects, it is proven that python is used as the programming language in most of the machine learning projects which has led to more libraries that could support more complex functions.

- Python also supports both the OOP concepts and also the functional concepts. Since machine learning it is the best practice to use code in functional and also in a software engineering aspect where the OOP is used.

5.1.4. Libraries

Name	Features
TensorFlow	Powerful library for machine learning task. It has lot of pre-built functions with mathematical expressions
Python GUI	PyGUI structure, it is more popularly called, is a simple API that allows developers to create user interfaces for Python applications using native elements.
NumPy	Main use for multidimensional array with mathematical expressions.
Polygon	Polygon is a Python package for working with polygonal shapes in 2D. It includes Python bindings for gpc, Alan Murta's excellent General Polygon Clipping Library, and several extensions written in C and pure Python.

5.1.5. IDE

PyCharm chosen for the overall full development process. Google cloud platform was chosen for the model training and testing all experiments. After limiting the google cloud platform services, the author has to test and experiments in PyCharm. PyCharm also chosen for frontend development.

5.1.6. Technology Selection Summary

System Components	Selected Technology
Python model implemantation	Tensorflow and mobilenet-ssd
Programming Languages	Python
System	Frontend- python
	Backend-python

IDE	PyCharm

5.2. Implementation of Core Functionalities

5.2.1. INTEL OPENVINO TOOLKIT

Model Optimizer evaluates trained neural network models in up to speed (TensorFlow, Caffe, ONNX, and so on), tunes and converts them, and then optimizes inference on target devices. This results in an Advanced Representation (AR), which is saved in a structured format for use during startup.

The Inference Engine executes the model inference in an intermediate representation on a given device (CPU, Integrated Graphics, Movidius Neural Compute Stick, Neural Compute Stick 2 [10], Vision Accelerator Design with Intel® Movidius TM Vision Processing Unit (VPU), FPGA). If a given device supports multiple computing devices, it is feasible to integrate automatic neural network inference division between devices (Heterogeneous Plugin) or run a single network on multiple devices simultaneously (Multi-Device Plugin). Figure 17 depicts a typical deployment process for a trained model using OpenVINO.

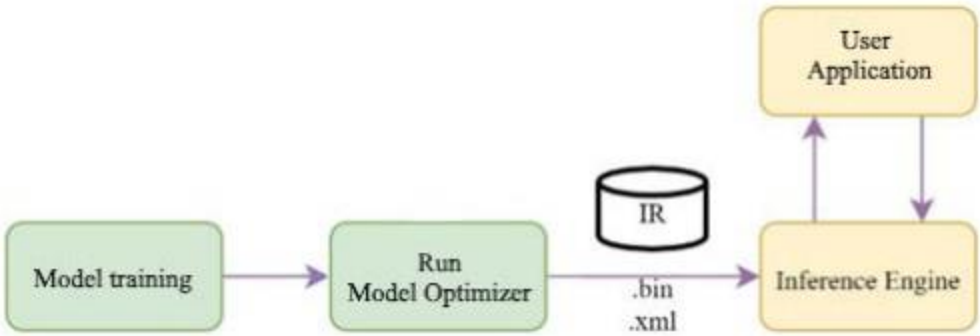


Figure 23 Deployment diagram of a trained model using OpenVINO

5.2.2. SSD MobileNet V2

One of the most important criteria in any deep learning framework is the preparation of datasets for training and testing. The dataset is critical because the deep learning convolutional neural network requires a large number of training, testing, and validation samples. To work on traffic light detection, high-quality images of traffic lights with varying backgrounds were captured. These images were taken in the city area during various weather conditions, which correspond to different lighting conditions. 551 images were collected and divided into training and testing sets. The images of traffic lights were taken in a variety of poses, orientations, and perspectives. This enables the deep learning convolutional neural network to effectively learn the desired object. 441 images were chosen for training and 110 for testing out of a total of 551 images. The images were cropped to a square ratio and then resized to 800 by 800 pixels in size. After that, the images are annotated and saved in XML format. The XML file is converted into CSV format for both the Fast RCNN and SSD Mobile Net V2 architectures. These CSV files were transformed into TF records, which will be fed into the deep learning framework. The training phase will begin after the TF records are generated. To achieve a reasonable performance, the training phase was carried out until the loss was less than 0.09. Figure 3 depicts some of the captured traffic light images that have been labeled for training purposes. Figure 18 depicts the training of the object detection framework.

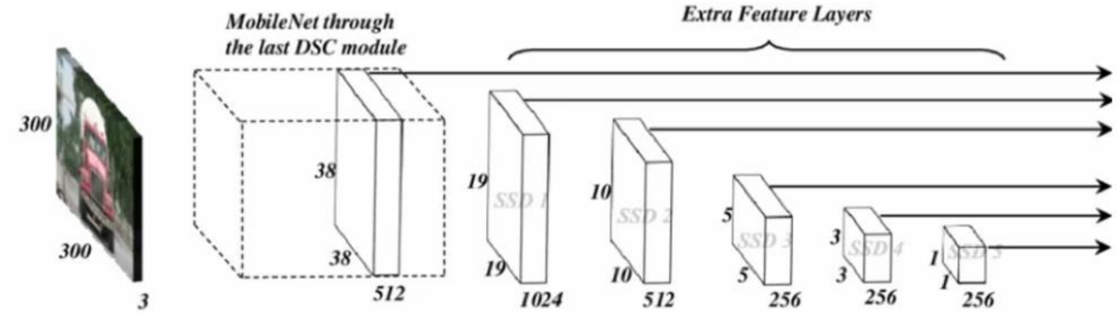


Figure 24 MobileNet architecture

Many real-world applications, such as self-driving cars, require recognition tasks to be completed in a timely manner on a computationally limited device. MobileNet was created in 2017 to meet this requirement.

MobileNet's core layers are based on depth-wise separable filters. The first layer is an exception, as it is a full convolution.

Around the same time (2016), the Google Research team developed SSD: Single Shot detector to meet the demand for models that can run in real-time on embedded devices without sacrificing accuracy significantly.

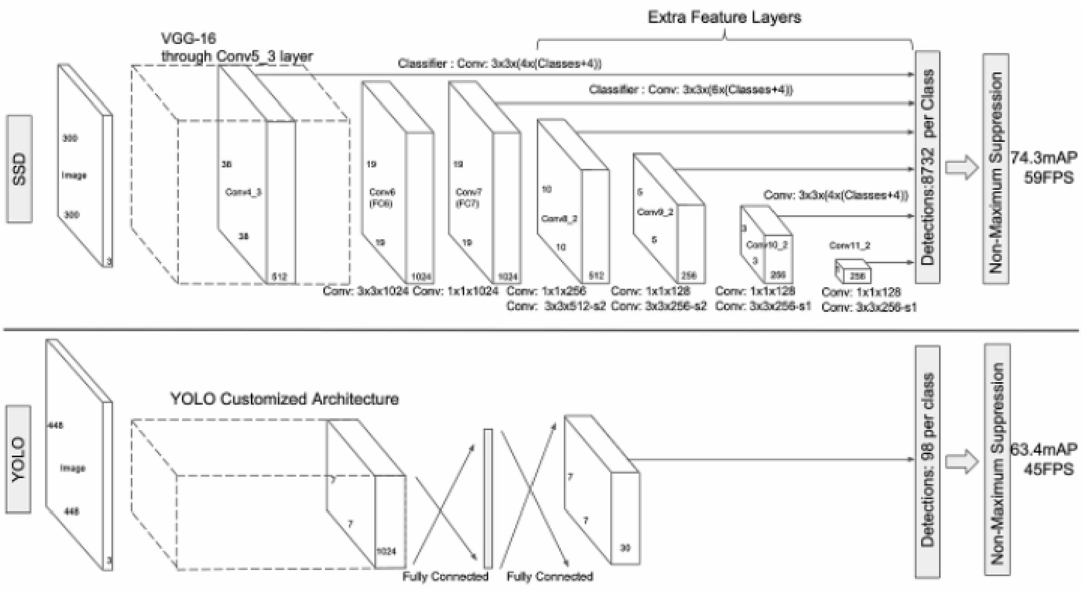


Figure 25 SSD Architecture

Single Shot Object Detection (SSD) detects multiple objects in an image with a single shot. The SSD method is based on a feed-forward convolutional network, which generates a fixed-size collection of bounding boxes and scores for the presence of object class instances within those boxes.

It is divided into two parts:

1. Extract feature maps
2. Detect objects using a convolution filter.

SSD is designed to be independent of the base network, allowing it to run on top of any base network, including VGG, YOLO, and MobileNet.

MobileNet was integrated into the SSD framework to address the practical limitations of running high-resource and power-consuming neural networks on low-end devices in real-time applications. As a result, when MobileNet is used as the base network in the SSD, it is referred to as MobileNet SSD.

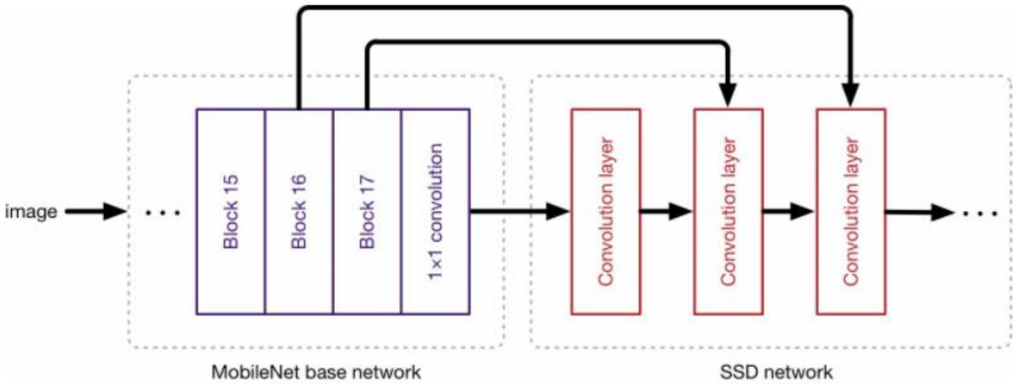


Figure 26 Mobile Net SSD overview

The Mobile Net SSD method was trained on the COCO dataset and then fine-tuned on the PASCAL VOC dataset, achieving 72.7 percent mAP (mean average precision).

7.3.1.2 Tracking Online And In Real Time With A Deep Association Metric

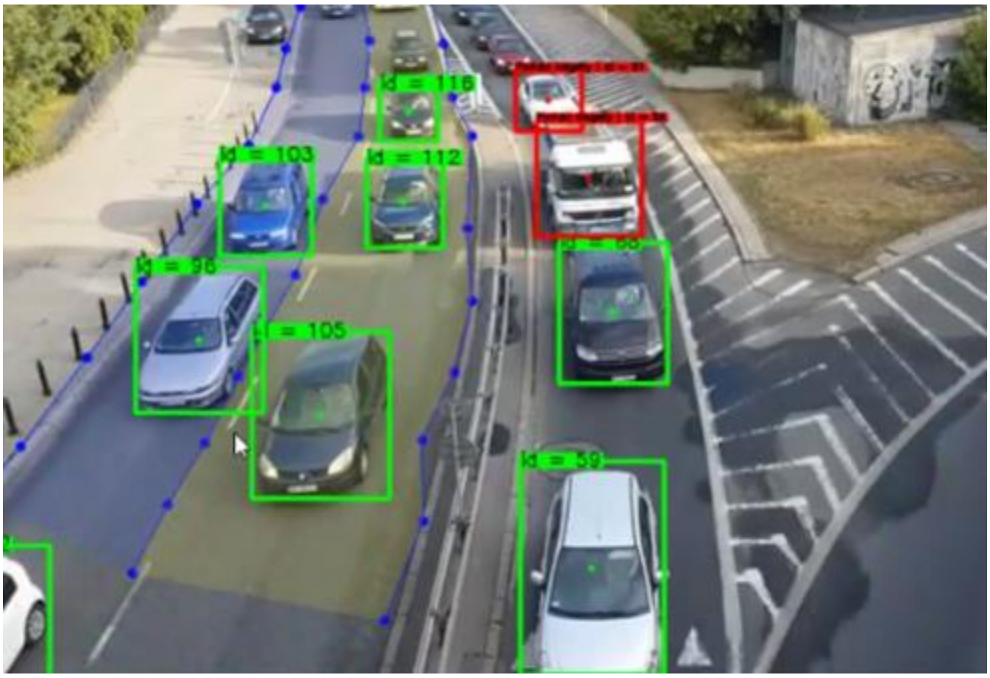


Figure 27 Vehicle Tracking and Counting Using Deep Sort

SORT returns a relatively high number of identity switches despite achieving overall good performance in terms of tracking precision and accuracy. This is because the employed association metric is only accurate when the uncertainty in state estimation is low. As a result, SORT struggles to track through occlusions, which are common in frontal-view camera scenes. We solve this problem by replacing the association metric with a more informed metric that incorporates motion and appearance data. We use a convolutional neural network (CNN) that has been trained on a large-scale vehicle re-identification dataset. We increase robustness against misses and occlusions by integrating this network, while keeping the system simple to implement, efficient, and applicable to online scenarios. To facilitate research experimentation and practical application development, we have made our code and a pre-trained CNN model publicly available.

```python
@jit
def iou(bb_test, bb_gt):
    """
    Computes IUO between two boundary boxes in the form [x1,y1,x2,y2]
    """
    xx1 = np.maximum(bb_test[0], bb_gt[0])
    yy1 = np.maximum(bb_test[1], bb_gt[1])
    xx2 = np.minimum(bb_test[2], bb_gt[2])
    yy2 = np.minimum(bb_test[3], bb_gt[3])

    w = np.maximum(0., xx2 - xx1)
    h = np.maximum(0., yy2 - yy1)
    wh = w * h
    o = wh / ((bb_test[2] - bb_test[0]) * (bb_test[3] - bb_test[1])
    + (bb_gt[2] - bb_gt[0]) * (bb_gt[3] - bb_gt[1]) - wh)

    return(o)
```

Figure 28 omputes IUO between two boundary boxes in the form [x1,y1,x2,y2]

7.3.1.3 Detections are assigned to the tracked object (both represented as bounding boxes)

Returns 3 lists of matches, unmatched detections and unmatched trackers

```python
def associate_detections_to_trackers(detections, trackers, iou_threshold = 0.3):
    """
    Assigns detections to tracked object (both represented as bounding boxes)

    Returns 3 lists of matches, unmatched_detections and unmatched_trackers
    """
    if len(trackers) == 0:
        return np.empty((0, 2),dtype=int), np.arange(len(detections)), np.empty((0, 5),dtype=int)
    iou_matrix = np.zeros((len(detections), len(trackers)), dtype=np.float32)

    for d, det in enumerate(detections):
        for t, trk in enumerate(trackers):
            iou_matrix[d,t] = iou(det, trk)
    # Minimise the total assignment cost
    matched_indices = linear_assignment(-iou_matrix)
    matched_indices = np.asarray(matched_indices)
    matched_indices = np.transpose(matched_indices)
    # Find unmatched detections
    unmatched_detections = []
    for d, det in enumerate(detections):
        if d not in matched_indices[:, 0]:
            unmatched_detections.append(d)

    # Find lost tracklets
    unmatched_trackers = []
    for t, trk in enumerate(trackers):
        if t not in matched_indices[:, 1]:
            unmatched_trackers.append(t)
```

Figure 29 Assigns detections to tracked object

7.3.2 Kalman Filters process

Following the initial detection, the detected data (bounding box positions) are compared with the bounding box positions of the existing KalmanBoxTracker objects (tracking data objects) using an Intersection Over Union (IOU) matrix at a discrete interval of the frame sequence (once every 4 frames). If the newly detected objects do not match any existing tracking data objects, they are routed to the next stage of the pipeline. When a tracking object is associated with a detected object, the hit streak attribute in the corresponding KalmanBoxTracker object is increased by one and the time since update attribute is set to zero. This attribute stores the number of consecutive track detect position matches observed by each tracking object.

```python
class KalmanBoxTracker(object):
    """
    This class represents the internal state of individual tracked objects observed as bbox.
    """
    count = 0
    def __init__(self, bbox, length, stdvar,img=None):
        """
        Initialises a tracker using initial bounding box.
        """
        # Define constant velocity model
        self.kf = KalmanFilter(dim_x=7, dim_z=4)
        self.kf.F = np.array([[1,0,0,0,1,0,0],[0,1,0,0,0,1,0],[0,0,1,0,0,0,1],[0,0,0,1,0,0,0],  [0,0,0,0,1,0,0],[0,0,0,0,0,1,0],[0,0,0,0,0,0,1]])
        self.kf.H = np.array([[1,0,0,0,0,0,0],[0,1,0,0,0,0,0],[0,0,1,0,0,0,0],[0,0,0,1,0,0,0]])

        self.kf.R[2:, 2:] *= 10.
        self.kf.P[4:, 4:] *= 1000.
        self.kf.P *= 10.
        self.kf.Q[-1, -1] *= 0.01
        self.kf.Q[4:, 4:] *= 0.01
```

Figure 30 KalmanBoxTracker implemantation

7.3.3 System used python libraries

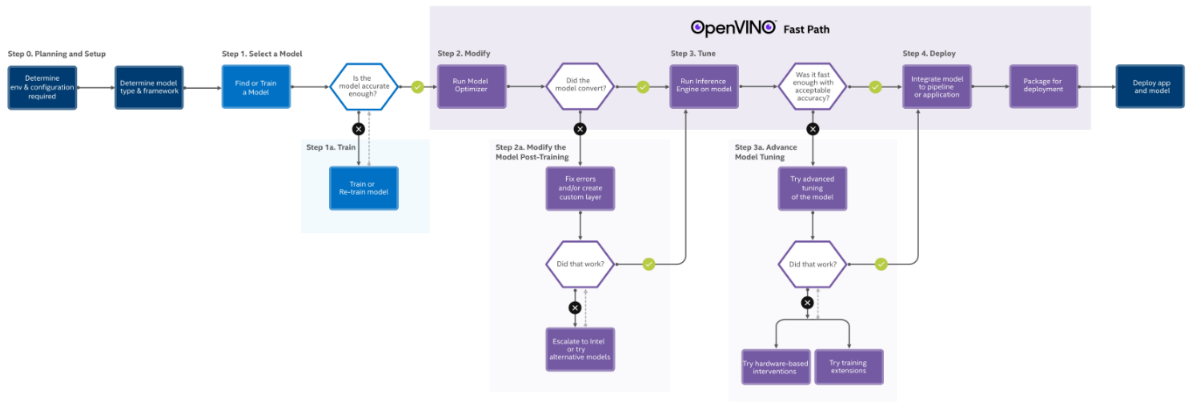
pip install -r requirements.txt

```
certifi==2021.5.30
charset-normalizer==2.0.3
cycler==0.10.0
filterpy==1.4.5
idna==3.2
kiwisolver==1.3.1
llvmlite==0.36.0
matplotlib==3.3.4
numba==0.53.1
numpy @ file:///D:/bld/numpy_1626682185159/work
Pillow==8.3.1
pyparsing==2.4.7
python-dateutil==2.8.2
PyYAML==5.4.1
requests==2.26.0
scipy==1.5.4
six==1.16.0
urllib3==1.26.6
wincertstore==0.2
```

Figure 31 requirements.txt

7.3.3 1 Optimizer (Open Vino)

The optimizer is a critical component of the model. With the release of 2018 R3, the Model Optimizer introduces a new method for converting models created with the TensorFlow* Object Detection API. In comparison to the previous approach, the new process yields more accurate inference results and does not necessitate the modification of any configuration files or the provision of complex command line parameters.



Model Preparation

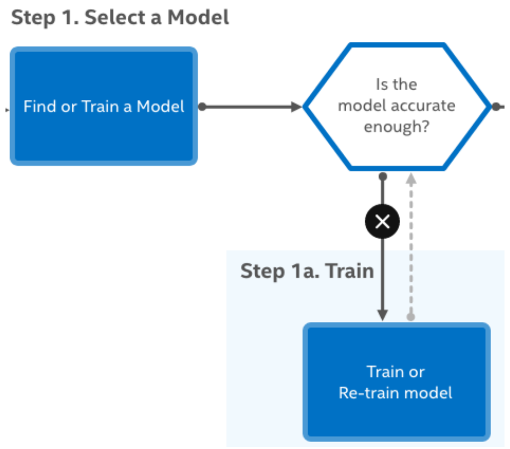


Figure 32 Model Preparation

Model Conversion

Because neural networks contain layers that are not on the list of known layers for supported frameworks, you can use Custom Layers to modify the conversion and optimization process.

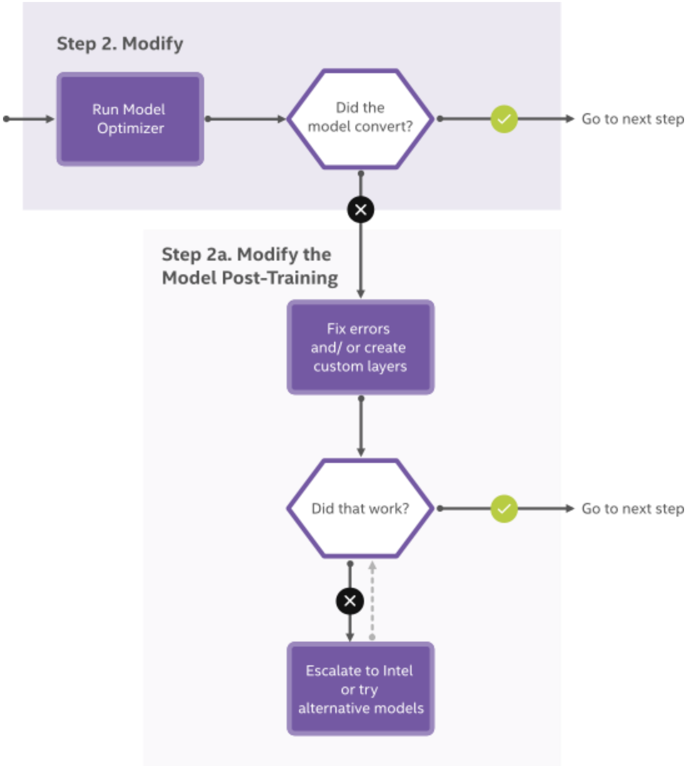


Figure 33 Model Conversion

Running and Tuning Inference

Use the Post-training Optimization Tool to accelerate deep learning model inference by quantizing it to INT8. The Model Quantizer utility can be used to quantize Open Model Zoo models.

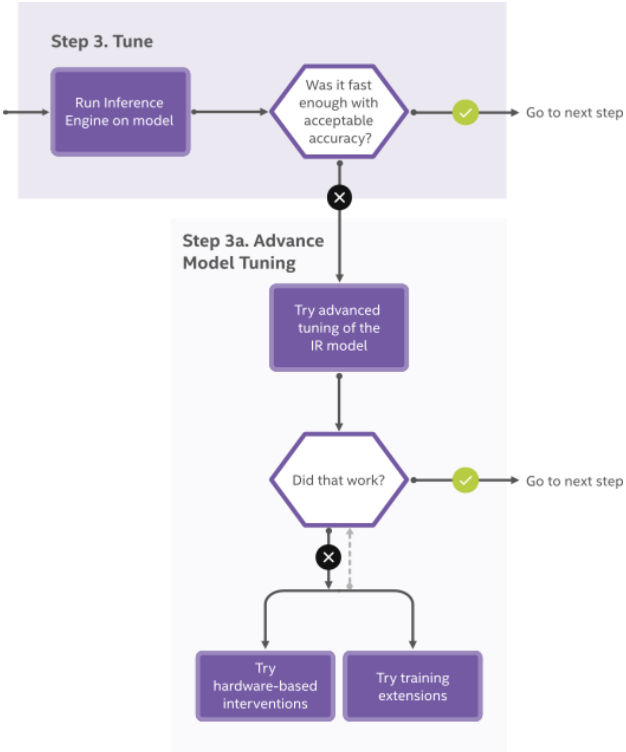


Figure 34 Running and Tuning Inference

Vehicle-detection-0202

```xml
<?xml version="1.0" ?>
<net name="vehicle-detection-0202" version="10">
    <layers>
        <layer id="0" name="image" type="Parameter" version="opset1">
            <data element_type="f16" shape="1, 3, 512, 512"/>
            <output>
                <port id="0" names="image" precision="FP16">
                    <dim>1</dim>
                    <dim>3</dim>
                    <dim>512</dim>
```

Figure 35 xml file

This is a vehicle detector with two SSD heads from 1/16 and 1/8 scale feature maps and clustered prior boxes for 512x512 resolution based on the MobileNetV2 backbone.

Eg:

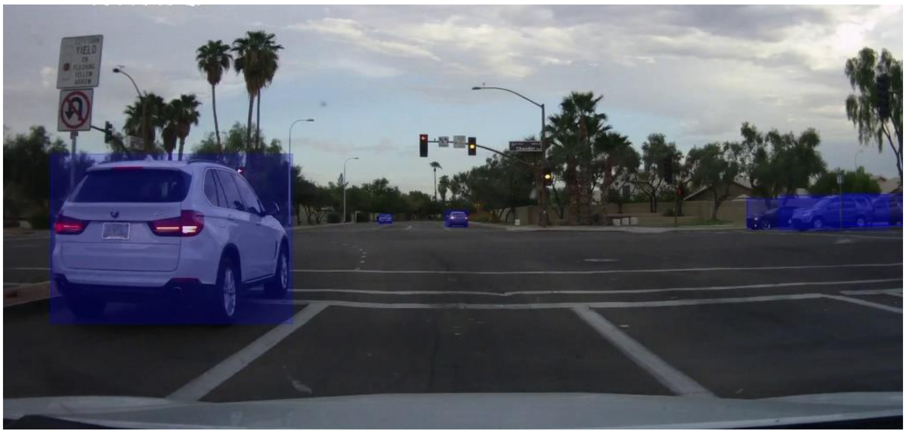


Figure 36 vehicle detector that is based on MobileNetV2

5.3. Generate Video

For video generation, this approach provides non-technical users with basic functionalities such as adding videos and camera details.

```
Save = Checkbutton(gui, text="Save Video", variable=varck,
                   bg='light green',font=("Helvetica", 10))
Save.place(x=111, y=404,anchor='c')

Load = Button(gui, text="Load", fg="Black",
```

Figure 37 saved video

5.4. Implementation of APIs

This system has a lot of API calls to handle all data requests. Core API implementations are listed below.

1. For Uploading the video file
2.

```
Input = Button(gui, text="Input DIR", fg="Black",
               command=input_path,height=2, width=19)
Input.place(x=111, y=30,anchor='c')
Output = Button(gui, text="Output DIR", fg="Black",
                command=output_path,height=2, width=19)
Output.place(x=111, y=100,anchor='c')
```

3. Assigns detections to tracked object

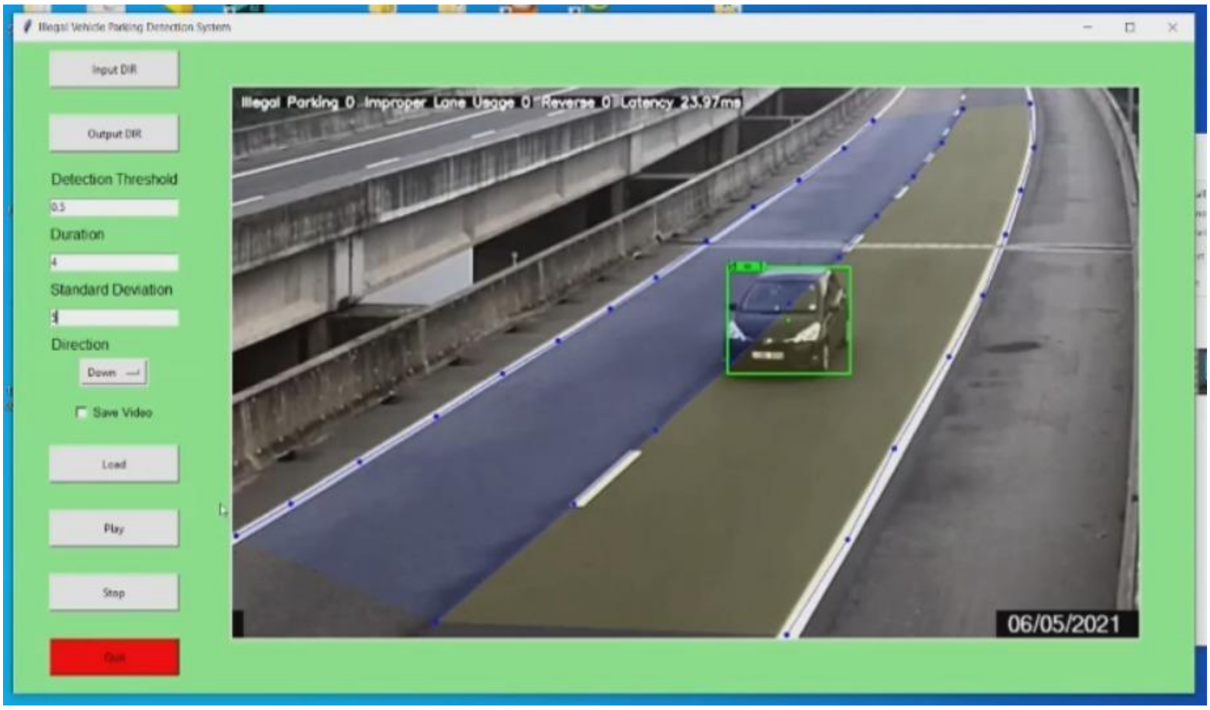
```
"""
if len(trackers) == 0:
    return np.empty((0, 2),dtype=int), np.arange(len(detections)), np.empty((0, 5),dtype=int)
iou_matrix = np.zeros((len(detections), len(trackers)), dtype=np.float32)

for d, det in enumerate(detections):
    for t, trk in enumerate(trackers):
        iou_matrix[d,t] = iou(det, trk)
# Minimise the total assignment cost
```

4. Count Vehicles

```
self.frame_count += 1
# Get predicted locations from existing trackers.
trks = np.zeros((len(self.trackers), 5))
to_del = []
ret = []
for t, trk in enumerate(trks):
    pos = self.trackers[t].predict(img) #for kal!
    trk[:] = [pos[0], pos[1], pos[2], pos[3], 0]
```

5.5. User Interface



6. TESTING

6.1. Overview

The main focus of this chapter is applying different test process to proposed prototype. In order to ensure the prototype is working according to expectation, the Author outlines test targets and objectives, including test criteria for the system, and fits the requirements outlined in the existing chapters. Then author will test the functional and non-functional requirements of the prototype after identifying and defining the test criteria based on the provided test scheme in this chapter. In addition, throughout the testing stage, limitations and evaluations will be documented in this chapter.

6.2. Testing Objectives and Goals

The objective of testing is to determine whether or not the intended requirements are satisfied in the actual system and to keep the system consistent. The following research objectives were established in attempt to optimize the testing process.

a) To verify whether the proposed approach satisfied the functional requirements.
b) To verify whether the proposed approach satisfied the non-functional requirements.
c) Verify whether the proposed hybrid model and Virtualization working properly.
d) Identify any bugs or flaws that were overlooked during advancement.

6.3. Criteria for Testing

- **Functional Quality** - Functional quality is a type which includes in testing where the functional requirements are tested in the system.
- **Structural Quality** - Non-functional requirements for the project, as well as aspects such as code quality, will be validated.

Name of the Test	Description	Test Category	Status
Functional Testing	To verify whether the proposed approach satisfied the functional requirements.	Black Box	Done

Non-Functional Testing	To verify whether the proposed approach satisfied the non-functional requirements.	Black Box	Done
Module and Integration Testing	To verify combine components work as expected.	Both	Done
Accuracy Testing	To verify the accuracy of the proposed approach.	Black	Done
Performance Testing	To verify the performance of the proposed approach	Black	Done

6.4. Model Testing

Model testing is a method of determining test cases based on a demonstration that represents the beneficial characteristics of the framework under test.

8.4.1. Tensor board

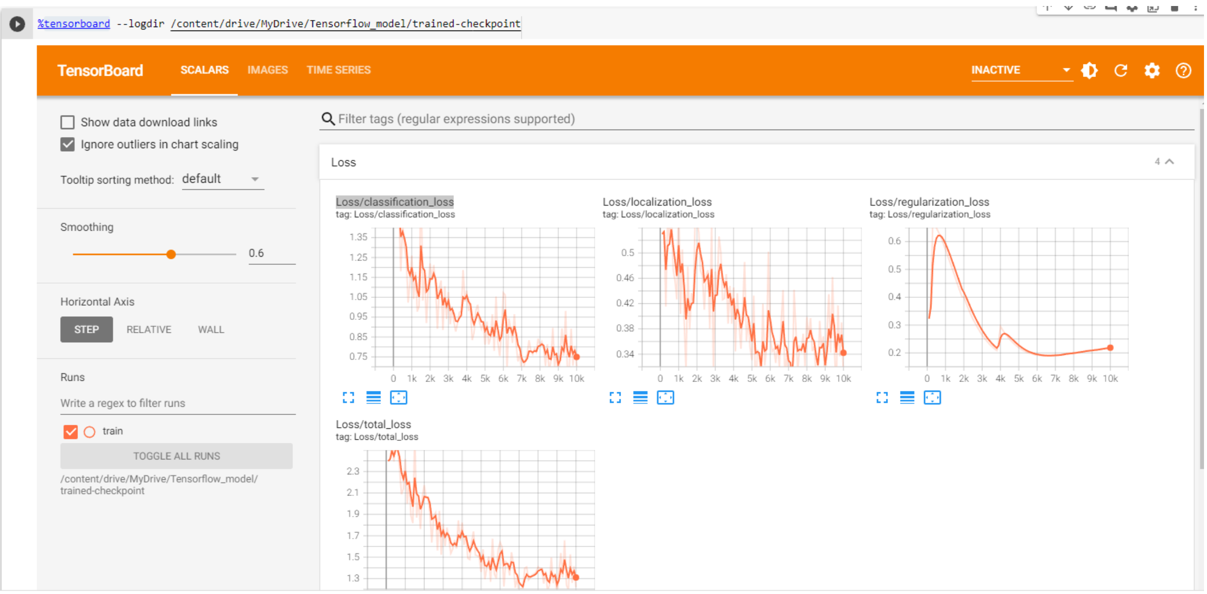


Figure 38 Tensorboard

Vehicle classification loss

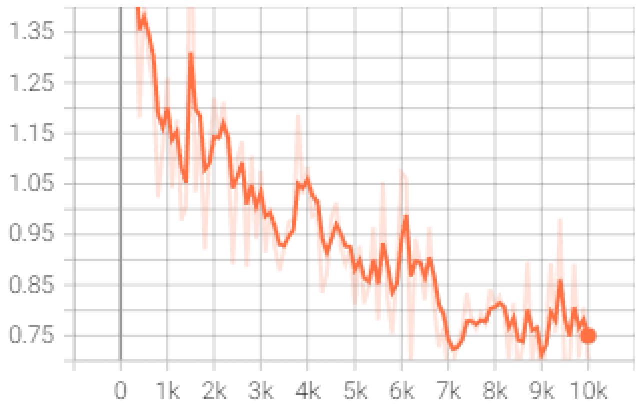


Figure 39 classification loss

Bounding box Localization loss

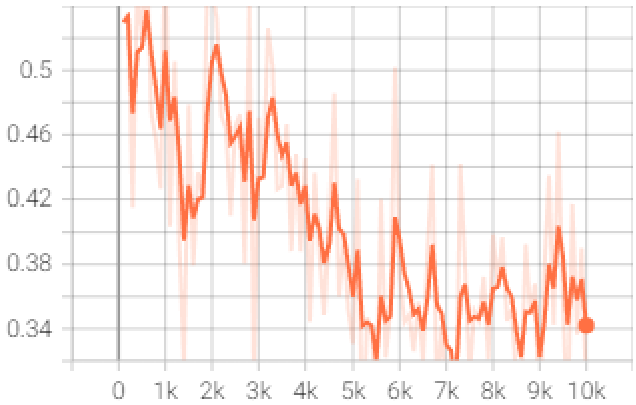


Figure 40 Bounding box Localization loss

6.5. Accuracy

6.5.1. Model Specification

METRIC	VALUE
Average Precision (AP)	90.6%
Target vehicle size	40 x 30 pixels on Full HD image
Max objects to detect	200
GFlops	2.798
MParams	1.079
Source framework	Caffe*

6.6. Benchmarking

6.6.1. Competitive Benchmarking

Under Literature review, exiting systems of normal vehicle detection systems were identified. In this section author tried to compare the novel approach with the existing systems based on accuracy. The majority of researchers have focused on state-of-the-art approaches.

Vehicle detection: speed and accuracy comparison (Faster R-CNN, R-FCN, SSD, FPN, RetinaNet and YOLOv3)

Performance:

Method	mAP	FPS	batch size	# Boxes	Input resolution
Faster R-CNN (VGG16)	73.2	7	1	~ 6000	$\sim 1000 \times 600$
Fast YOLO	52.7	155	1	98	448×448
YOLO (VGG16)	66.4	21	1	98	448×448
SSD300	74.3	46	1	8732	300×300
SSD512	76.8	19	1	24564	512×512
SSD300	74.3	59	8	8732	300×300
SSD512	76.8	22	8	24564	512×512

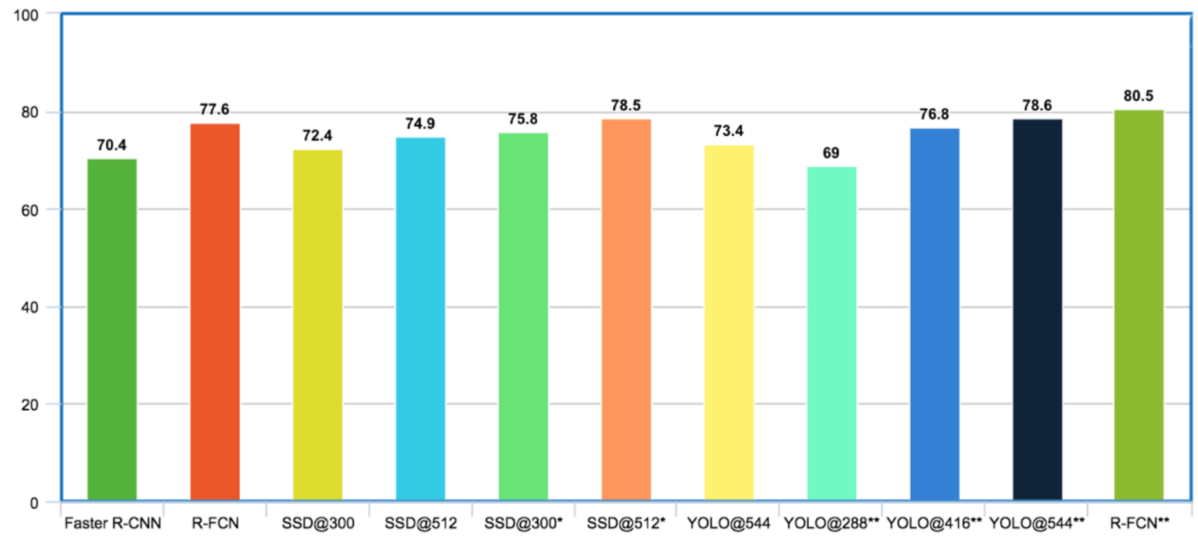
Figure 41 Speed is measure with a batch size of 1 or 8 during inference.

Result on MS COCO:

Method	data	Avg. Precision, IoU:			Avg. Precision, Area:			Avg. Recall, #Dets:			Avg. Recall, Area:		
		0.5:0.95	0.5	0.75	S	M	L	1	10	100	S	M	L
Fast [6]	train	19.7	35.9	-	-	-	-	-	-	-	-	-	-
Fast [24]	train	20.5	39.9	19.4	4.1	20.0	35.8	21.3	29.5	30.1	7.3	32.1	52.0
Faster [2]	trainval	21.9	42.7	-	-	-	-	-	-	-	-	-	-
ION [24]	train	23.6	43.2	23.6	6.4	24.1	38.3	23.2	32.7	33.5	10.1	37.7	53.6
Faster [25]	trainval	24.2	45.3	23.5	7.7	26.4	37.1	23.8	34.0	34.6	12.0	38.5	54.4
SSD300	trainval35k	23.2	41.2	23.4	5.3	23.2	39.6	22.5	33.2	35.3	9.6	37.6	56.5
SSD512	trainval35k	**26.8**	**46.5**	**27.8**	**9.0**	**28.9**	**41.9**	**24.8**	**37.5**	**39.8**	**14.0**	**43.5**	**59.0**

Figure 42 COCO test-dev2015 detection results

Accuracy Comparison



SSD can be trained from beginning to end to improve accuracy. SSD makes more predictions and has a wider range of coverage for location, scale, and aspect ratios. With the improvements mentioned above, SSD can reduce the input image resolution to 300 300 while maintaining a comparable accuracy performance. By removing the delegated region proposal and using lower resolution images, the model can run in real-time and still outperforms the state-of-the-art Faster R-CNN in accuracy.

Fastest

- SSD with Mobile Net offers the best accuracy-to-speed ratio among the fastest detectors.
- SSD is fast, but it performs poorly for small objects when compared to others.
- With lighter and faster extractors, SSD can outperform Faster R-CNN and R-FCN in accuracy for large objects.

6.7. Functional Testing

#	Requirement	Input Process	Expected output	Actual output	Status
1	Upload CCTV video	Click on the "Upload File" button and then choose the video (s).	Display the video file in the video Panel with a classification label.	Display the video file in the video Panel with a classification label.	Pass
2	Input detection threshold value, duration, standard deviation	detection threshold value = 0.5, duration=4, standard deviation=5	User can see the input fields filled	User can see the input fields filled	Pass
3	Generate video	User must select button save video.	Saved parking & lane violation detection video	Saved parking & lane violation detection video	Pass
4	Draw the lanes	Mark 1st lane and 2nd lane	Real time detection lane violation vehicles	Real time detection lane violation vehicles	pass
5	Click play button	Click play button	User can view real time parking & lane violation detection	User can view real time parking & lane violation detection	pass

6.8. Non-Functional Evaluation

6.8.1. Model Accuracy Testing

In model accuracy testing, the author tests this novel approach with different methods.

Data Train : Data Test (%)	Threshold (%)	Number of False Detection	Object Detection Accuracy Level (%)	Output Sound Accuracy Level (%)
70 : 30	85	14	85,86	100
80 : 20		8	91,92	100
90 : 10		5	94,95	100

Figure 43 Result of Accuracy of Output

- Classification Report

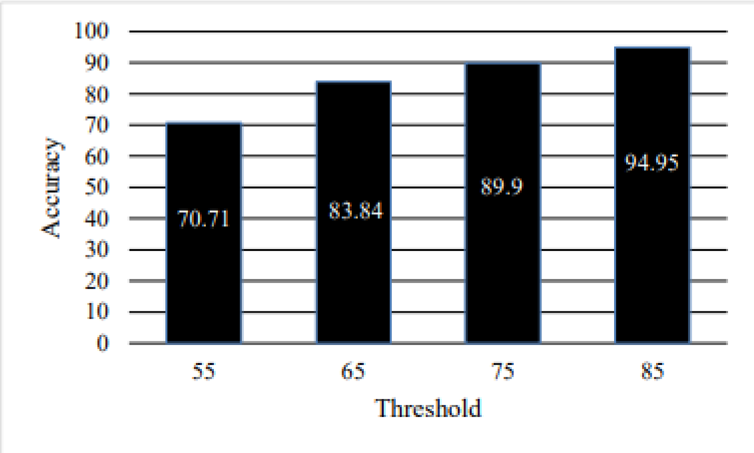


Figure 44 Accuracy with 90% : 10% of Training Data and Testing Data

6.9. Limitations of the testing process

Since this is a deep learning study in the vehicle detection industry. Complications will inevitably arise during the production and testing phases. In order to address these constraints, the production process must be continued for a prolonged period of time. The restrictions are listed below,

- The number of different datasets of real CCTV video data to validate the systems directly impacts accuracy and other metric metrics. It would be excellent if they were obtained using various background data collection techniques/devices.
- According to the Covid-19 outbreak, domain and technical evaluators was tested the system in limited circumstances.

7. SYSTEM EVALUATION

7.1. Evaluation Overview

The previous chapter described the testing process for the implemented system, and it was determined that the application meets the required proposed specifications. The author discusses how he plans to evaluate this project in this chapter. It was carried out using a variety of evaluation criteria, self-evaluation, and different evaluators to determine the advantages and disadvantages of the prototype.

7.2. Methodology and Approach to Evaluation

The process of evaluation is the most significant phase of a successful research project based on evaluated comments and feedbacks from the domain and technical evaluators. Evaluation results will likely indicate that there are advantages and limitations in the program considering key system components. It is viewed as the main qualitative process in which the potential benefit based on stated criteria can be calculated. Due to the COVID19 circumstance, all evaluators were contacted via telephone and online meetings. The expressway management and technical domain experts have a very busy schedule and very limited time to spend extra work. So, the author tried to get the best value from the received timeslot. Then author fully focused on getting evaluation ideas and all the feedbacks wrote in a paper. After that inserted into the report. To analyze qualitative data thematic analysis has been selected. Based on the prototype analysis, quantitative evaluations were made. Then, findings in comparison with similar items identify the limitations. The following subsections explain evaluation criteria and outcomes.

7.3. Evaluation Criteria

As an evaluation process for the approach implemented, qualitative and quantitative techniques have been adopted. In accordance with the evaluation criteria indicated below, the application will be evaluated by appointed evaluators.

No	Criteria	Purpose of Evaluating
1	The project's overall concept.	To receive feedback of the proposed system whether how important to the domain.

2	The project's complexity and scope.	To better evaluate the project scope, domain experts must evaluate whether the domain's context is specifically described
3	The design, architecture, and implementation of the system	To determine whether finished product meets the required specifications.
4	Proposed solution and prototype	To evaluate whether if an acceptable proof of concept has been provided in implementing the proposed system.
5	Future enhancements and limitations in proposed solution.	To identify the limitations and how it achieves in future enhancement.

7.4. Self-Evaluation

Criteria	Evaluation
The project's overall concept.	The proposed complete parking and lane violation analyzing system is reduce traffic police experts valuable time and support them to get more efficient final decision. Most of research focused only classification, pre trained models and limited number of abnormalities. Most of the management domain users have not technical knowledge with numeric values or graph readings. So, there is no decision support system for non-technical expressway management domain users. Also, expressway management domain and technical domain experts are very satisfied about proposed concept for this fulfillment of research gap. Therefore, the author's concept is very important and reasonable for the development of AI systems in the current situation.
The project's complexity and scope.	The author's scope was very much affected by the timelines of the project. In PhD and MSc projects with many people and several years to spend, most abnormality classification research is also developed. In less than 6 months, this project was to be developed. The scope was therefore narrowed to supervised learning and only to simple detection tests. Under

	this scope, the depth was successfully researched. More efforts should also be made in the future to establish various sorts of learning.
The system's design, architecture and implementation	Design and architecture have been evolved successfully using tiered architecture. The virtualization and report were done well with an exciting GUI. The technologies to be used were very thoroughly examined.
Proposed solution and prototype	The prototype has been well developed and includes the proposed solution according to software engineering standards. Although further improvements can be made to the performance of the system, it was sufficient for this research endeavor.
Future enhancements and limitations in proposed solution.	Future enhancements and limitations are discussed in conclusion and Real-time detection and combine more violation detection testing methods are important future works. The small dataset is the one of major limitations and it must be expanded to get more efficient results.

7.5. Selection of the Evaluators

Domain Category	Name	Evaluating Criteria
Expressway management	Mr. Sadaruwan Gamwarige Control Room Operator at Southern Expressway	To Evaluating Criteria table, 1,2,3, and 5 criteria are evaluated.

7.6. Evaluation Result

7.6.1. The project's overall concept.

Mr. Sadaruwan	Great idea, Currently, we haven’t a solution like this for automated

Gamwarige	parking and lane violation detection testing. This solution will make remarkable improvements in traffic rues violated vehicle detection. This is very interesting and impressive concept with advancement of technology. Other important thing is saving the time of traffic police members and this solution will help to get the right fast decisions with a high-efficiency rate.

7.6.2. Project's complexity and scope.

Mr. Sadaruwan Gamwarige	Parking violation detection and lane violation detection are too wide area, and this proposed solution is nicely narrow down into traditional identify manually parking violation detection. It will help to get more accurate result and time management stuff. But this is very challenging.

7.7. Summary of project's complexity and System Scope Evaluation

The examiners conclude that the project's identified scope of this research have been clearly demonstrated, and positive feedback has been received. According to evaluation, the declared scope is a great contribution to the software and automated identify domains.

7.7.1. System's design, architecture, and implementation.

Mr. Kasun Gamage	During the demonstration, the architecture and design flow discussed are very detailed and nicely designed. His design, architecture, and implementation are one of the greatest options he took following his research into existing research work. Virtualization part also very interesting and challenging part for undergraduate student.

7.8. Summary of System's design, architecture, and implementation Evaluation

The technical domain specialists done this design, architecture and implementation evaluation. The selection of design and implementation of technologies was received from most evaluators with excellent feedback.

Proposed solution and prototype

Mr. Sadaruwan Gamwarige	Prototype for usage purpose is simple and perfect. The approach student developed is an excellent piece of work and I respect his encouragement to design and implementing such a system.

7.8.1. Future enhancements and limitations in proposed solution

Mr. Sadaruwan Gamwarige	The project Limitations and further works have been completely justified.

7.9. Limitations of Evaluation

Effectively the Covid-19 pandemic terminated all world activities. In addition, Sri Lanka has gone into lockdown in order to avoid a global disaster. Unfortunately, the project's evaluation had to be completed at this time. Expressway management members have evaluated that system. Furthermore, violation detection domain specialists were unable to gain access due to the situation at Covid-19. Thus, to meet these difficulties, the approach of evaluation needs to be changed.

7.10. System Functional Requirements Evaluation

No	System Requirement		Level of Priority	Status
FR1	In order to upload the videos, users need to have access to the local machine.		High	Implemented
	Description	To obtain the lane violation detection, video		

		file of the CCTV's should be uploaded.		
FR2	The video that are uploaded have to be processed.		High	Implemented
	Description	To classify the detection, the video that are uploaded need to be processed.		
FR3	System should display all the violated vehicle count scores.		High	Implemented
	Description	The transparency is high when all the final scores are displayed and saved.		
FR4	System should generate detected vehicle		High	Implemented
	Description	By using new detection techniques, the video that contains the mismatch due to the violation is highlighted.		
FR5	System should generate video that could be understood by the non-technical personnel.		High	Implemented
	Description	The final video includes all the identified traffic rules violated vehicles.		

7.11. System Non-Functional Requirements Evaluation

No	System Requirement	Level of Priority	Status
NR1	**System Accuracy:** When identifying in parking & lane violation in the detection, the accuracy level need to be high because the people who use this system do not have technical expertise. Further this finally affects the decision of the legal.	High	Implemented

NR2	**Performance:** The users need the results with minimum wait time. They do not want to wait many hours looking for the results. This system provides results within a few minutes.	High	Implemented
NR3	**Usability:** The target audience of this system is non-technical personnel. Since they do not have technical knowledge and also since it's not their job, the system should be user friendly and easy to handle.	Medium	Implemented
NR4	**Maintainability:** Due to the rapid changes in violation detection, code changes and other different changes would need to add to the system while going forward. In order to add or remove features from the system, the proposed solution needs high maintainability.	High	Implemented
NR5	**Extendibility:** The ability to extend the solution is easy to identify new violation detection.	Medium	Implemented

7.12. Summary

The chapter's assessment was hampered by the Covid-19 condition that prevailed in the region. This shifted the way people think of assessment. Professionals from the traffic management sector and the deep learning sector were used for the test due to the complex circumstances. Among them, the idea piqued my curiosity. Good feedback was also provided to the other assessment parameters. The possibility of implementations in other fields of vehicle detection was a popular comment given to the author. Many of the system's functional and non-functional specifications are met. Finally, the author's self-evaluation revealed that he is happy with the work he has done with this project.

8. CONCLUSION

8.1. Overview

The final section elaborates of the development's goals and priorities. Following that, the author shows how he used the experience he gained during his degree and how he used his current skills. After that, we'll talk about learning results before going on to shortcomings and violation detection. Following that, the chapter details the achievements and publications that were made. Finally, the chapter addresses how the method will be improved in the future.

8.2. Research Aims and Objectives Achieved

8.2.1. Project Aim

The study's goal is to design, develop, and test accurate parking violation and lane violation analyzing system that can generate a report which can be easily understandable by non-technical users. This system is based on the main automated detection. Initially, the author aimed to give this valuable system to expressway traffic management. But after questionnaire findings and advice of traffic police domain experts, this system was restricted to only expressway management domain.

Completion of the project's objectives

Objective	Description	Status	Evidence
Literature Survey	• Examine previous traditional detection studies and the machine learning models that were used. • The development of an integrated system would be aided by research into various technologies. • Identifying databases of CCTV datasets from expressway and analyzing the composition of the data set.	Complete	Chapter 02

Requirement Analysis	• Expressway management members on the real-world applicability of vehicle detevtion & classification schemes before making recommendations. • Learn about the functionality that should be included in the integrated system's GUI to meet the needs of expressway.	Complete	Chapter 04
Design	Create prototypes that resolve the following issues: • A data input feature that wraps or converts data into the required data structure for high classification accuracy. • To boost feature extraction, create a machine learning model. • Create a deep learning approach to increase detection accuracy. • Create visualization for highlight the identified restricted area. It will help to misleading decisions. • Create video including identified veicles and vehicle details. It will help to get final decisions.	Complete	Chapter 06
Development	• Implement a prototype with built elements, such as a data input element, a deep learning model, visualization and a video representation.	Complete	Chapter 07

Testing	• Evaluate the proposed prototype. • Prototypes should be tested on both a unit and a practical basis. • In comparison to current ML and mathematical models created by experts, you should use the automated method. • Requirements, both practical and non-functional, and accuracy evaluation.	Complete	Chapter 08

8.3. Use of New Skills

The author experienced multiple interesting concepts during this project and a few of them are,

- How to do deep research in wide area and how critical narrow down into important part.
- How to label images from CCTV video
- Comparing and critical evaluation of different approaches and techniques
- Critically identify the functional and non-functional requirements.
- In implementations, author got lot of experience with TensorFlow and openvino using their different kind of algorithms.
- How to work with a new technology and how it can be handling.
- How to proper research documentation.

8.4. Achievement of Learning Outcomes

Many lessons were learned and experienced at the conclusion of the research study. Below are the learning results obtained from the project,

Learning Outcomes	Description
L1	Research and development process and workflows. The method differs greatly from the implementation of apps. The whole thing is that systematically there are open improvements and solutions with the appropriate time and deduction

	approaches are found. For the remainder of his life, the author would continue to keep things going.
L2	The most appropriate tools, techniques and methods are analyzed. Identify a significant research gap for success of research.
L3	To understand the basics of this project is to learn how to manage data sets of machine learning projects. When you have the basic and systemic knowledge about information, it is just an application for most people to use ML algorithms to achieve the results you need.
L4	Was able to scratch at mathematical mathematics skills. Instead of libraries doing all the process management, you should do it yourself. I gained experience in developing and analyzing machine learning algorithms from the ground up, as well as computational math.
L5	Assists with understanding the importance of being on schedule and well planned in both science and life
L6	This research gave me to machine learning experience, and it was a fantastic chance to learn more about it.
L7	In research project, self-learning is the most important thing for problem solving and error handling. The author achieved all the thigs by self-learning.

8.5. Problems and Difficulties

Problems and Challenges	**Solution and description of the problem**
Improper problem domain experience	The project related to violation detection domain, and it has wide area of domain knowledge. Also, the author has minimum experience of it. These topics are explored in depth at traffic police detection level studies due to their complexity. As an outcome, in order to define and develop the project, the researcher will have to dedicate significant time to reading additional research articles.
Lack of dataset	The most important thing in the data science research project is a valid, balanced data set. Also, the final performance of the projects based on data size and quality of the data. Therefore, the author had to search suitable data set in the initial stage of the project. But there was limited dataset

	for CCTV video after label images. After refereeing a lot of research papers and reviews, the author found balanced violated vehicle detection.
Lack of resource requirements	The author had lot of experiments for creating the model and testing the model. Author had normal laptop and it is not possible to use training. So author used, google Colab and another cousin’s laptop for get more accuracy and other experiments.
Limited time frame	Another serious issue throughout the process was the lack of time. Unexpected challenges arose as a result of the global outbreak crisis, causing the development and testing of core functionality to take much longer. The author followed time management and techniques and well scope into specific area.
Lack of Testing	Specially in visualizing part, author had major issues with output. Because of he hasn’t knowledge about the detection of lane. So, author resolve this issue working with Mr. Sadaruwan. He helps to test one by one video and it will help to get more accurate system.

8.6. Deviations

In this final year research project, the author's initial topic was finalized and submitted on the CDAP “Detecting and classification for traffic rules violated vehicles”. But as he progressed by exploring the literature review and implementation deeply, the author had to change the detection of violation test type and data type due to below reasons,

- Limited Resources - Video processing wants high resources.
- Unbalanced huge video datasets (2TB CCTV data) -Regarding CCTV video dataset, it has huge size of each video and lot of videos are not labeled.

Due to the above reasons, the author changed the idea into real time camera processing detection. Other gaps are same as cover in this violated vehicle detection test. So, visualization and output video generation are implemented as promised.

8.7. Limitations of the Research

Limitations	Description of Limitation
Dataset	Was unable to find suitable more various data include dataset.
Limited Evaluators	In covid 19 pandemic situation in lockdown country very busy and they haven't lot of time to evaluation. So, evaluation was limited to few people.
Visualization Testing	In virtualization, the author cannot test more scenarios, because of one evaluator contribute to test less than 10 videos. It is not sufficient to testing. So, its done in limited time.

8.8. Future Enhancements

Considering the development of the proposed system to a very successful level, several components have been identified which have to be evaluated and handled to accomplish future improvements. In addition, master's level with higher-resource environments have found project scope-related literature. With regard of the fact that this project has been conducted in compliance with a bachelor's degree constraint, further improvements are listed below.

Enhancements	Description
Real time video processing	So, these systems should be update with those high video processing.
Enhance the balance dataset	Overfitting is the major problem in unbalanced and small datasets. So, enhancement of balanced dataset will give more accuracy and prevent the overfitting.
Complete solution for two violation types	Combine solution for violation detection and tests. It can be identified easy.
Identify different time	When the rainy time, evening time parking & lane violation detection.
One platform to all traffic rules violated detection system.	This platform will be very useful to safe the valuable traffic police expert's time.

8.9. Concluding Remarks

This research is focus on the parking violation detection and lane violation detection from expressway, and the project's author has ultimately met his goal. As during analysis phase, the A broader range of target audiences responded positively to the project, including domain specialists, industry professionals, and general researchers. During requirement gathering and implementation, there are numerous problems and barriers to overcome. These systems can detect lane violation vehicle detection and parking violated vehicle. Throughout the research, the author had able to discover new deep learning principles, libraries, and tools. The author proved as the final result that this approach can be used instead of traditional ways to identify disorders. Moreover, during the university course, this project may be viewed as an excellent opportunity to face challenges and limitations while working in a group. Finally, after nearly 1 year of hard work, the author is satisfied with the performance.

9. REFERENCE

[1] Tianfu He, Jie Bao, Ruiyuan Li, Sijie Ruan, Yanhua Li, Chao Tian, and Yu Zheng. 2018. Detecting Vehicle Illegal Parking Events Using Sharing Bikes' Trajectories. In Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining (KDD '18). ACM, New York, NY, USA, 340–349. https://doi.org/10.1145/3219819.3219887

[2] Jong Lee, M.S. Ryoo, Matthew Riley, and J.K. Aggarwal. 2009. Real-Time Illegal Parking Detection in Outdoor Environments Using 1-D Transformation. Circuits and Systems for Video Technology, IEEE Transactions on 19 (08 2009), 1014 – 1024. https://doi.org/10.1109/TCSVT.2009.2020249

[3] Sarker Mostafa kamal. 2015. Detection and Recognition of Illegally Parked Vehicle based on Adaptive Gaussian Mixture Model and Seed Fill Algorithm. The Journal of Information and Communication Convergence Engineering (JICCE) 13 (09 2015), 197–204. https://doi.org/10.6109/jicce.2015.13.3.197

[4] Xuemei Xie, Chenye Wang, Shu Chen, Guangming Shi, and Zhifu Zhao. 2017. Real-Time Illegal Parking Detection System Based on Deep Learning. 23–27. https://doi.org/10.1145/3094243.3094261

[5] S. Messelodi, C. Modena, N. Segata, and M. Zanin, "A kalman filter based background updating algorithm robust to sharp illumination changes," in International Conference on Image Analysis and Processing, ser. LNCS, vol. 3617, 2005, pp. 163–170

[6] YOLO: Real-Time Object Detection. https://pjreddie.com/darknet/yolov2/. Accessed: 2019-07-30.

[7] H. Gong, W. Yan, and H. Chu, “Illegal parking detection using object interaction model,” Video Engineering, p. Z1, 2017

[8] Wahyono and K. Jo, "Cumulative Dual Foreground Differences for Illegally Parked Vehicles Detection," IEEE Transactions on Industrial Informatics, vol. 13, no. 5, pp. 2464-2473, 2017.

[9] MobileNetV2: The Next Generation of On-Device Computer Vision Networks, available online: https://ai.googleblog.com/2018/04/mobilenetv2-next-generation-ofon.html

Dataset - Available: Sri Lanka Expressway Management CCTV data

Appendix

Figure 45 difference camera view point

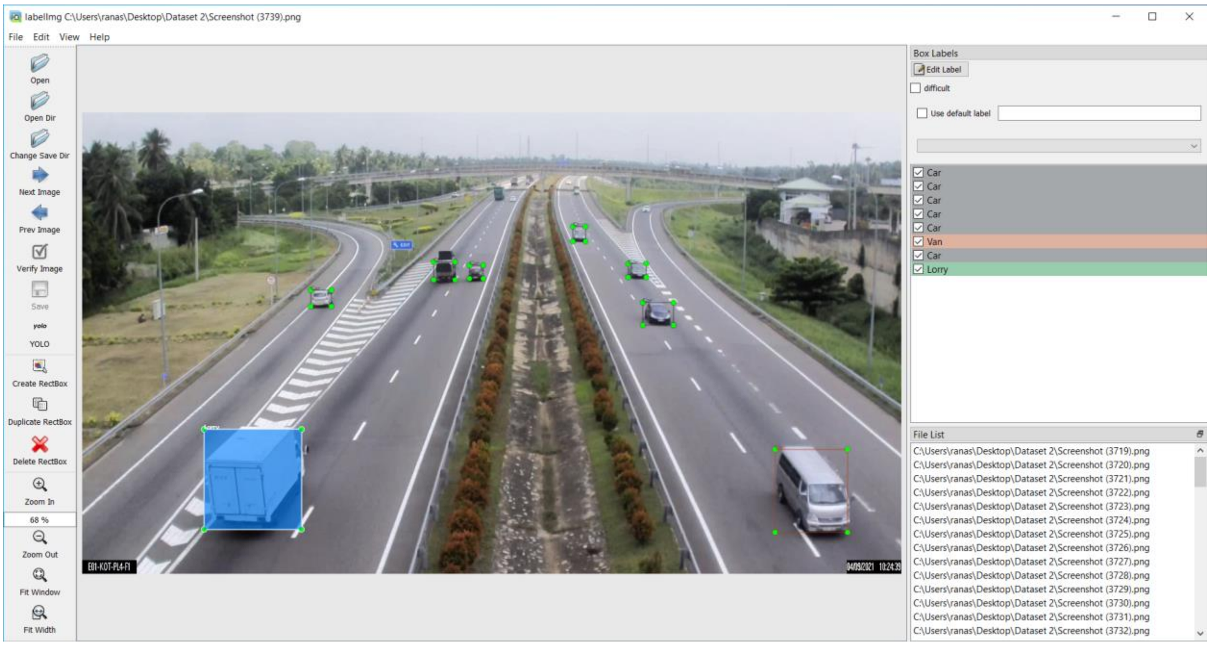


Figure 46 Add Label images dataset using python labelImg

parking and lane violation

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