RACING CAR DETECTION USING CASCADED CLASSIFIER

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ORIGINAL LITERARY WORK DECLARATION

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ABSTRACT

Human error tends to occur especially when it comes to recognizing or detecting an object, the situation becomes worst when human has made the wrong judgement due to poor observation skills, causing a side effect to what happens subsequently. To minimize these wrong judgement, machine learning is proposed to assist them via detection and classification. Machine vision system is one of the technology where it will be a great useful application in the near future for it will enable a system to analyze and communicate with other devices to run its respective task. The general concept of how a machine vision system works is fully based on the fundamental of image processing, therefore the main requirement for a machine vision system is combination of both hardware and software to execute its task. This study is performed to detect racing cars from any sources that are obtained with a robust, stable and high efficiency.

ABSTRAK

Kesalahan manusia cenderung berlaku terutamanya apabila mengenal pasti atau mengesan objek, keadaan menjadi semakin memburuk apabila mereka membuat sesuatu keputusan yang salah disebabkan pemerhatian yang buruk, hal ini menyebabkan kesan sampingan kepada apa yang berlaku seterusnya. Untuk mengurangkan penghakiman yang salah ini, pembelajaran mesin dicadangkan untuk membantu mereka melalui pengesanan dan klasifikasi. Sistem Pengilhatan Mesin adalah salah satu teknologi yang merupakan aplikasi yang berguna dalam masa yang akan dating disebabkan keupayaan untuk membolehkan sistem ini menjalankan analisasi dan komunikasi dengan peralatan lain untuk menjalankan tugas masing-masing. Konsep umum bagi sistem penglihatan mesin berfungsi sepenuhnya berdasarkan asas konsep pemprosesan imej, oleh itu keperluan utama untuk sistem penglihatan mesin adalah gabungan antara perkakasan dan perisian untuk melaksanakan tugasnya. Kajian ini mencadangkan untuk mengesan kereta lumba dari mana-mana sumber yang terdapat dalam kaedah yang bercekap, stabil dan mempunyai kecekapan yang tinggi untuk membantu manusia menyelesaikan masalah ini.

.

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LIST OF SYMBOLS AND ABBREVIATIONS

ANN	:	Artificial Neural Networks
BoW	:	Bag-of-Words
CNN	:	Convolutional Neural Network
DoG	:	Difference of Gaussians
GPUs	:	Graphical Processing Units
GUI	:	Graphical User Interface
ROI	:	Regions of Interest
SIFT	:	Scale-Invariant Feature Transform
SURF	:	Speeded-Up Robust Features
V-J	:	Viola-Jones
XML	:	Extensible Markup Language

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CHAPTER 1: INTRODUCTION

1.1 Background

Machine vision system is one of the technology where it will be a great useful application in the near future for it will enable a system to analyze and communicate with other devices to run its respective task. The general concept of how a machine vision system works are fully based on the fundamental of image processing, hence the requirement for a machine vision system is combination of both hardware and software to execute its task.

In the industries, these systems are required for a greater robustness, stability and efficiency, these requirements are important as it will yield in different types of productions, improve the manufacturing process and ensure the safety of the workers in their working field. However, some of the application are still required to perform manually with the machine due to lack of researching and instability of the systems to perform automatically, causing extra workforce in order to hire a person to operate the machine manually.

Image processing is a step that will convert the image data into a digital form, by using this information, it will enable the particular system to analyze it and perform the specific task more easily, however these algorithms requires a few stages in order to make the system to be able to apply it on the field, one of the most important stages for this system is to learn from the conceptual object first in order to be able to be detected in the field [1]. However, it has some disadvantages especially when the properties of recognition are same as the other object, for examples size or color. Suitable algorithm and methods are required to ensure that a higher probability/success rate will be achieve to be able to detect the correct object.

Object detection has been a widely used application in this decade, a frequently used application for detection is facial recognitions which these applications can be seen in camera's function, however object detection is not frequently used in both industry as well as the commercial due to the complexity of the algorithms. Taking an example in the sports sector, some judges or commentators are still not relying on object detection system for their working purpose, this can cause human errors which wrong judgement was called upon during that instance.

To assist both judges and commentators or any users, a study of object detection has been conducted. To simplify the study purpose, racing cars has been selected for this studies that will be related to the proposed Research Project title, "Racing Car Detection Using Cascaded Classifier".

1.2 Problem Statement

The aim of this project is to determine the best method for object detection because different objects have different characteristics. Theoretically, a successful detection is solely based on features, data sizes, quality of the images etc. The situation arises when some of the testing data will be detected wrongly due to the same properties as the wrongly classified learning data. For example, the system might misclassify a team of racing car as another team due to the existence of wheel on both racing cars. Besides that, an unsupervised algorithm is needed in order to ensure that the system will be user friendly by the user without continuously supervising it to ensure the task are done correctly. With this object detection, the users will be able to track any different teams of racing cars that they wish for analyze purposes, this could reduce any potential human errors that will incurred in the near future.

1.3 Objectives

The objectives of this research are stated as below:

1. To study the detection method on any objects for performing subsequent object recognition.
2. To understand how feature extraction method will used on an object for object recognition.
3. To design an object recognition system that will improve the efficiency of the system.

1.4 Scope

This study will cover on how cascaded training will be used for object detection applications since it is commonly used for pattern recognition applications. Besides that, as stated earlier, different team of racing cars has different features that represents each of them respectively, therefore an unsupervised learning is used to determine the accuracy of the system since cascaded training can be supervised learning or unsupervised learning. At the end of the study, different teams of racing cars will be able to be detected correctly with minimum error.

1.5 Thesis Organization

This thesis is organized in five chapters. In Chapter 1, the explanation for the project which will be given in a general term, problem statements of this project will be elaborated followed by the scopes of the project will be covered in this project.

Chapter 2 describes the fundamental the fundamental of object detections and any relative trainings that can be used for object detection. It will further discuss about the characteristic and applications used in cascaded learnings or any other terms that can be related to the project.

In Chapter 3, it describes the methodology on how to develop the systems that can detect the racing cars correctly for this project.

As for Chapter 4, the results that are obtained are discussed as well as both discussions and analysis for this project. The strength and weakness of this project are also discussed in this chapter.

Finally, in Chapter 5, a conclusion is made for this project and recommendations for future works for this project will be the ending for this thesis.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter discusses about the theoretical background on understanding of detection applications in image processing. It is important to understand how image processing is used for detection purposes by understanding its fundamental algorithms. The common algorithms that was used for detection in image processing is the facial detection, which is the Viola-Jones algorithm, designed by both Paul Viola and Michael Jones in the year of 2001 [1]. Further studies were made by researchers around the globe that further enhance this algorithm, Nguyen and et al. has created a software based on the Graphical Processing Units (GPUs) by implying Viola-Jones algorithms in it. Xu. et al. have conducted a study that further enhanced the V-J algorithms that was used for vehicle detection on unmanned aerial vehicle imagery.

The algorithm of object detection was further enhanced by combinations of V-J algorithms with other algorithms such as Artificial Neural Networks (ANN) [4], AdaBoost algorithms and et cetera. Rashidan et al. has studied on conducting the analysis of Artificial Neural Network and V-J Algorithm based on moving object detection [4]. Peleshko and Soroko has made a research on the usage of Haar-like features and AdaBoost algorithm in V-J method for object detection [5].

Further enhancement was made when researchers started conducting their studies onto video-based detection by various algorithms. Wu et al. has conducted a study by using 5 layers of CNN as their classifier for real-time running detection from a moving camera [6]. Guo has studied an efficient method for object tracking algorithms of a video by using a dynamic model that is optimized in mean-shifted algorithms [7].

2.2 Viola-Jones Algorithms

A common application of detection in image processing is face detection in the early 2000s which was created by Paul Viola and Michael Jones [1] on an algorithm that has the ability of quick object detection using a boosted cascade of features which comprises of three key contributions: Integral Images, Learning Algorithms and Cascading.

Integral Images are the images that allows the features for detection to be computed quickly which these images represent the images with similar summed up area of table used in the computer graphics done by Crow [9], these images can be computed by using a few operations per pixels. Once the images are computed, Haar-like features will be able to compute at any scale or location at a certain of time.

Learning Algorithms is a simple and efficient classifier that is built by Freund and Schapire [8], this algorithm is also known as AdaBoost algorithm that was built based on selecting a small number of features which are important from the library of features. This algorithm uses the Haar-like features which is larger than number of pixels in each image sub-window that will ensure that the learning process will be executed faster than pixels and will exclude the majority of features but focused on the critical features only. Tieu and Viola have conducted a study by using AdaBoost algorithm to constraint the weaker classifier by depending only a single feature, as a result they are able to obtain a boosting process on each stages of classification, with each times of feature selections, a new weaker classifier is produced [10]. This has improved the efficiency of the classifications on every stage as the stages goes on.

Cascading is a method that combines the classifiers to discard the background regions quickly and computing on object-like regions. This method will combine the successful complex classifier in a cascade structure that will improve the speed of detection that focus mainly on the promising regions on each image. With cascading is being implied into the algorithm, the algorithm will focus more attention into the promising region, which unrelated images will be filtered out to ensure a shorter time is used for detection. Cascading are proposed by both Viola and Jones to be constructed during the early stages in order to reject a majority of images and focus subsequently for promising regions at the late stages [1].

Besides that, Viola and Jones had also used the Haar basis function which harbors based on using the features rather than pixels, resulting easier to process and higher efficiency for detection. Figure 2.1 shows the rectangular features shown relative to the enclosing detection windows where the sum of the pixel in white region is subtracted from the black region within the rectangular.

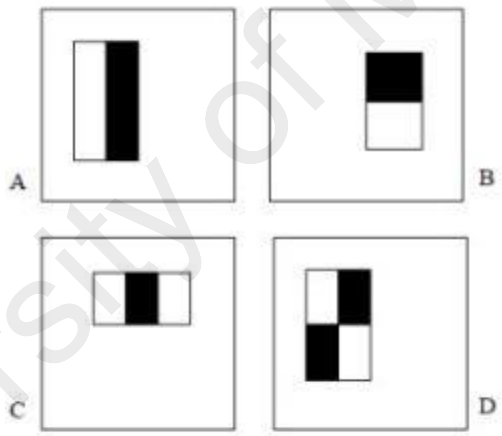


Figure 2.1: Two rectangular features shown in (A) and (B). (C) shows three rectangular features and (D) shows four rectangular features [1].

Based on all the contributions that have been mentioned earlier and the Haar basis function, Viola and Jones were able to construct the V-J algorithms that was used for facial recognition. Figure 2.2 shows results of the facial detection that was based on the V-J algorithms.

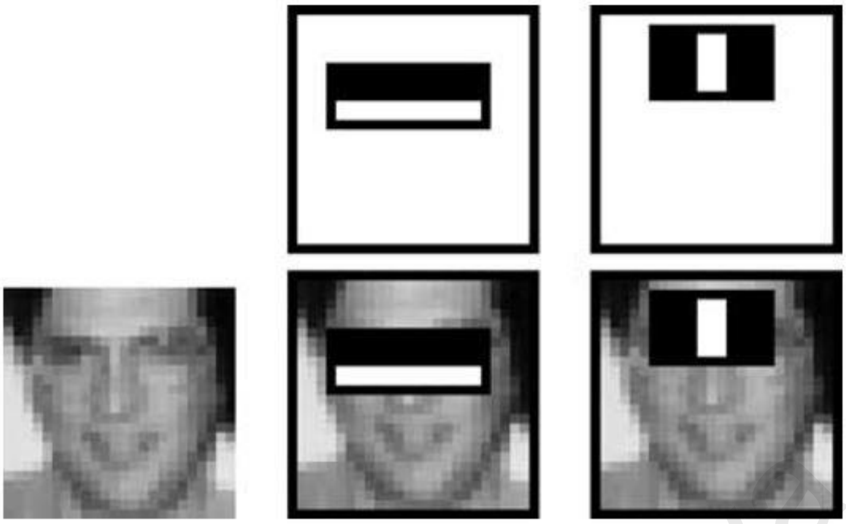


Figure 2.2: Facial Recognition that is based on Viola-Jones algorithm [1].

2.3 Object Detection

Object detection is an expansion of computer vision research which adapted from the machine learning methods. Detection was made by determining the location and the scale of the object at particular instances based on a set of classes of objects. Further information was extracted from the detected objects during the detection progress. Depending on the applications, some of the detection were made based on multiple object classes while others were made with single object class [11].

Vershae and Ruiz have gathered surveys on detections and recognitions that has been published worldwide and have concluded four main problems that are related to object detections, these problems are object localization, object presence classification, object recognition and view and pose estimation [11].

Object detection is described as the determination of the location and the scale of the single object based on the particular image. Object presence classification is corresponded with determining the object towards a suitable class based on the image without any information given. Object recognition is defined as determining the object specified correctly based on the image and finally, view and pose estimation is the view and position of the object are determined based on the image [11].

In the early days, Fischler and Elschlager have proposed using template based matching technique for object detection before V-J algorithm was introduced [11 – 12]. As the times goes on, more algorithm has been introduced after V-J algorithms such as Neural Networks, Support Vector Machining and et cetera. When studies of facial detection have reached the peak point, studies on computer vision detection has start to diverting towards objects that people are often to interact with, such as pedestrians, body parts and et cetera. Most of these object detections are based on the same basic scheme, which is known as the sliding window, the function of sliding window is to detect the object appearing in the image in different location and scales with an exhaustive searching using a classifier [11]. The classifier usually works on a given scale or size of the sample data and classify the test data that have different versions and sizes. Besides sliding window technique, there are some other alternatives as well. Bag-of-Words (BoW) is one of the alternatives which used to verify the presence of the objects on the image [13] where in some cases it might have a better efficiency than other algorithms. Multistage particle windows or samples patches is another alternative that can be used which aimed to reduce exhaustive search all over the images, Prati et al. has conducted research by using multistage particle window for pedestrian detection, Figure 2.3 shows how multistage particle works where the distribution of particles are spread across the windows of image in every stages, when the number of stages increased, the particles has started to accumulated onto some area, these area are known as Regions of Interest (ROI).

Figure 2.3: Pedestrian detection using Multi-Stage Particle Windows [13].

Another alternative used is key points findings, unlike the previous two alternatives that are mentioned which performs classifications based on reducing the number of image patches, key points finding is done by finding the features that representing the particular object and matches them with the test images, where Azzorpardi and Petkov have made a study to understand the limitation of key points finding by detecting the shoes in different complex scenes. Figure 2.4 shows the detection that was made by Azzorpardi and Petkov [14].

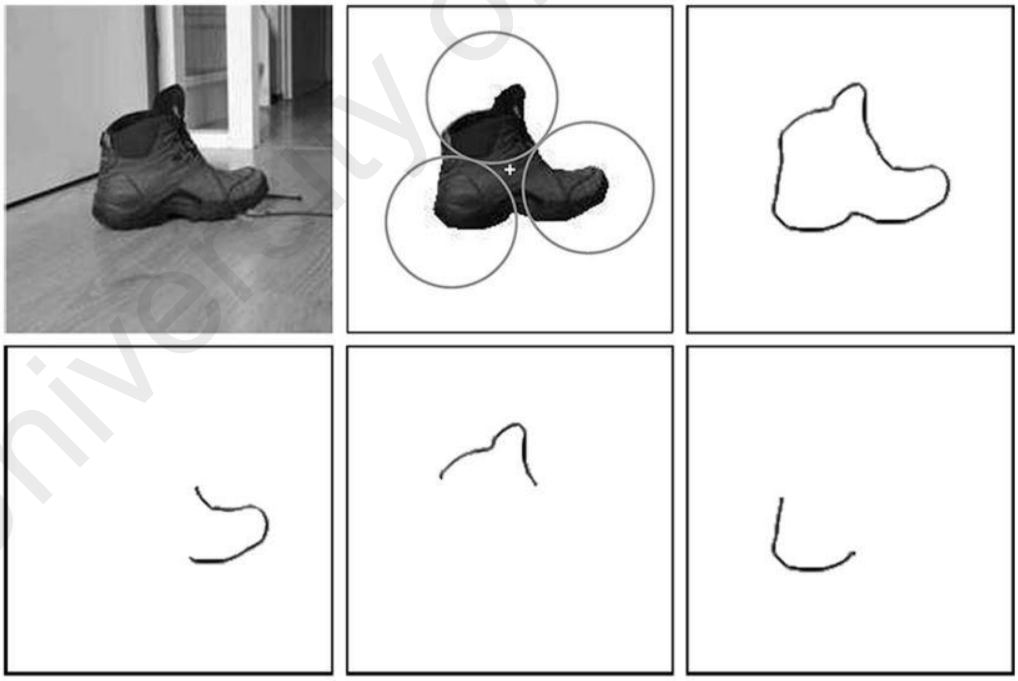


Figure 2.4: Shoe Detection using Key Points Finding [14].

Although there are a few alternatives that can be used for object detections besides algorithms such as V-J algorithms and et cetera, however according to Vershae and Ruiz thinks that these alternatives does not guarantee that all the objects will be detected during the particular instances [11]. Therefore, object detection has moved into a more advanced approach which is split into few categories, where each categories has their own pros and cons.

2.3.1 Coarse-to-Fine and Boosted Classifier

This category is considered the most popular approaches, one of the commonly used boosted cascaded classifier that was introduced is the V-J algorithms that has been mentioned earlier [1]. The classifier has a better efficiency in rejecting the test data through the filters, but unlike the multi-stage particles, the boosted classifier does not correspond with the image patches onto the object in the image. This classifier is commonly used due to generating an additive classifier which is easy to control the complexity of each stages during the classification and boosting can be used for feature extraction during training. When efficiency is the key requirement, the coarse-to-fine classifier is proposed as the suitable object detection classifier, one of the example is face detection that was studied by Verschae and Ruiz using a unified learning framework for detection and classification using a nested cascade of boosted classifier [15]. Figure below shows the block diagram of the unified learning framework that was done by Verschae and Ruiz [15].

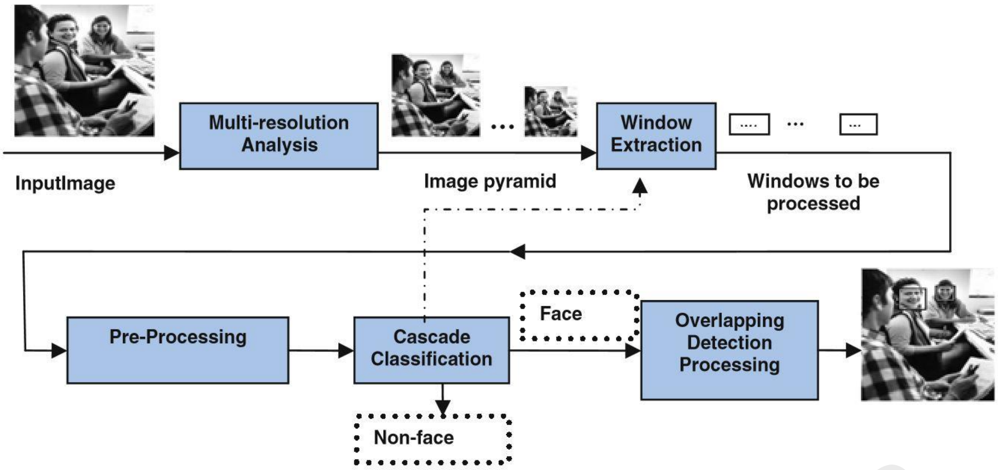


Figure 2.5: Block Diagram of the Unified Learning Framework for Face Detection [15].

2.3.2 Dictionary Based

Dictionary Based is an approach where a dictionary of features will be shared across all the categories, allowing all images to be in the same feature of space for classification purpose [16]. A study was done by Mutch and Lowe using this concept for class recognition with limited receptive fields, this approach was used because it was designed for single object detection per image only. Therefore, this approach is not robust for handling if two or more objects appeared in the image as well as the localization of the object is might not be accurate compare to another category. Figure below shows one of the result obtained from Mutch and Lowe during their studies.

Figure 2.6: Classification of Bicycle using Dictionary Based Detection [16].

From Figure 2.6, we have observed that there is some misclassification from the result obtained by Mutch and Lowe. Therefore this has justify that this approach cannot be handled robustly well and there are some accuracy issue.

2.3.3 Deformable Part-Based Model

This category is considered to be robust compare to other approaches which consider both object and part models in the image as well as their relative positions. However, Verschae and Ruiz also noted that this approach is rather time-consuming comparing to other approaches during training and this approach has a difficulty in detecting an object which are small in scales. A relevant study was made by Yan et al. by developing a faster deformable part-based model for object detection by modifying the model into a cascaded Deformable Part-Based Model for a faster evaluation since speed is a bottleneck for this model, the method that was proposed by Yan et al. were observed to have an increase of four times the speed faster than traditional model [17].

2.3.4 Deep Learning

Deep learning is a subset of artificial intelligence, which is commonly known as the machine learning. Deep learning will evaluate the examples from the model that was given by the user and execute based on the instructions that has been given instead of being taught by a massive list of rules for problem solving [18]. If a well-suited model is designed, this model will be able to solve a complex problem with good accuracy.

According to Deng and Yu [19], deep learning is a type of algorithm that uses a cascaded non-linear model that uses for feature extraction and transformation. The model can be a supervised or unsupervised algorithm that can be used in pattern or statistical classification. The algorithm is learning a multiple level of representation that will correspond with different levels of abstractions which are in the form of hierarchy concepts.

According to Goodfellow et al. [20], Deep learning is the only reliable approach on building an Artificial Intelligence system that can operate in the real-world environment as a machine learning. Deep learning has a better flexibility by learning any representation in the world since it is a kind of representation learning with has a higher level of schematics of process, this can be shown is Figure 2.7 and Figure 2.8 respectively.

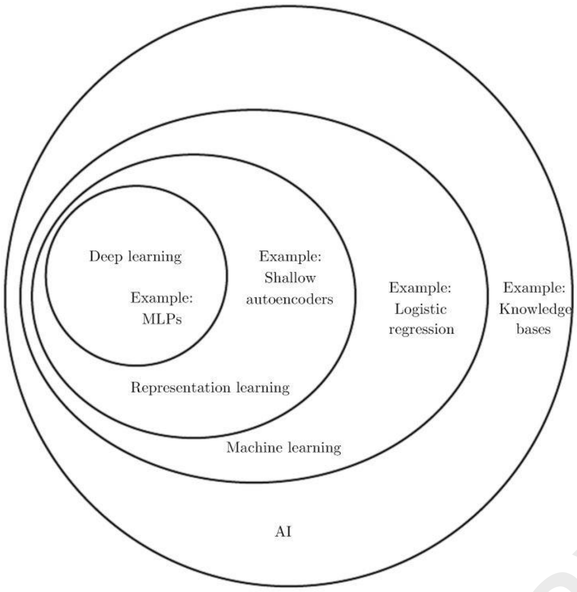


Figure 2.7: A Venn Diagram That Shows Deep Learning Is a Subset of Artificial Intelligence, Machine Learning and Representation Learning [20].

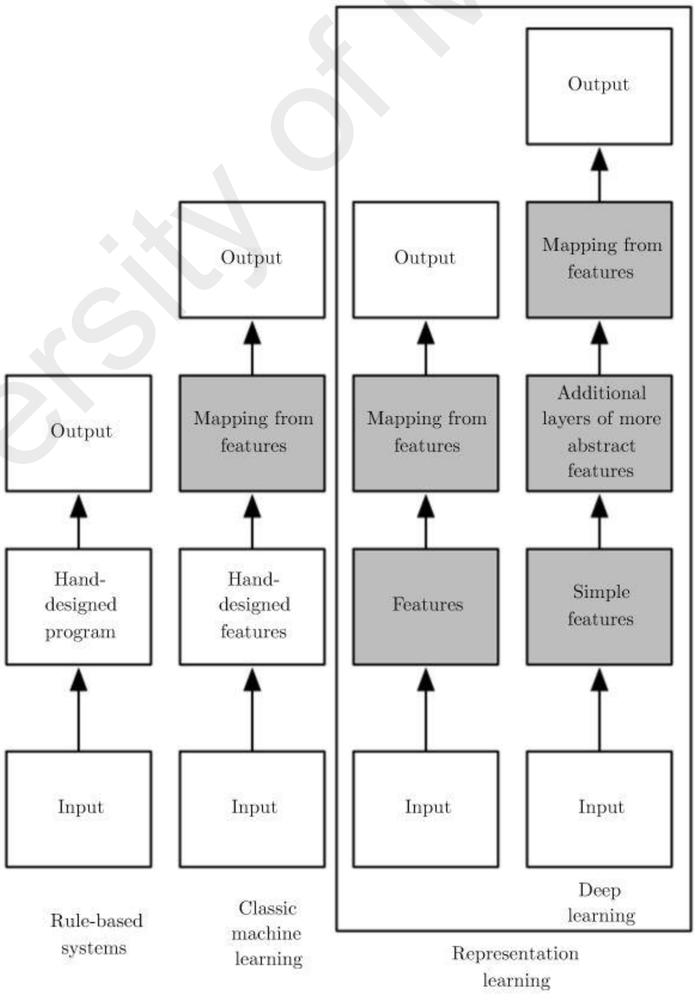


Figure 2.8: Schematic Levels of Each Learning [20].

Bengio et al. have concluded that in although many deep learning algorithm were framed as an unsupervised learning instead of supervised learning which will label the information that are readily available for training and more focusing on feature engineering, these unsupervised algorithm will make full use of the unlabeled data that were given where supervised algorithm cannot do that, making the unsupervised learning has a better benefit than supervised learning because these unlabeled data are usually more abundant comparing to the labelled data.

Vershae and Ruiz [11] have stated that the key difference between deep learning and other approaches that have been mentioned previously is this approach is learned from the feature representation rather than being designed by the user, however this will bring forth a drawback which is a large amount of sample data are required for deep learning to undergo training in order to ensure a good accuracy can be achieved. A study of detecting pedestrian using Deep Learning was done by Ouyang and Wang [22], since pedestrian are considered to have a non-rigid deformation in the image, Ouyang and Wang has designed a deep model by convolving the image with a smaller size filter into a numbers of feature maps so that these feature maps can be processed by continuous layer before reasoning model are able to estimate the detection.

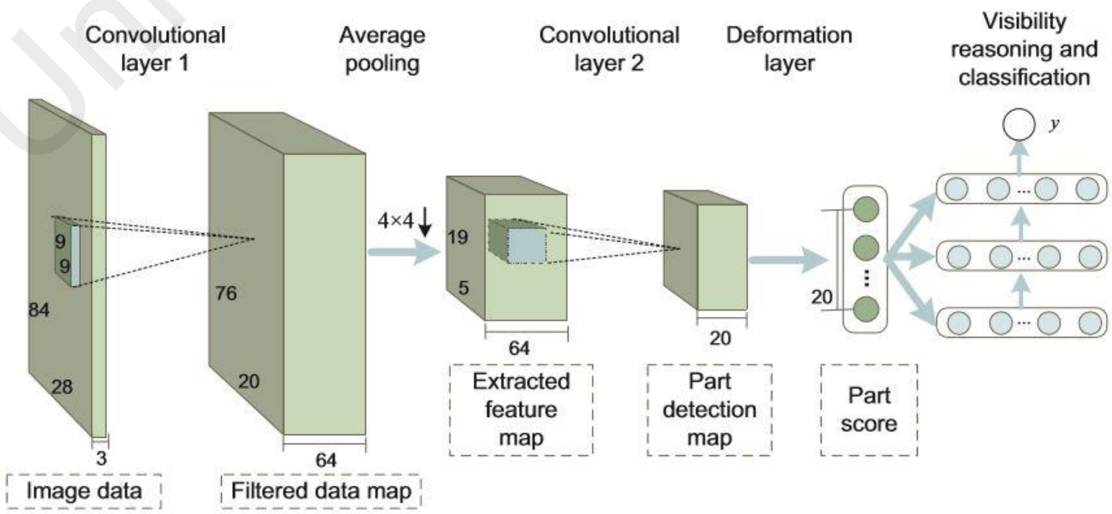


Figure 2.9: Proposed Deep Model for Pedestrian Detection [22].

Based on the designed deep model, Ouyang and Wang are able to obtained an improvement of detection by reducing the average miss detection rate than usual.

2.3.5 Trainable Image Processing Architectures

This category of approach tends to require both parameters of the predefined operators and the combined operators to be learned before any execution. This approach is highly suitable for building several modules of larger system especially in robotic vision system. A framework that combines both computer vision and machine learning for the purpose of object detection in a humanoid robot was designed by Leitner et al. using this approach with several filters and localization to ensure the humanoid robot will be able to adapt to the surrounding in both 2-Dimensional and 3-Dimensional planar [23]. Figure below shows the architecture model that was designed by Leitner et al.

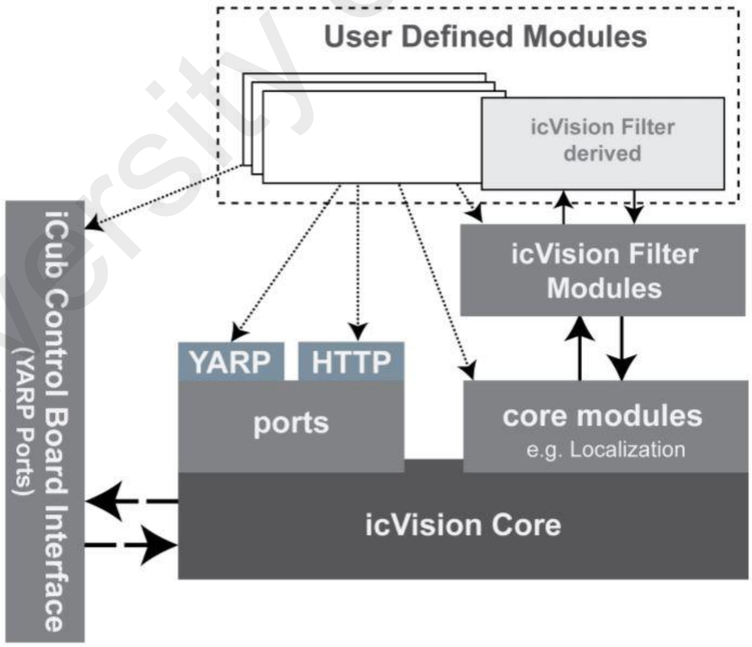


Figure 2.10: Architecture of Framework for Trainable Image Processing for Humanoid Robot by Leitner et al. [23].

2.4 Feature Extraction

For moving objects in a non-stationary background, classification using feature extraction has become an important part of detection that created a vast area for study. With an instance of detection to be obtained, the feature extraction algorithms have become a well-recognized algorithm for applying into the real-world detection applications. This algorithm is suitable to be used with equipment such as digital camera, traffic camera and etc. Feature extraction is done within the test image by recognizing the object based on the information from the reference image. This algorithm will act as the signature to the image that detects meaningful features, which is known as the feature descriptors from the database given [25].

According to Lal and Arif, there are a wide variety of algorithm that represents feature extraction such as Harris Corner Detector, Scale-Invariant Feature Transform (SIFT), Speeded-Up Robust Features (SURF), K-Mean Clustering and etc where Harris, SURF and SIFT are adopted from key point features detection [26].

Harris Corner is a detection algorithm that detects the corner by forming a local search windows that will be shifting the window pixel-by-pixel in all direction. The variance of the pixel intensity will help the algorithm to detect both high and low brightness level where the shifting process will mean the variation of the pixel intensity. Along the shifting, when a significant changes of pixel intensity is detected, the corner will be detected, however, when there are no pixel intensity changes along the edge, an edge region is detected [26].

Scale-Invariant Feature Transform (SIFT) detector consist of four main stages which are the space extrema detection, key point localization, orientation computation and key point descriptor extraction. Scale-space extrema detection identify the potential key points when severeal Gaussian blurred images at different scales are produced by the input image using the Difference of Gaussians (DoG). The DoG will then compute from neighbours in scale space before proceeding to next stage, which is the key point localization which the candidate key points found in DoG will be determined whether the value will against the ratio of eigenvalues of the Hessian matrix, those unstable key points will be eliminated at this stage. At third stage, the computation will assign a principal of orientation to each key point before entering the final stage, which will compute a highly distinctive descriptor for each key point which results each feature will become a vector for the descriptors to analyze [27].

The SURF Detector on the other hand employs the integral image and efficient scale space construction in order to generate efficient key points and descriptors. Unlike SIFT, SURF only require two stages, key point detection and key point description. During the first stage, the integral image undergoes fast computation of approximation using Laplacian of Gaussian images via box filter. Once obtaining the Hessian matrix, the determinants is then used to detect the key point, hence the SURF will be build to its own scale space by keeping the image size same while varying the filter size. On the second stage, which is the final stage, each detected key points will be assigned for a reproducible orientation which is in linear axis, the descriptor will then be computed by constructing a window square centering around the key points and oriented along the orientations that have been obtained before. The SURF descriptor will be invariant in terms of rotation, scale and contrast while partially invariant to other transformations [28].

The K-Mean Clustering is a typical clustering algorithm that undergo the process of searching for data points which are close within the point at a specific range. It involves of grouping the data into a disjoined cluster so that the number of each cluster would be approximately the same among all clusters throughout the image. K-mean is a simple algorithm that has fast computational time by partitioning each cluster into k cluster that are represented by an adaptive-changing centroid, these centroid are known as the cluster center. Like all data analysis, the k-mean will start from some random initial values which is known as the seed-points, then it will compute the square distances between the inputs and the centroids before assigning the input to the nearest centroid. As the algorithm further cluster into k disjoint subsets, the will minimize the mean square error function [29].

Lal and Arif has conducted study of feature extractions on blurred image using a few of the algorithms that has been mentioned. Figure 2.11 shows the sample blurred image that will be used for their study.

Figure 2.11: Sample Blurred Image [26].

The cyclist in the blurred image will be acting as a moving object for the study. Using the Harris Corner Detection, the image turns out to be sharp with lesser noise and a significant of points are detected, there are no points that are detecting the background. Figure 2.12 shows the result of Harris Corner Detection.

Figure 2.12: Harris Corner Detection Result [26].

The sample image was then being tested using SURF algorithm and SIFT algorithm, Lal and Arif concluded that these feature detectors will still work well on blurry images by detecting sufficient points on the moving object. They also concluded that SURF algorithm was able to detect more points in the background comparing Harris and SIFT. Figure 2.13 shows the result using SURF algorithm while Figure 2.14 shows the result using SIFT algorithm.

Figure 2.13: SURF Detector Result [26].

Figure 2.14: SIFT Detector Result [26].

From this study, Lal and Arif made a conclusion that although both Harris Corner Detection and SURF Detector are able to process the information relatively faster than SIFT Detector, but Harris Corner Detection are seemingly more susceptible to noise and smooth pixel intensity level while SIFT Detector will detect the maximum amount of feature points, causing a longer processing time. SURF Detector on the other hand are able to detect a considerable amount of points towards moving object as well as backgrounds, which will make the computation involve in differentiating between background and foreground much easier than Harris Corner Detection [26].

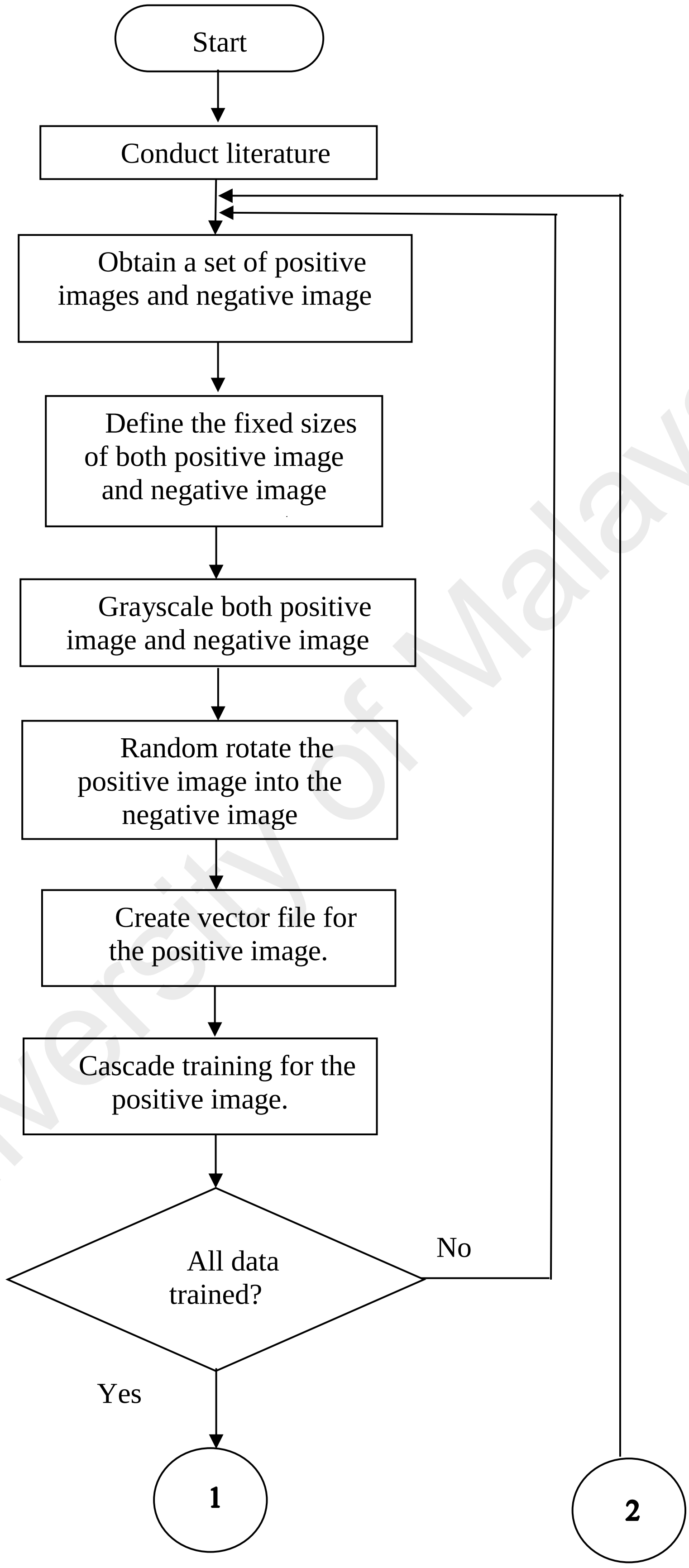
CHAPTER 3: METHODOLOGY

3.1 Introduction

Based on the Literature Reviews that has been discussed on Chapter 2 previously, this chapter discusses about the suitable method that can be applied onto the study. Based on Chapter 2, it is found that a cascaded training is suitable for this study since cascaded training will be able to assist the system to detect the object that was required with the capability of machine learning. Besides that, a cascaded classifier is proposed to be used in this study so that a shorter time with high efficiency of detection can be achieved by the system. The focus is to design a guarantee detection of racing car, which in this study, the scenario for racing cars will be Formula One racings for study purposes.

A programming will be explained at the end of this chapter to explain the flow process of the system with a simplified flow chart. The applications that was used in this study will be briefly explained as well. At the end of this chapter, the system will be able to conduct detection of racing cars on each team in Formula One racings in both imagery and video.

3.2 Flowchart



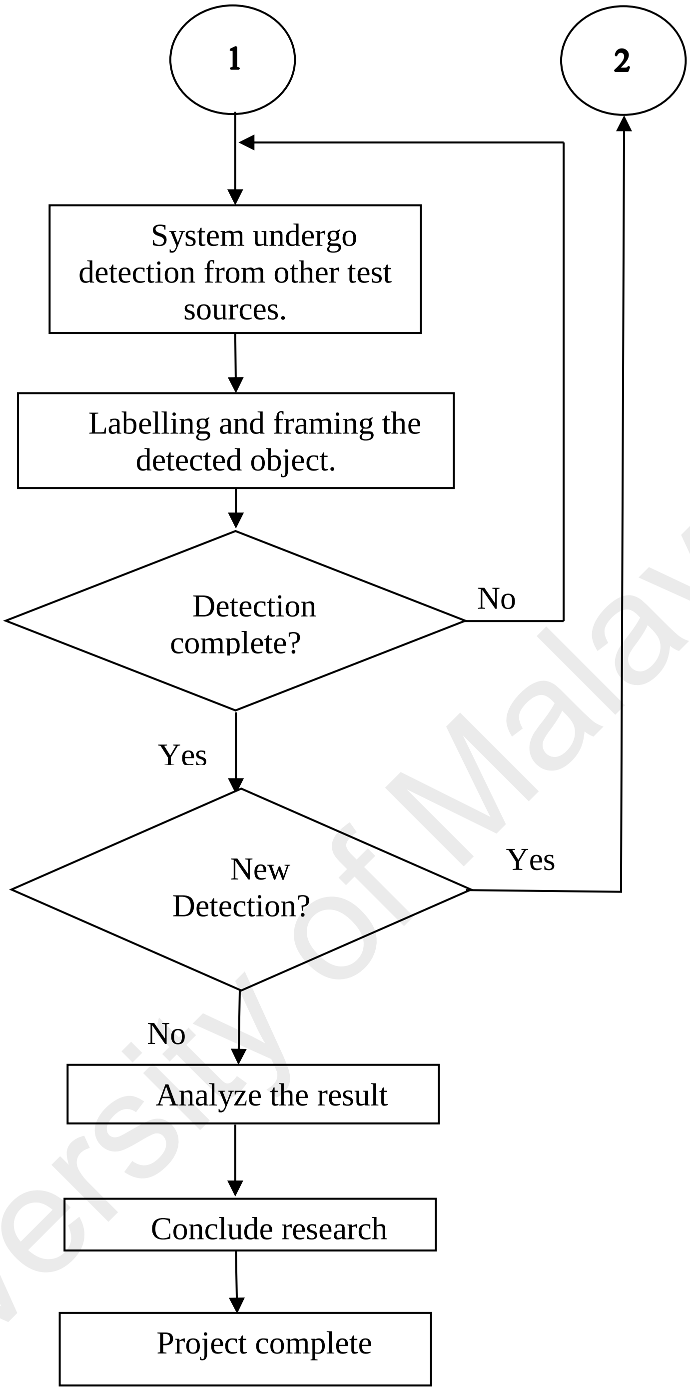


Figure 3.1: Flowchart of Analysis.

Based on the Figure 3.1, the explanation of the design and analysis of the racing car detection using a cascaded classifier will be done. A literature review and feasible studies were made in order to select the proper method to conduct the study since there are many methods for object detection as explained in Chapter 2. At the end of the process, a conclusion of the technique that was used in the project will be made and further recommendations for future works are proposed.

3.3 Modelling and Programming

To ensure an accurate object detection can be achieved a large number of images have to be collected for both positive images and negative images. Positive images are referred as the images that represents the object that will be detected from the test samples while negative images are images that does not have any relationships with the object that will be detected.

Both positive images and negatives images are taken from any sources available, to ensure that an optimum machine learning can be done, all the images are resized accordingly. The negative images are downloaded and converted into grayscale with a size of 1000x1000 pixels while the positive images are resized to 800x600 pixels using Python, a multi-programming language platform that most of the data processing modules are based on C language or C++ language with a much simpler Graphical User Interface (GUI) [24]. Python is widely used in many applications because of the capability to adapt to real time user requirements such as security, simulations, precision calculation etc. Figure 3.2 shows the Python command windows that will be involved in the study.

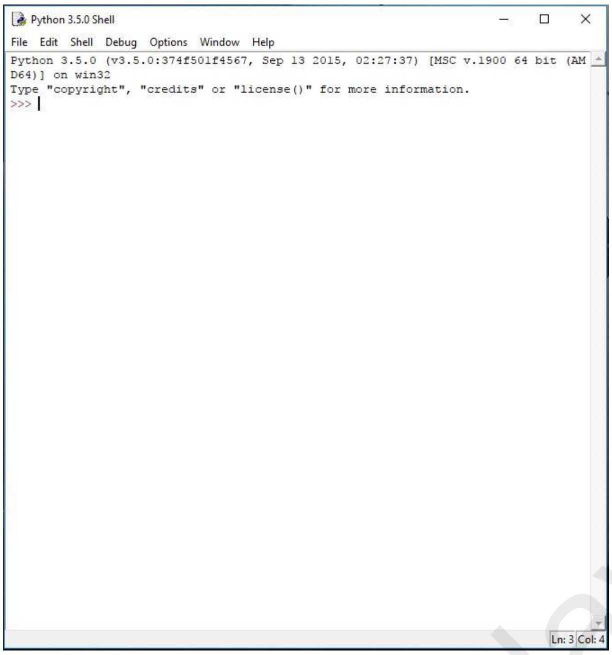


Figure 3.2: Python Command Windows.

In this study, a total of 11 teams in the Formula One racings are the positive images for detection. These images are taken from the web and predefined as the sample data, each teams' images are stored in separated folders so that the system can detect each team accordingly while the negative images are downloaded into a separated folder.

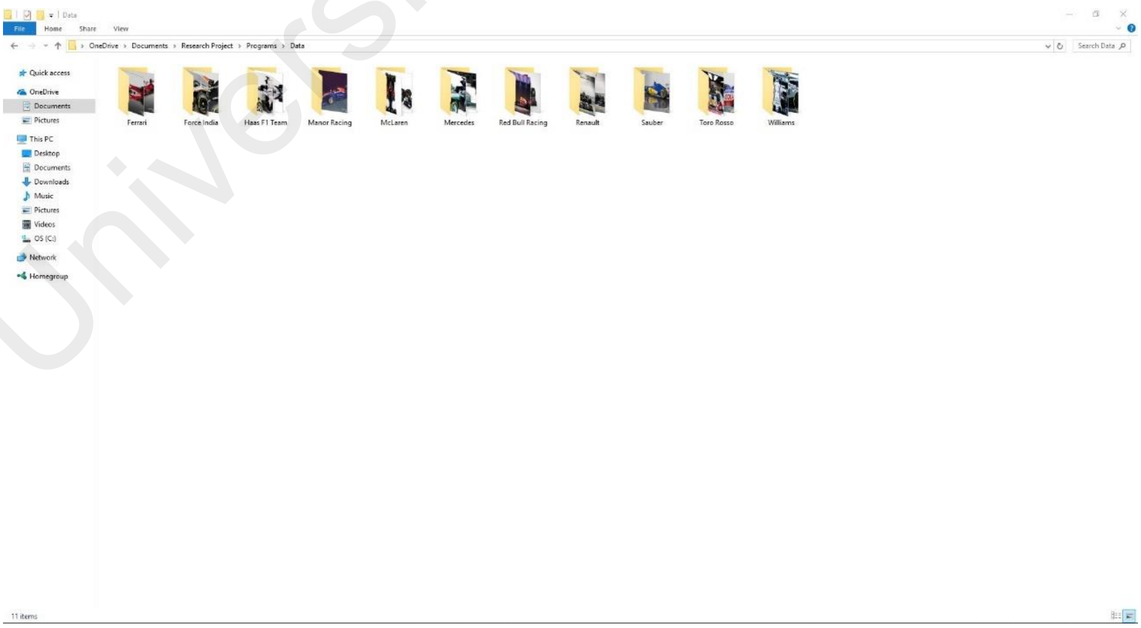
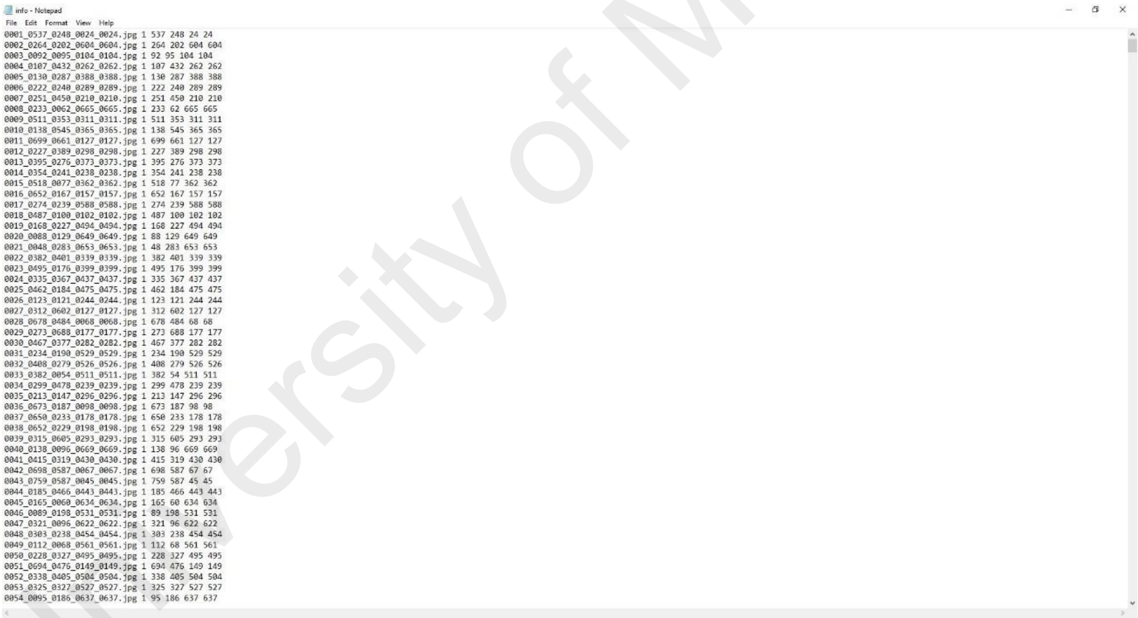


Figure 3.3: Each Teams Are Separated into Different Folders.

Figure 3.4: Negative Images.

A total of 2,292 negative images are collected for this study. Once this procedure is done, each of the positive images will then be infused onto these negative images with random rotation of the positive image in the negative images, this is to ensure that the number of positive images should be at least one times larger amount than the negative image so that the system will be able to classify the object more accurately. When this is being done, a text file will be created with a coordinate written on it to mark the coordinate of frame for indicating the position of the positive image. This is to separate out the positive image out from the negative image.

Figure 3.5: Positive Image (Sauber Racing Team) infused into the Negative Image.



info - Notepad

File Edit Format View Help

```
0001_0537_0248_0024_0024.jpg 1 537 248 24 24
0002_0264_0202_0604_0604.jpg 1 264 202 604 604
0003_0092_0095_0104_0104.jpg 1 92 95 104 104
0004_0107_0432_0262_0262.jpg 1 107 432 262 262
0005_0130_0287_0388_0388.jpg 1 130 287 388 388
0006_0222_0240_0289_0289.jpg 1 222 240 289 289
0007_0251_0450_0210_0210.jpg 1 251 450 210 210
0008_0233_0062_0665_0665.jpg 1 233 62 665 665
0009_0511_0353_0311_0311.jpg 1 511 353 311 311
0010_0138_0545_0365_0365.jpg 1 138 545 365 365
0011_0699_0661_0127_0127.jpg 1 699 661 127 127
0012_0227_0389_0298_0298.jpg 1 227 389 298 298
0013_0395_0276_0373_0373.jpg 1 395 276 373 373
0014_0354_0241_0238_0238.jpg 1 354 241 238 238
0015_0518_0077_0362_0362.jpg 1 518 77 362 362
0016_0652_0167_0157_0157.jpg 1 652 167 157 157
0017_0274_0239_0588_0588.jpg 1 274 239 588 588
0018_0487_0100_0102_0102.jpg 1 487 100 102 102
0019_0168_0227_0494_0494.jpg 1 168 227 494 494
0020_0088_0129_0649_0649.jpg 1 88 129 649 649
0021_0048_0283_0653_0653.jpg 1 48 283 653 653
0022_0382_0401_0339_0339.jpg 1 382 401 339 339
0023_0495_0176_0399_0399.jpg 1 495 176 399 399
0024_0335_0367_0437_0437.jpg 1 335 367 437 437
0025_0462_0184_0475_0475.jpg 1 462 184 475 475
0026_0123_0121_0244_0244.jpg 1 123 121 244 244
0027_0312_0602_0127_0127.jpg 1 312 602 127 127
0028_0678_0484_0068_0068.jpg 1 678 484 68 68
0029_0273_0688_0177_0177.jpg 1 273 688 177 177
0030_0467_0377_0282_0282.jpg 1 467 377 282 282
0031_0234_0190_0529_0529.jpg 1 234 190 529 529
0032_0408_0279_0526_0526.jpg 1 408 279 526 526
0033_0382_0054_0511_0511.jpg 1 382 54 511 511
0034_0299_0478_0239_0239.jpg 1 299 478 239 239
0035_0213_0147_0296_0296.jpg 1 213 147 296 296
0036_0673_0187_0098_0098.jpg 1 673 187 98 98
0037_0650_0233_0178_0178.jpg 1 650 233 178 178
0038_0652_0229_0198_0198.jpg 1 652 229 198 198
0039_0315_0605_0293_0293.jpg 1 315 605 293 293
0040_0138_0096_0669_0669.jpg 1 138 96 669 669
0041_0415_0319_0430_0430.jpg 1 415 319 430 430
0042_0698_0587_0067_0067.jpg 1 698 587 67 67
0043_0759_0587_0045_0045.jpg 1 759 587 45 45
0044_0185_0466_0443_0443.jpg 1 185 466 443 443
0045_0165_0060_0634_0634.jpg 1 165 60 634 634
0046_0089_0198_0531_0531.jpg 1 89 198 531 531
0047_0321_0096_0622_0622.jpg 1 321 96 622 622
0048_0303_0238_0454_0454.jpg 1 303 238 454 454
0049_0112_0068_0561_0561.jpg 1 112 68 561 561
0050_0228_0327_0495_0495.jpg 1 228 327 495 495
0051_0694_0476_0149_0149.jpg 1 694 476 149 149
0052_0338_0405_0504_0504.jpg 1 338 405 504 504
0053_0325_0327_0527_0527.jpg 1 325 327 527 527
0054_0095_0186_0637_0637.jpg 1 95 186 637 637
```

Figure 3.6: Text File That Describe the Coordinate of Each Positive Image in the Negative Image.

This text file is then being brought forward for further processed with further resizing of 20x20 pixels as an input training for the system classifier, this file is known as the vector file. Vector file also describes the background of each images in a more thorough way for training purposes. Once the vector file is created, the vector file will be set as the input for the classifier training, an Extensible Markup Language (XML) file is created at the end of the training, this file is used as the library sources for the detection system. During the training, the training samples will undergo few stages of training depending on the quality of the images. At each stage, the input will be taken from the output of the previous stage for the training, therefore the number of stages indicating the number of hidden layers in the training stages. Figure 3.7 shows one of the result of a complete stage during the training.

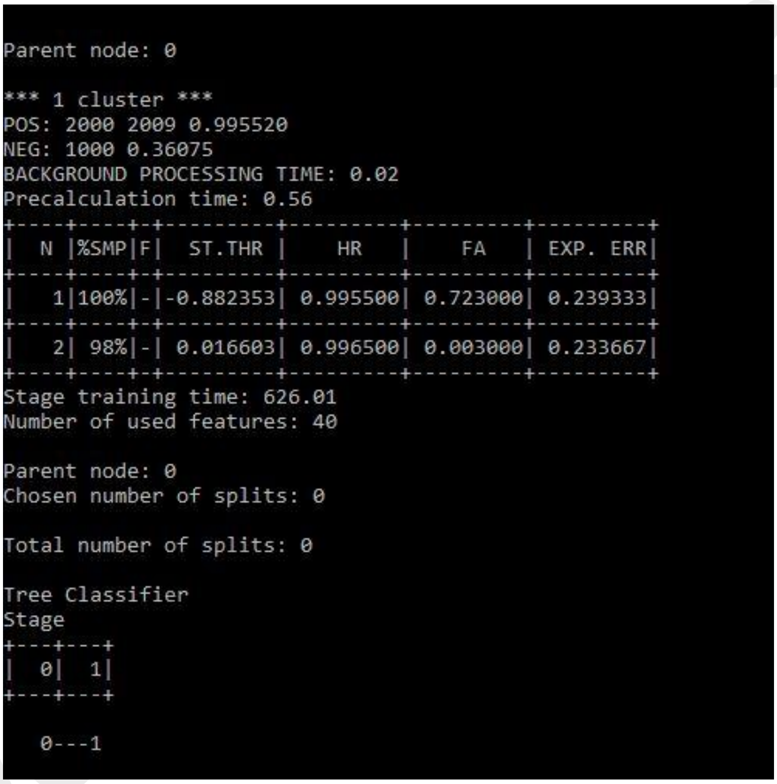


Figure 3.7: A Completed Training Stage.

Based on Figure 3.7, the data display that 0.016603 of threshold stages was done at the end of this stage with 0.233667 of strong classification error. This stage has taken up to 626.01 seconds with 40 features used for this stage of training. The results of each training vary due to the features and quality of each positive images differs from each other, if a lesser features or quality are used during the training, the training result may result to failure. The result of current stage of training will be brought forth to the next training as the training input of next stage. When the quality of the positive image is considered detailed, the number of stages of the training or the training time will be longer. The training result of each team are shown in Table 3.1 and the content of the XML file is shown in Figure 3.8.

Table 3.1: Training Result for Each Team.

Team	Number of Data	Number of Sample Images	Number of Epoch (Stages)	Average Time Taken for Training (Minutes)	Number of Features Used
Ferrari	14	28,000	11	300.96	43
Force India	7	14,000	11	72.30	50
Haas	15	30,000	8	59.45	46
Manor Racing	1	2,000	11	146.13	60
McLaren	12	24,000	10	70.58	50
Mercedes	9	18,000	6	49.36	43
Red Bull	6	12,000	6	55.54	40
Renault	10	20,000	3	32.34	40
Sauber	8	16,000	8	80.24	40
Toro Rosso	6	12,000	11	98.74	60
Williams	10	20,000	11	68.63	50

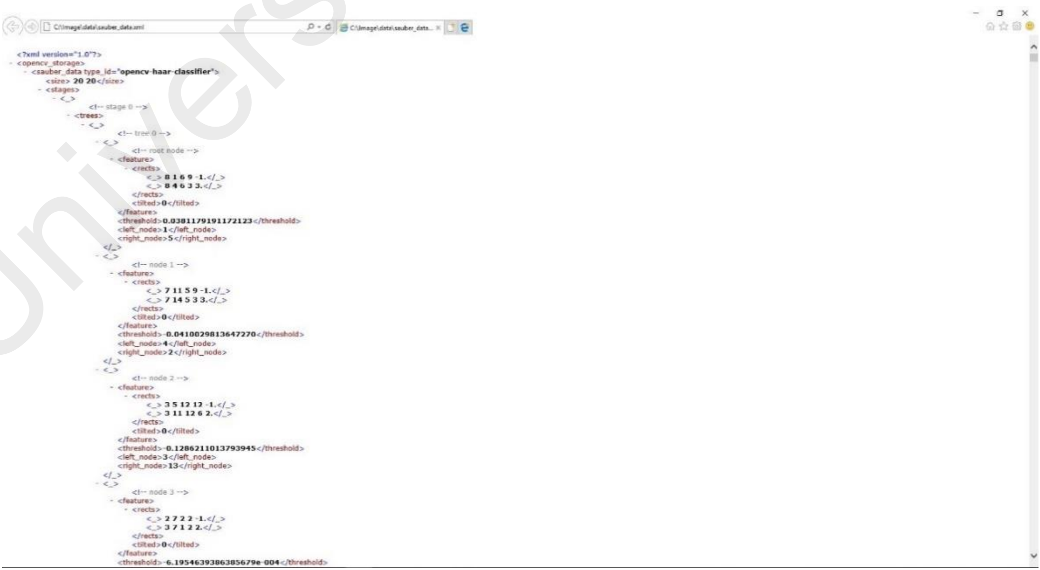
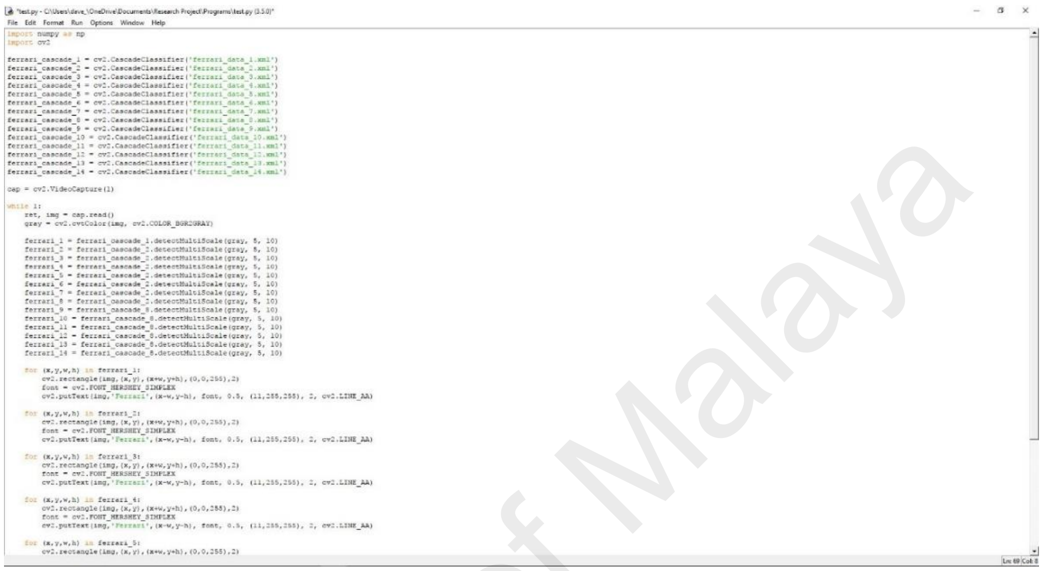


Figure 3.8: Content in the XML File.

Once the XML file for each positive sample are created, these files will be brought forward into the detection system, which the system is programmed from the Python as shown in Figure 3.9. The full programming of the racing car detection is attached in Appendix A.




```
import numpy as np
import cv2

ferrari_cascade_1 = cv2.CascadeClassifier('ferrari_data_1.xml')
ferrari_cascade_2 = cv2.CascadeClassifier('ferrari_data_2.xml')
ferrari_cascade_3 = cv2.CascadeClassifier('ferrari_data_3.xml')
ferrari_cascade_4 = cv2.CascadeClassifier('ferrari_data_4.xml')
ferrari_cascade_5 = cv2.CascadeClassifier('ferrari_data_5.xml')
ferrari_cascade_6 = cv2.CascadeClassifier('ferrari_data_6.xml')
ferrari_cascade_7 = cv2.CascadeClassifier('ferrari_data_7.xml')
ferrari_cascade_8 = cv2.CascadeClassifier('ferrari_data_8.xml')
ferrari_cascade_9 = cv2.CascadeClassifier('ferrari_data_9.xml')
ferrari_cascade_10 = cv2.CascadeClassifier('ferrari_data_10.xml')
ferrari_cascade_11 = cv2.CascadeClassifier('ferrari_data_11.xml')
ferrari_cascade_12 = cv2.CascadeClassifier('ferrari_data_12.xml')
ferrari_cascade_13 = cv2.CascadeClassifier('ferrari_data_13.xml')
ferrari_cascade_14 = cv2.CascadeClassifier('ferrari_data_14.xml')

cap = cv2.VideoCapture(1)

while 1:
    ret, img = cap.read()
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

    ferrari_1 = ferrari_cascade_1.detectMultiScale(gray, 5, 10)
    ferrari_2 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_3 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_4 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_5 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_6 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_7 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_8 = ferrari_cascade_2.detectMultiScale(gray, 5, 10)
    ferrari_9 = ferrari_cascade_8.detectMultiScale(gray, 5, 10)
    ferrari_10 = ferrari_cascade_8.detectMultiScale(gray, 5, 10)
    ferrari_11 = ferrari_cascade_8.detectMultiScale(gray, 5, 10)
    ferrari_12 = ferrari_cascade_8.detectMultiScale(gray, 5, 10)
    ferrari_13 = ferrari_cascade_8.detectMultiScale(gray, 5, 10)
    ferrari_14 = ferrari_cascade_8.detectMultiScale(gray, 5, 10)

    for (x,y,w,h) in ferrari_1:
        cv2.rectangle(img,(x,y),(x+w,y+h),(0,0,255),2)
        font = cv2.FONT_HERSHEY_SIMPLEX
        cv2.putText(img,'Ferrari',(x-w,y-h), font, 0.5, (11,255,255), 2, cv2.LINE_AA)

    for (x,y,w,h) in ferrari_2:
        cv2.rectangle(img,(x,y),(x+w,y+h),(0,0,255),2)
        font = cv2.FONT_HERSHEY_SIMPLEX
        cv2.putText(img,'Ferrari',(x-w,y-h), font, 0.5, (11,255,255), 2, cv2.LINE_AA)

    for (x,y,w,h) in ferrari_3:
        cv2.rectangle(img,(x,y),(x+w,y+h),(0,0,255),2)
        font = cv2.FONT_HERSHEY_SIMPLEX
        cv2.putText(img,'Ferrari',(x-w,y-h), font, 0.5, (11,255,255), 2, cv2.LINE_AA)

    for (x,y,w,h) in ferrari_4:
        cv2.rectangle(img,(x,y),(x+w,y+h),(0,0,255),2)
        font = cv2.FONT_HERSHEY_SIMPLEX
        cv2.putText(img,'Ferrari',(x-w,y-h), font, 0.5, (11,255,255), 2, cv2.LINE_AA)

    for (x,y,w,h) in ferrari_5:
        cv2.rectangle(img,(x,y),(x+w,y+h),(0,0,255),2)
```

Figure 3.9: Programming Code in Python with XML File Defined into the Detection System.

3.4 Conclusion

To ensure an accurate object detection can be achieved, the preprocessing have to be done accordingly. This process is illustrated in the Figure 3.10.

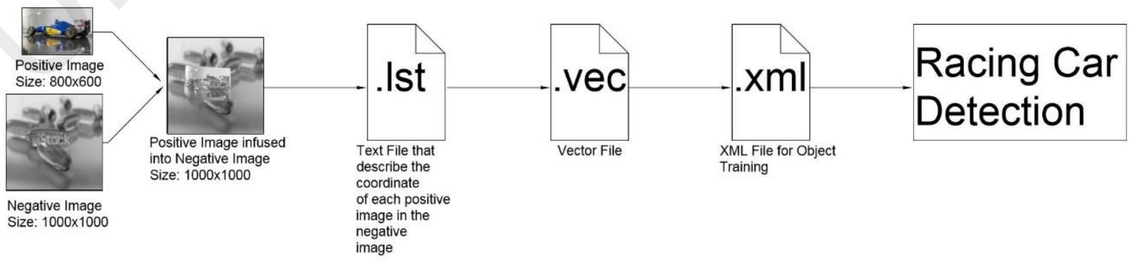


Figure 3.10: Steps of the Training Stages.

Once the training is completed, the racing car detection is made from different sources. The result and analysis for this study are explained in the next chapter. Therefore, to ensure that a successful detection can be made, the sample data have to be sufficiently larger than the negative images, thus infusing the positive image into negative image is an imminent process. To further improve the result of the training, a more detailed or better quality positive image should be used so that the system can be training better for detection.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter will briefly explain the outcome of the object detection for each team in Formula One racings. The study was conducted using a few resources available to test the accuracy of the detection on every racing teams.

Once the experiment was conducted, an error of analysis will be conducted to justify the error that was obtained throughout the experiment. A general discussion and a summarized conclusion will be done as the ending for this chapter.

Based on previous chapter, the methodology of the modelling and programming has been explained in order to conduct this experiment. Using Python, the racing car detection was executed with plugin of resources available.

4.2 Theoretical Experiment for Object Detection

Theoretically, based on the literature reviews on Chapter 2, with the sample images are trained respectively in the grayscale form, the test image is detected accordingly given the exact features and characteristics matches the sample images. Consider that the test images contain zero noises, the accuracy of the racing cars detection should be achieving optimum efficiency since all the features extracted from the test images are extracted correctly for comparison purposes with the sample image for detection purpose.

As mentioned in Chapter 2, with a cascaded classifier is applied into the system, the detection process should be faster compared to non-cascaded classifier since the processing are done in cascaded form. Therefore, the detection for the racing cars could be done in real-time applications.

4.3 Results

The experiment was conducted based on the methodology that was described from Chapter 3, a total number of 182,000 sample images was trained for this experiment and a total of 2,200 images from all 11 teams of Formula One racing teams was tested for this experiment. The results are obtained based on the experiment that has been conducted as mentioned in Chapter 3. The experiment was conducted with a 2 Megapixels webcam to capture images and videos for detection. Figure 4.1 to Figure 4.11 shows the detection of each Formula One racings team.

Figure 4.1: Detection of Ferrari Racing Team.

Figure 4.2: Detection of Force India Racing Team.

Figure 4.3: Detection of Haas Racing Team.

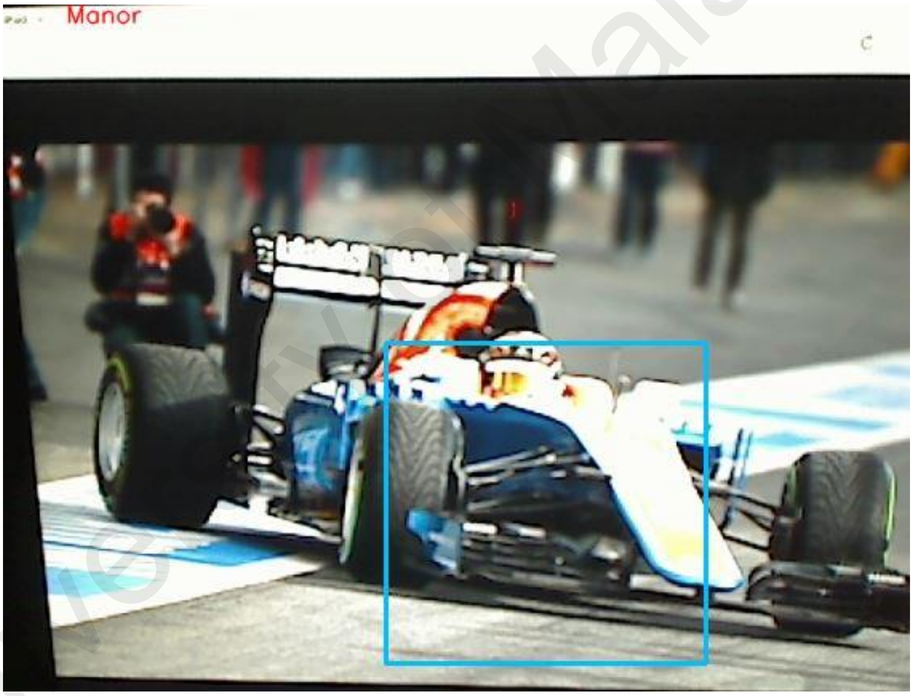


Figure 4.4: Detection of Manor Racing Team.

Figure 4.5: Detection of McLaren Racing Team.

Figure 4.6: Detection of Mercedes Racing Team.

Figure 4.7: Detection of Red Bull Racing Team.

Figure 4.8: Detection of Renault Racing Team.

Figure 4.9: Detection of Sauber Racing Team.

Figure 4.10: Detection of Toro Rosso Racing Team.

Figure 4.11: Detection of Williams Racing Team.

Besides focusing on detecting single team at a time, the experiment had also attempted on detecting more than one racing team. Figure 4.12 shows the original image of the that will be used for detecting more than one racing team.

Figure 4.12: Original Image for Detection.

The experiment was conducted based on the image as shown in Figure 4.12 for detection, the result is shown as figure below.

Figure 4.13: Detection of Ferrari Racing Team and Williams Racing Team.

Besides that, the experiment was conducted with a few highlights videos taken from any sources for detection. Figure below one of the successful result that was obtained from this experiment.

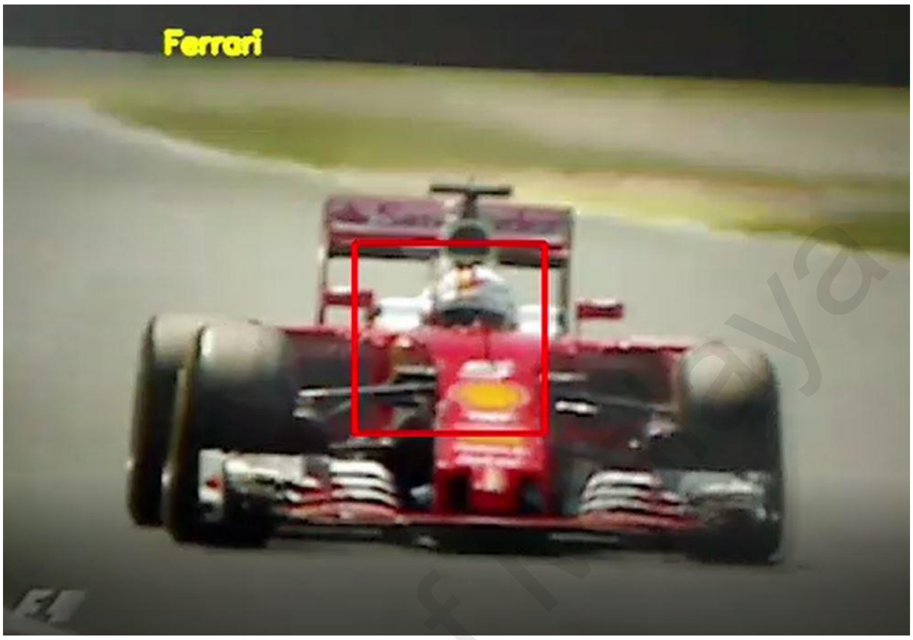


Figure 4.14: Video Detection for Ferrari Racing Team.

The overall results in terms of accuracy was shown in Appendix C in a table form.

4.4 Discussion

In order to obtain a better accuracy, the training data should be sufficient for machine learning purposes, this is to ensure that the references for the machine learning for comparison are suffice so that the correct object can be detected.

Some images require a higher stage of training or a longer time to be trained during the training time, this is because the quality of the image is extremely high, causing the learning to be taken place with a longer time to process the image data to extract the useful information for coming stages.

Last but not least, using a cascaded classifier is suitable for this experiment because cascaded classifier gives the advantage of reducing the processing time, which in return brought a real-time detection to be conducted as mentioned previously.

4.5 Error of Analysis

The error of analysis for this experiment was done in order to understand the reasons of error occurred throughout this experiment. The error of analysis for each team was calculated based on following equation.

$$Error\ of\ Analysis = \frac{|Number\ of\ Correctly\ Detected\ Images - Number\ of\ Test\ Images\ Per\ Team|}{Number\ of\ Test\ Images}\ X\ 100\% \qquad (4.1)$$

Based on the Equation 4.1, the error of analysis was shown is Table 4.1.

Table 4.1: Error of Analysis on Racing Car Detection.

Team	Number of Accurate Detected Inputs	Number of Inaccurate Detected Inputs	Accuracy (%)	Error of Analysis (%)
Ferrari	190	10	95.0	5.0
Force India	197	3	98.5	1.5
Haas	194	6	97.0	3.0
Manor Racing	188	12	94.0	6.0
McLaren	191	9	95.5	4.5
Mercedes	194	6	97.0	3.0
Red Bull	192	8	96.0	4.0
Renault	196	4	98.0	2.0
Sauber	189	11	94.5	5.5
Toro Rosso	190	10	95.0	5.0
Williams	194	6	97.0	3.0

The result has reflected that a higher number of training images will gives a lower percentage of error compared to data that have a lower number of training images.

4.6 Summary

This chapter has featured the results that have been collected for detecting each team in Formula One racings based on different type of sources available. The detection are done by using a cascaded classifier with a Haar Training algorithms in order to achieve a higher accuracy with the assist of the literature reviews that was mentioned from Chapter 2. The experiment that was conducted are able to detect other objects with given sufficient amount of sample images for training purposes.

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CHAPTER 5: CONCLUSION

5.1 Introduction

In this chapter, the objectives and scope that was mentioned for this study are analyzed and discussed briefly. Problems that has arised throughout this experiment are also analyzed and recommendations for improving this study are also included stated in this chapter.

5.2 Conclusion

This study proposes a cascaded classifier with Haar Training algorithm being used for racing car detection in order to detect the selected racing car from any sources available. The proposed method will be able to tackle problems to detect the racing car for analyzing purposes without human error during the analysis.

Haar training has contributed most in this study with bringing in the advantages into this study such as the features can be automatically being deduced and generate a desired outcome via optimally tuning the parameters. Haar training is also considered to be robustness for variations of automatically learned application by ensuring a large number of datasets are given for the training. This algorithm has the capability of being reusability with the neural networks architecture are able to be used for various applications without any alterations. However, this learning has some disadvantages which has brought forth the difficulty for the detection system to achieve maximum accuracy, one of the disadvantages is that it will have difficulty to understand the surrounding theory of the data, in this study, it will be the background of the object. Besides that, a low in quality of images will cause a difficulty during the training, this will easily be causing the failure in training stages and hence wasting the time for the training stage to be completed.

5.3 Recommendation for Future Project

The suggestion and recommendation for future works is a more advanced tool with larger amount of datasets to be used for detection purposes so that the detection can be made within the system itself and hence, the detection can be done in a faster way compare to current method. Besides that, the input devices for the detection system are suggested to have a better specification so that the accuracy of the detection can be higher. Lastly, the detection system is proposed to be designed in a more automatic method with self-training and self-detecting function in the near future by using other learning methods such as Deep Learning and etc.

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