

Vehicle Tracking using Video Cameras

By

Girberth Anak Johnson

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronic Engineering)

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CERTIFICATION OF APPROVAL

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Dissertation submitted to the
Electrical and Electronic Engineering Programme
Universiti Teknologi PETRONAS
In partial fulfillment of the requirement for the
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(ELECTRICAL AND ELECTRONIC ENGINEERING)

Approved by

Mr Patrick Sebastian

University Teknologi PETRONAS

TRONOH, PERAK

December 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

GIRBERTH ANAK JOHNSON

ABSTRACT

In Malaysia, road crime cases keep increasing days to days and the resolved cases are very minimal. This leads to how importance it is to improve our security system, especially in vehicle's surveillance system. In a common security application, human observation plays an important role as they need to monitor the camera's output on a TV and detect when any expected events occur. However, relying on human's eyes is not a reliable system as the technology now allows an automatic detection system. The 'Vehicles Tracking System Using Video Cameras' is the basic solution to those problems. The scope for this project is narrowed down to moving vehicles on the road. The main idea of this project is to track vehicle using their colour properties. Different vehicle's image has different colour properties. These colour properties will set as an identification of a vehicle. This identification will be utilised to track down the identified vehicle earlier. MATLAB is utilised for the algorithm development. In MATLAB, background subtraction is performed as to extract the foreground image from the background image. The foreground image will be further analysed and processed to gather as much as data. The data will include the colour properties of the image. The result shows that information stored in colour properties are sufficient to be used for vehicles tracking.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

According to Oxford Dictionaries, “automatic” is defined as ‘a device or process working by itself with little or no direct human control’. In recent years, with a great technology, it allows us to have an automatic detection system. Automatic detection system in some ways, will greatly improve our surveillance system we already have now.

Generally, vehicle tracking is a system to track down vehicles on the road, in which to reduce the road crime among the road users. However, the conventional way of security system that relies on human observation has many disadvantages. This leads to the idea of having an automatic detection in vehicle’s tracking system. Thus, in this work, a system is developed to track vehicles using two cameras utilizing the colour properties of the vehicles. The colour properties will set as an identification of the vehicles. Other than that, having single camera tracking is known for limited in the scope of its applications. This initiates the needs for a multiple-cameras system for completely monitoring and tracking a target. This project will cover vehicles tracking, re-identification of vehicles and analysis between both cameras. In this project, it also emphasizes the relation between the two cameras.

1.2 PROBLEM STATEMENTS

1.2.1 Problem Identification

With the increase of the crime rates in our country, civilian feels uneasy to solely relying on the protection of law. Thus, with the technology we have now, there is no reason not to have an extra security for the betterment of our community. This brings out an idea to have video monitoring by the installation of cameras in selected areas.

The conventional way how our security system works, is by the observation through the monitor by the personnel, continuously. Obviously, this kind of system is solely relying on human's monitoring. From the problem stated, it is identified that human monitoring can be improved by having an automatic detection system.

1.2.2 Significance of the Project

In security system, mistakes cannot be compromised. Thus having the automated system, we can reduce the involvement of human personnel in security department.

The project is very significant as upon completion of this project, it can become a basis to an automatic detection for the vehicles tracking. It will also give lots of benefits to the communities.

Remote Vehicle Tracking will become one of the most useful applications in Malaysia if the application is introduced properly and communities have the knowledge regarding technology.

1.3 OBJECTIVE AND SCOPE OF STUDY

1.3.1 Objectives

There are three main objectives that need to be achieved for this project which are:

- To identify the characteristics and parameters required for vehicle tracking
- To utilize the known parameters for general classification of vehicles
- To develop algorithm to detect and track vehicles

1.3.2 Scope of Study

The scope for this project will be based on the following elements:

- Objective
- Type of cameras used
- Experiment area
- MATLAB

The objective of this project is very clear, in which we want to develop an algorithm based on the characteristic of a vehicle. For the whole project, vehicle will be our subject to study about.

In this project, cameras are used to capture videos. Thus, the cameras used are set to be the same type of cameras. This is to ensure that the videos captured are having the same properties.

The experiment area is where the experiment is carried out. The experiment is carried out to capture few videos of vehicles on the road. The cameras are located opposite to each other at the walk bridge for the experiment to be carried out.

The whole process of this project mainly involves the development of algorithm. This is mainly done by utilising MATLAB application. Codes are written and video is run in MATLAB.

1.4 THE RELEVANCY OF THE PROJECT

The project is relevant to the security application out there as the result from this project can be utilized by the security department to enhance their surveillance technique by implementing the automated system.

The project is also relevant as it only revolves around the understanding of current video tracking system and image processing technique which enables to develop algorithm used in detecting and tracking vehicle

1.5 FEASIBILITY OF THE PROJECT WITHIN THE SCOPE AND TIME FRAME

It is feasible to complete the project within the time frame given, based on the scope of work and objectives stated above. Thus, the given 8 months (2 semesters) time, it is feasible to complete the work.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND SUBTRACTION

Background subtraction is a crucial and fundamental step in image processing. To simplify, background subtraction is the extraction of foreground image which will be used for further image processing. Background subtraction revolves in two main processes which are background modelling and foreground detection [2]. Background modelling is the creation of a background's model which can be updated periodically and foreground detection works on the intensity based on the model created at the background modelling [3]. However,[4] stated that dynamic backgrounds and sudden illumination changes are common problems arise associated with background subtraction especially in open and public spaces. Thus, in project like vehicle tracking, images are very sensitive to surrounding's light intensity. Simple change likes movements of clouds do affect the result produced. This is because such changes will affect the light intensity of the surrounding area, which directly affects the illuminance. Concerning to this, in [5], they foresee this problem. To solve this, [5] design illumination feedback kinetics which comprise two main phases, illumination approximation for feedback and background image adjusting, which simplified as, an algorithm that can adapt with the surrounding changes light intensity.

2.2 COLOUR IMAGE

In image processing, colour properties are very important. Different image have different colour properties. Thus, regards to which application we are dealing with, choosing the right type of colour image is very crucial. In[4], the paper concluded that the YCbCr and HSV have a better tracking performance compared to gray scale and RGB. Therefore, YCbCr and HSV are robust enough to develop tracking algorithm[4]. Other than that, RGB also not the best choice for computer based surveillance system application [4]. In this project, YCbCr will be focused for the algorithm development. The image captured by the camera is the RGB typed image.

In the MATLAB function, the RGB image will be change to YCbCr to get more robust algorithm.

Table below summarise the result obtained from [1] which clearly show YCbCr is better than RGB and gray scale.

Color Spaces	Video 1	Video 2	Video 3	Video 4
Grayscale	97.1	93.7	96.0	95.6
RGB	93.7	93.3	96.3	95.6
YCbCr	100	100	100	98
CbCr	100	100	100	99

Table 1: Tracker Detection Rate (%) [1]

2.3 VEHICLE DIMENSION

The object of interest for this project is the vehicles. The first part of the project, it will focus on the 4-wheeled vehicles such as cars, van and lorry. Thus, vehicle dimension is important as it need to be recognized and classified. Parameter need to be considered is their physical approaches [6]. The physical approaches to look into are the dimension of the vehicle which comprises their width and length. In this project, the image capture at the first camera will give the identification to the vehicle. Thus to give an identification, there is a need of information extraction from the vehicle itself. As considered in [6], [7] comes out with an idea of utilizing the stereoscopic video for the estimation of moving vehicle's length which can be used for vehicle type classification [8]. The idea [8] illustrated is further explained in Fig 1. The known width and length (dimension) will categorize the vehicles into car, lorry or van. Then, other than that, parameter such as colour also greatly utilized. Having the dimension and colour, the vehicle will be given identification. The identification is needed to differentiate the vehicles from each other. With this, the image at the second camera will use to compare then identifies the vehicles.

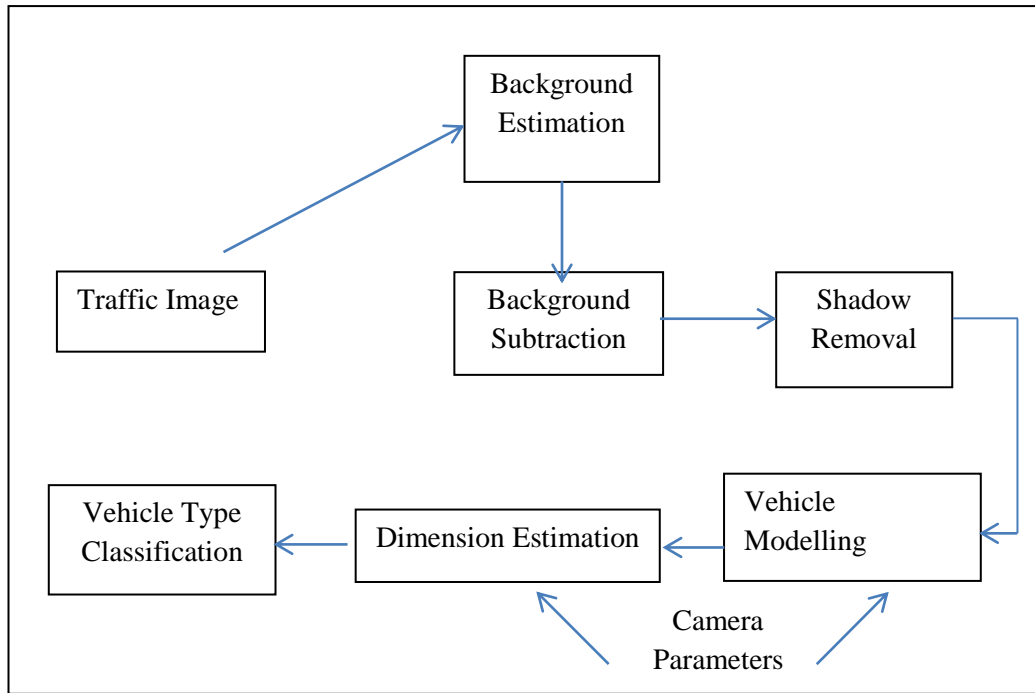


Figure 1: Conceptual Diagram for Proposed Method in [8]

2.4 TRACKING PERFORMANCE

Hardware such as the cameras will capture the videos; however the tracking algorithm will serve their part in producing such a good tracking result. Thus, tracking performance will serve as a result to the tracking method applied. The tracking performance leads to the development of Tracker Detection Rate (TDR) and Object Tracking Error (OTE) to measure the tracking algorithm performance[9]. Relating the TDR and OTE, [9] come out with a new metric which able to determine the consistency of tracking. Such evaluation also show the robustness of an algorithm made. Other than evaluation, the performance test also can be benchmark to know if the algorithm needs to be modified.

For this, an overall scoring is needed to do evaluation on different kind of trackers so that the best can be choose[10].

CHAPTER 3

METHODOLOGY

In this project, we want to prove that the colour properties can be set as identification for vehicle thus, used for the vehicle tracking.

3.1 RESEARCH METHODOLOGY

The project will be carried out according to these phases:

It is very essential to get the basic ideas of the project. Research through internet and books give some ideas on how to carry out this project. Meetings with supervisor also needed to seek for guidance and consultation regarding the project. For this project, research is narrowed down to image processing related articles. First, we need to choose the image type. The camera will capture the RGB type of image. Based on research done, YCbCr image is found more robust in terms of tracking algorithm. Next, research is done on the vehicle's dimension and colour. These two physical parameters are very important to serve as information carrier.

Experiment Setup

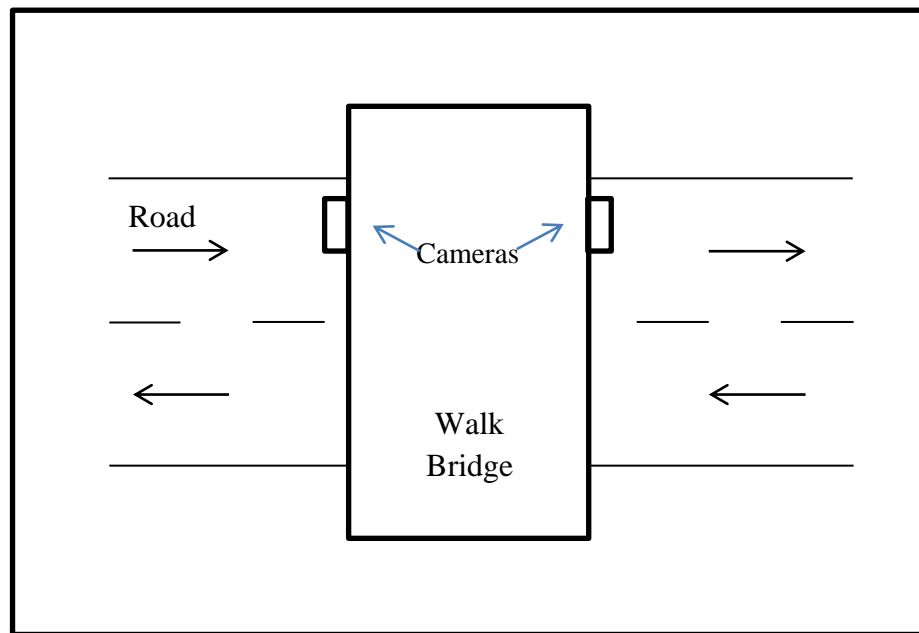


Figure 2: Illustration of cameras's location

Selection of experimental area is the road with average traffic. Figure 2 shows the location of cameras which are at 180° position, upper side of the road, at the walk bridge nearby Universiti Teknologi PETRONAS. The position of the camera is important as we need the top view of the vehicles.

Algorithm Development

```
sName='test.avi';
fInfo=aviinfo(sName);
d=aviread(sName,1);
h=mexCvBSLib(d.cdata); %Initialize
mexCvBSLib(d.cdata,h,[0.01 5*5 1 0.5]);%Set parameters
figure(1)
for i=1:fInfo.NumFrames
    d=aviread(sName,i);
    imMask=mexCvBSLib(d.cdata,h);
    imshow(imMask);
end
mexCvBSLib(h); %Release memory
```

Figure 3: The basic background subtraction code.

Figure 3 shows the basic code of background subtraction found in [2]. This code is utilized for the background subtraction technique.

mexCvBSLib

- interface to the foreground/background segmentation library

mexCvBSLib(image,h,parameters)

- the parameters set are [fAlphaT,fTb,bShadowDetection,fTau]

fAlphaT

- the speed of update
- if the required time interval is average over 100s, set Alpha to 1/100

fTb

- the threshold
- the typical value is 5 sigma, 5*5

bShadowDetection

- do shadow detection if ==1

fTau

- Tau is a threshold on how much darker the shadow can be
- For example, fTau= 0.5 means that if pixel is more than $1/0.5=2$ times darker, then it is not shadow

```

labelled=bwlabel(LMask);           % label the area in a mask
stats=regionprops(labelled,'basic'); % getting basic information
addstats=regionprops(labelled,'PixelIdxList'); %getting pixel location
identity=find([stats.Area]>500);   % getting area of identity of area larger than 500 pixels
identity=identity';

```

Figure 4: Region properties

Figure 4 show part of the algorithm to determine the region properties.

Regionprops used to measure the properties of image regions (blob analysis). Properties can be a comma-separated list of strings, a cell array containing strings, the single string 'all', or the string 'basic'. If properties is the string 'all', regionprops computes all the shape measurements, listed in Shape Measurements. If properties is not specified or if it is the string 'basic', regionprops computes only the 'Area', 'Centroid', and 'BoundingBox' measurements.

3.2 PROJECT ACTIVITIES

Fig. 3 shows the basic flow of project activities throughout the project period. The very first activity is research, where few related research papers are properly reviewed to get the basic understanding of the whole project. After the literature review, the video of vehicles are captured. However, it has to be ensured that the video are suitable to be used. The video then run in MATLAB through the written algorithm.

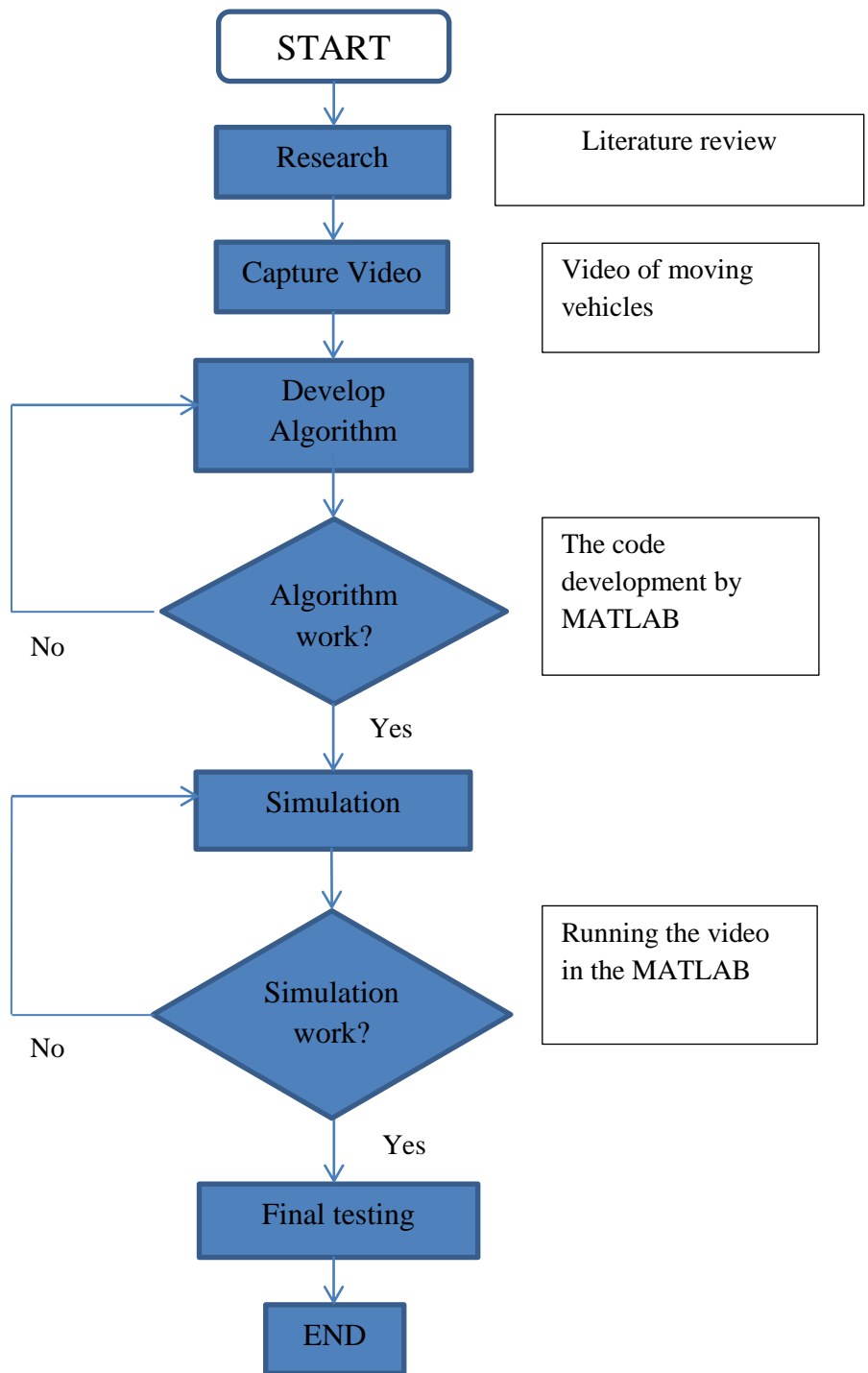


Figure 5: Flow chart of project's activities

3.3 KEY MILESTONES

Stages	Task	Duration	Status
FYP I	Selection of FYP topic	Week 1	Completed
	Preliminary Research Work	Week 2- Week 5	Completed
	Submission of Extended Proposal Defence	Week 6	Completed
	Proposal Defence	Week 8- Week 9	Completed
	Submission of Interim Draft Report	Week 13	Completed
	Submission of Interim Report	Week 14	Completed
FYP II	Submission of Progress Report	Week 8	Completed
	Pre-SEDEX (ELECTREX)	Week 11	Completed
	SEDEX	Week 12	Completed
	Submission of Draft Report	Week 13	Completed
	Submission of Dissertation (Soft Bound)	Week 14	Completed
	Submission of Technical Paper	Week 14	Completed
	Oral Presentation (VIVA)	Week 15	Completed
	Submission of Dissertation (Hardbound)	Week 16	Completed

Table 2: The key milestones for FYP I and FYP II.

Table 5 shows the key milestones that consists the two stages of final year project (FYP) which are FYP I and FYP II. FYP 1 planned for the first semester and FYP 2 is planned for the second semester. This project is accomplished within the time frame as planned in project Gantt chart. All the tasks are complete successfully as per schedule.

3.4 GANTT CHART

3.4.1 FYP 1 SEMESTER MAY 2013

Task/ Activity	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Selection of Project Title -FYP1 briefing -meeting from Supervisor -introduction to FYP topic	Light Blue	Light Blue					Light Red							
Preliminary Research Work -video recording			Light Blue	Light Blue	Light Blue		Light Red							
Submission of Extended Proposal Defence						Orange	Light Red							
Proposal Defence							Light Red	Light Blue	Orange					
Project work continues -algorithm development							Light Red			Light Blue	Light Blue	Light Blue		
Submission of Interim Draft Report							Light Red						Orange	
Submission of Interim Report							Light Red							Orange

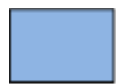
Table 3: Gantt Chart for FYP 1

3.4.2 FYP 2 SEMESTER SEPTEMBER 2013

Task/ Activity	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Develop algorithm using MATLAB -algorithm developed and improvised	PROCESS	PROCESS	PROCESS	PROCESS	PROCESS	MID SEMESTER BREAK									
Progress Report						MID SEMESTER BREAK	PROCESS	MILESTONE							
Pre – EDX -project is finalised -poster presentation						MID SEMESTER BREAK			PROCESS	PROCESS	MILESTONE				
Draft Report						MID SEMESTER BREAK						PROCESS	MILESTONE		
Final Report						MID SEMESTER BREAK								MILESTONE	
VIVA						MID SEMESTER BREAK									MILESTONE

Table 4: Gantt Chart for FYP 2

Legends:



PROCESS



MID SEMESTER BREAK



MILESTONE

3.5 TOOLS

For hardware, two cameras are used for this project. The two cameras are also fixed to be the same type of camera. This will ease the work as it will produce same type of image/video.

MATLAB R2010a is utilized for the software modelling and developing the algorithm. As this project mainly involved digital image processing, MATLAB is an ideal and suitable software tool as MATLAB consists of image processing tools box for analysis and visualization.

Microsoft word also utilize for the use of paperwork and documentation of report.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 FINDINGS

The experiment is narrowed down to one vehicle in one video to test the algorithm.

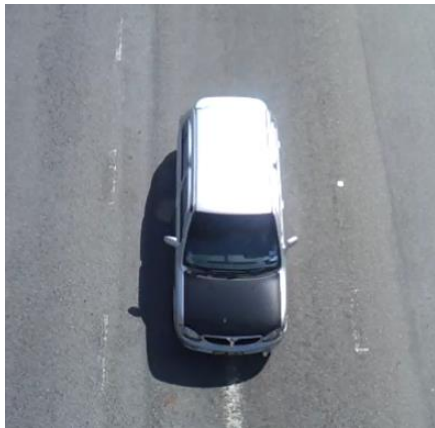


Figure 6: Incoming Vehicle
Captured by first camera

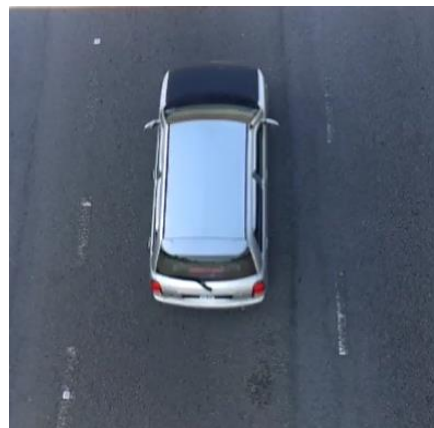


Figure 7: Passing Vehicle
captured by second camera

Figure 1 shows the image from the video captured by the first camera and Figure 2 shows the image from the video captured by the second camera.

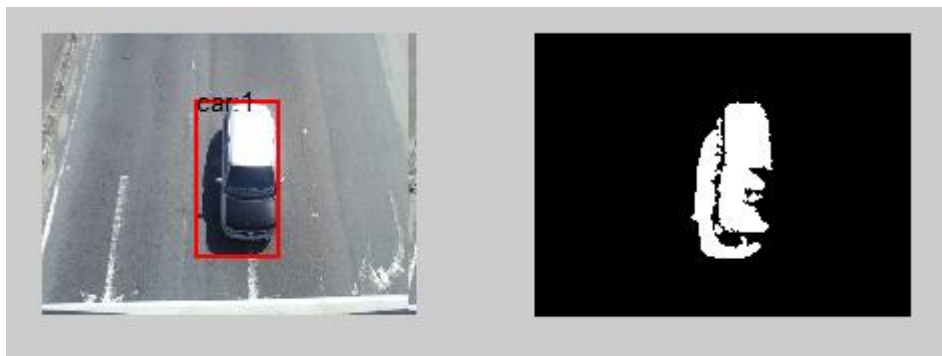


Figure 8: Background Subtraction of incoming vehicle



Figure 9: Background Subtraction of passing vehicle

The videos captured are run in the MATLAB. The data shown is taken from the MATLAB. The next few pages will compare the colour properties of vehicle between two cameras. The colour properties we are focussing are cb and cr, the blue-different chroma components and the red-different chroma components respectively. From the running MATLAB, we managed to get the mean and meadian value for both colour components. The data collected from MATLAB, for both cameras are used to utilised in the t-test. T- test is used for comparing the means of two samples (two cameras). In simple terms, the t-test compares the actual difference between two means in relation to the variation in the data (expressed as the standard deviation of the difference between the means).

Null hypothesis (an expectation - which the experiment was designed to test) is that there is no difference in colour values between the two cameras. The student's t-test will tell us if the data are consistent with this or depart significantly from this expectation.

For first set of data, comparison is made on the cb mean, between first and second camera.

Cb mean

First Camera

Frame	Colour Values
1	133.85
2	135.46
3	133.09
4	134.03
5	135.84
6	138.36
7	129.03
8	135.95
9	141.50
10	129.25
11	136.10
12	129.43
13	131.04
14	128.61

Table 5: Cb mean for first camera

Second Camera

Frame	Colour Values
1	131.79
2	151.98
3	132.27
4	152.35
5	132.63
6	152.39
7	152.55
8	134.02
9	141.52
10	152.49
11	137.81
12	136.57
13	146.13
14	136.78

Table 6: Cb mean for second camera

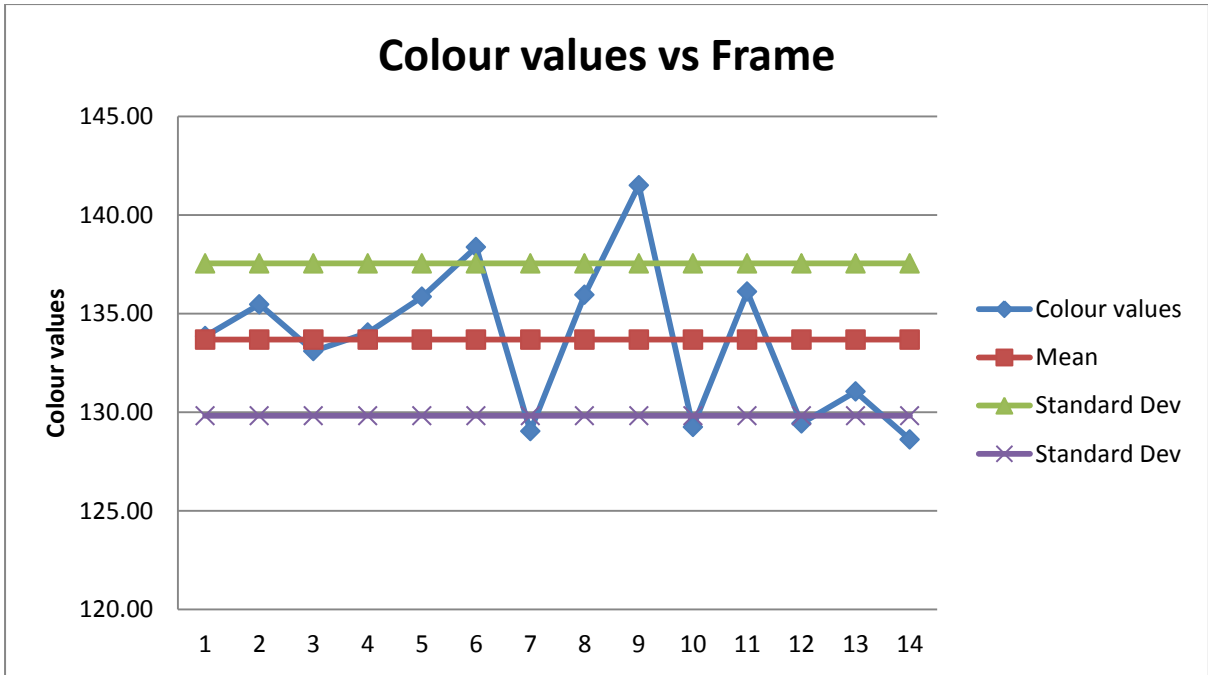


Figure 10: Cb mean for first camera

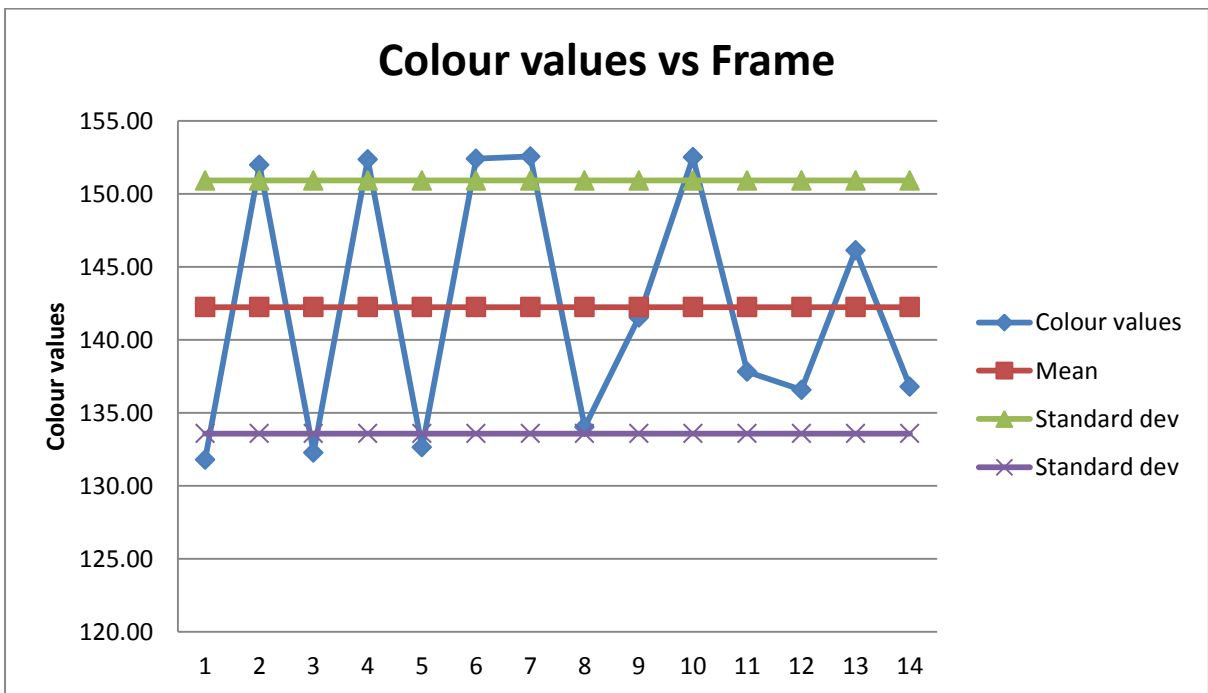


Figure 11: Cb mean for second camera

From the data tabulated above,

	First Camera	Second Camera
Total(sum of 14 data)	1871.59	1991.30
No. of data	14	14
Mean	133.68	142.24
Variance	14.88	75.16
Standard Deviation	3.86	8.67

Table 7: Calculated value for cb mean

$\sigma_d^2 =$ is the variance of the difference between the means

$\sigma_d =$ the standard deviation of the difference between the means

$$\sigma_d^2 = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2} = \frac{14.88}{14} + \frac{75.16}{14} = 6.43$$

$$\sigma_d = \sqrt{6.43} = 2.54$$

$$t = \frac{Mean_1 + Mean_2}{\sigma_d} = 3.37$$

Entering a t-table (See Appendix 1) at 26 degrees of freedom ($n_1 + n_2 - 2 = 26$) we find a tabulated t value of 2.06 ($p = 0.05$) going up to a tabulated value of 3.71 ($p = 0.001$).

Our calculated t value is within this range, so the difference between our means is very small, concluded that the means have very highly similarities.

Thus, the hypothesis for the first set of data (cb mean) is accepted.

Cb med

First camera

Frame	Colour Values
1	135
2	135
3	134
4	135
5	136
6	137
7	128
8	136
9	142
10	128
11	136
12	128
13	128
14	128

Table 8: Cb med for first camera

Second camera

Frame	Colour Values
1	132
2	154
3	132
4	154
5	133
6	154
7	155
8	134
9	143
10	155
11	140
12	137
13	150
14	137

Table 9: Cb med for second camera

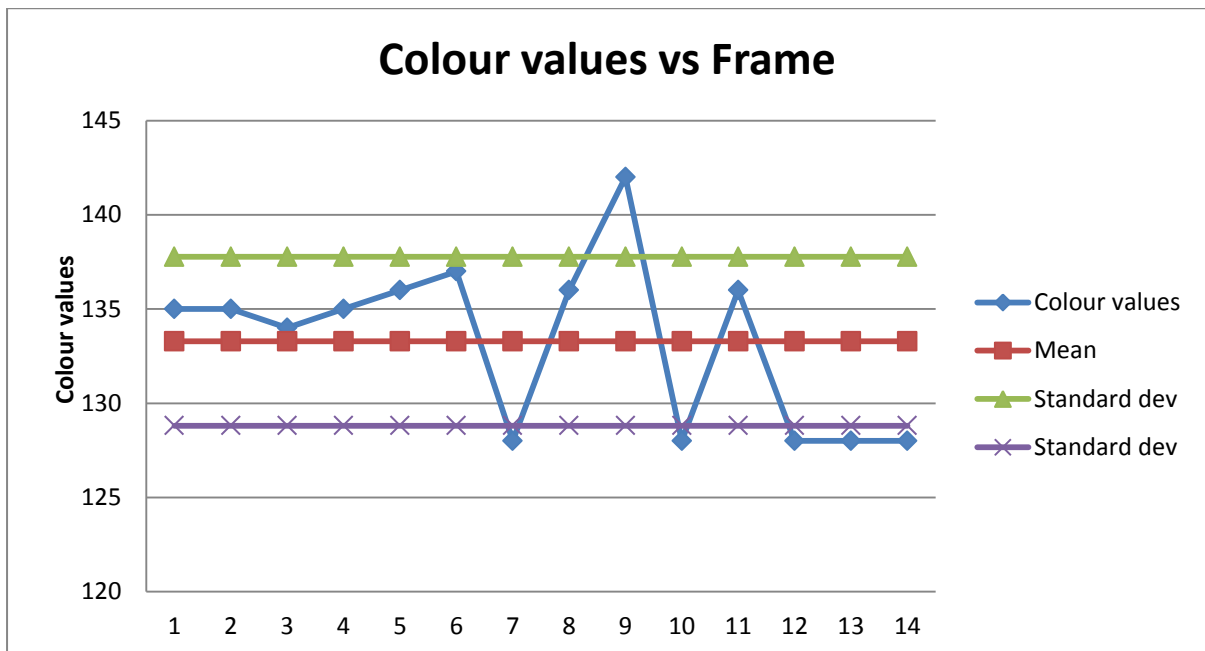


Figure 12: Cb med for first camera

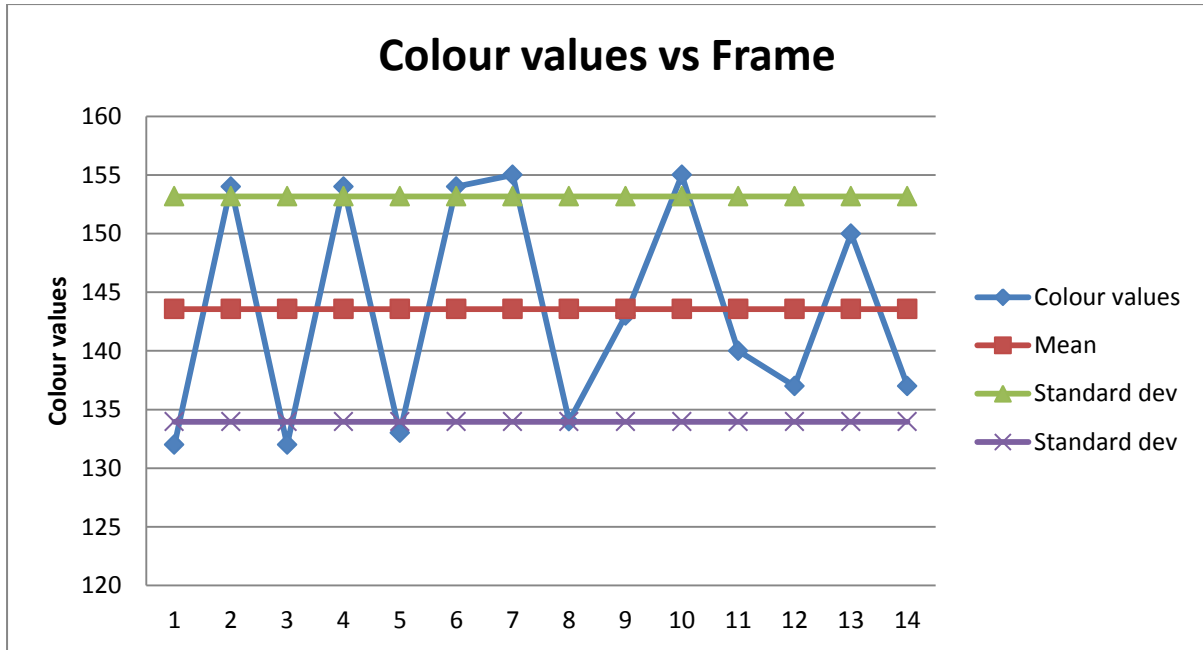


Figure 13: Cb med for second camera

From the data tabulated above,

	First Camera	Second Camera
Total(sum of 14 data)	1866	2010
No. of data	14	14
Mean	133.29	143.57
Variance	20.07	92.26
Standard Deviation	4.48	9.61

Table 10: Calculated value for Cb med

$\sigma_d^2 =$ is the variance of the difference between the means

$\sigma_d =$ the standard deviation of the difference between the means

$$\sigma_d^2 = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2} = \frac{20.07}{14} + \frac{92.26}{14} = 8.02$$

$$\sigma_d = \sqrt{8.02} = 2.83$$

$$t = \frac{Mean_1 + Mean_2}{\sigma_d} = 3.63$$

Entering a t-table (See Appendix 1) at 26 degrees of freedom ($n_1 + n_2 - 2 = 26$) we find a tabulated t value of 2.06 ($p = 0.05$) going up to a tabulated value of 3.71 ($p = 0.001$).

Our calculated t value is within this range, so the difference between our means is very small, concluded that the mean have very highly similarities.

Thus, the hypothesis for this set of data (cb med) is accepted.

Cr mean

First camera

Frames	Colour Values
1	124.85
2	124.60
3	125.19
4	124.93
5	124.39
6	122.29
7	127.30
8	124.19
9	120.02
10	127.00
11	123.71
12	126.70
13	125.41
14	127.34

Table 11: Cr mean for first camera

Second camera

Frame	Colour Values
1	125.10
2	109.98
3	124.52
4	109.35
5	125.02
6	108.94
7	109.76
8	121.84
9	121.06
10	110.43
11	124.22
12	122.17
13	116.29
14	122.27

Table 12: Cr mean for second camera

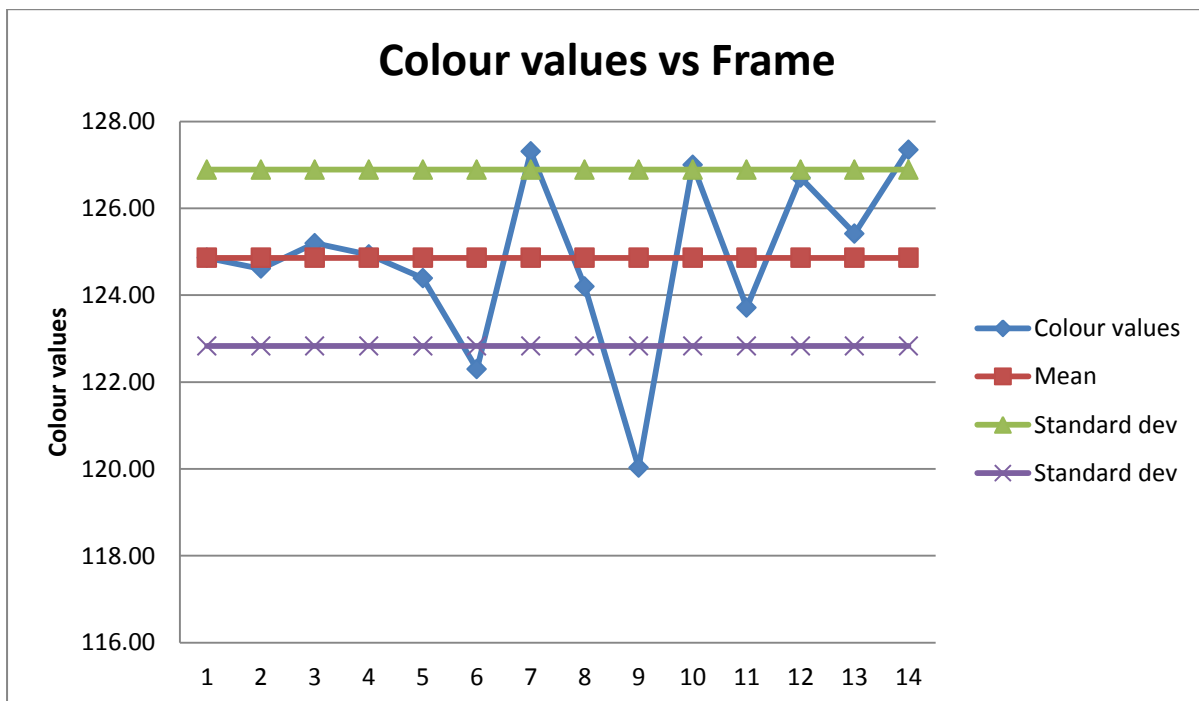


Figure 14: Cr mean for first camera

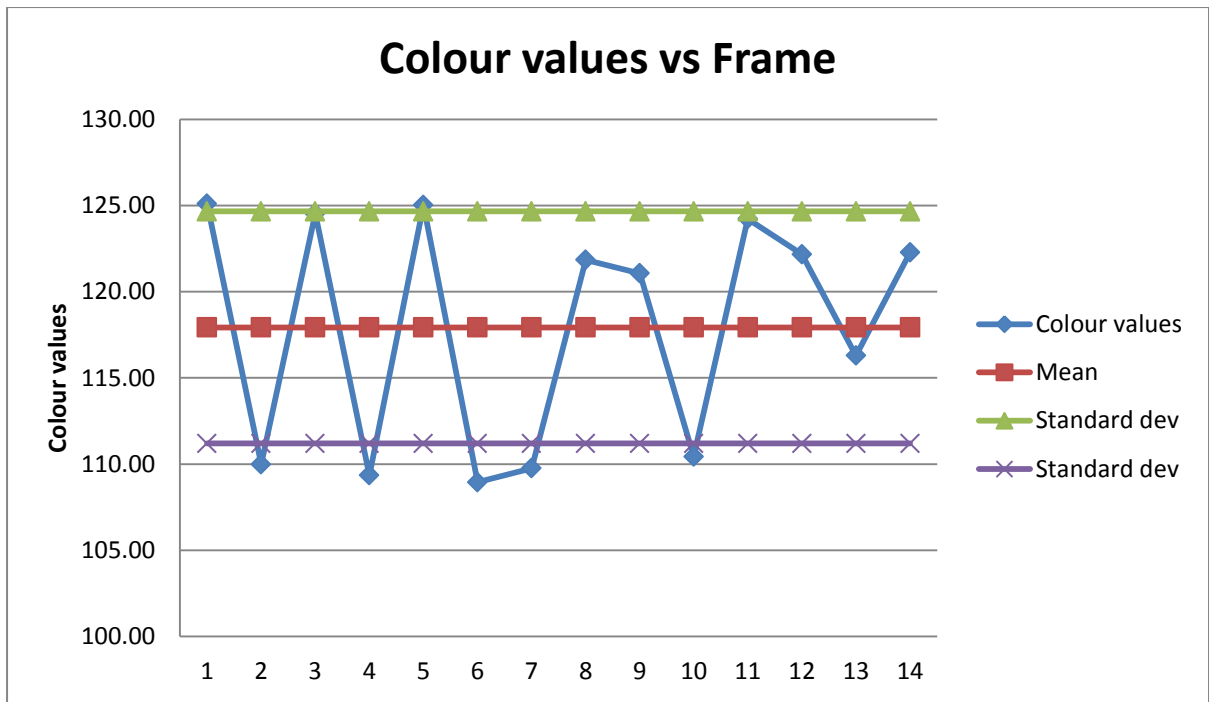


Figure 15: Cr mean for second camera

From the data tabulated above,

	First Camera	Second Camera
Total(sum of 14 data)	1747.99	1651.01
No. of data	14	14
Mean	124.86	117.93
Variance	4.12	45.34
Standard Deviation	2.03	6.73

Table 13: Calculated value for Cr mean

$\sigma_d^2 =$ is the variance of the difference between the means

$\sigma_d =$ the standard deviation of the difference between the means

$$\sigma_d^2 = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2} = \frac{4.12}{14} + \frac{45.34}{14} = 3.53$$

$$\sigma_d = \sqrt{3.53} = 1.89$$

$$t = \frac{\text{Mean}_1 + \text{Mean}_2}{\sigma_d} = 3.67$$

Entering a t-table (See Appendix 1) at 26 degrees of freedom ($n_1 + n_2 - 2 = 26$) we find a tabulated t value of 2.06 ($p = 0.05$) going up to a tabulated value of 3.71 ($p = 0.001$).

Our calculated $t=3.67$ value is within this range, so the difference between our means is very small, concluded that the mean have very highly similarities.

Thus, the hypothesis for this set of data (cr mean) is accepted.

Cr med

First camera

Second camera

Frames	Colour Values
1	125
2	125
3	126
4	125
5	124
6	123
7	128
8	124
9	120
10	128
11	124
12	128
13	128
14	128

Frame	Colour Values
1	125
2	109
3	124
4	108
5	124
6	107
7	108
8	121
9	121
10	109
11	123
12	120
13	113
14	120

Table 14: Cr med for first camera

Table 15: Cr med for second camera

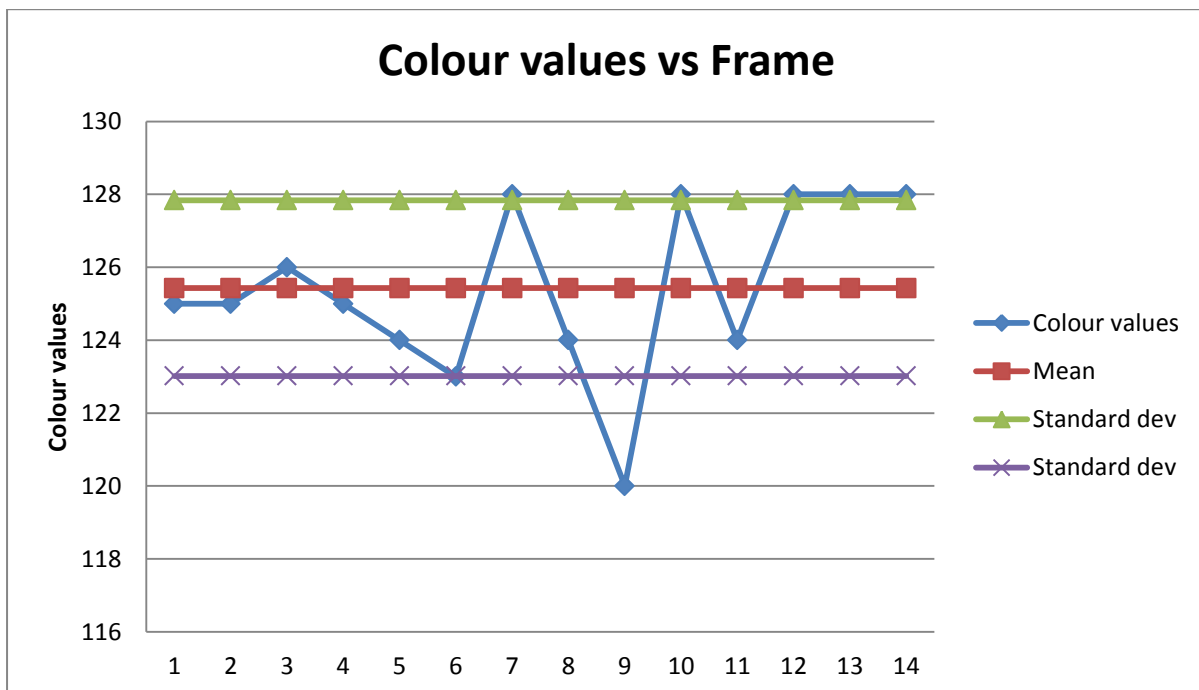


Figure 16: Cr med for first camera

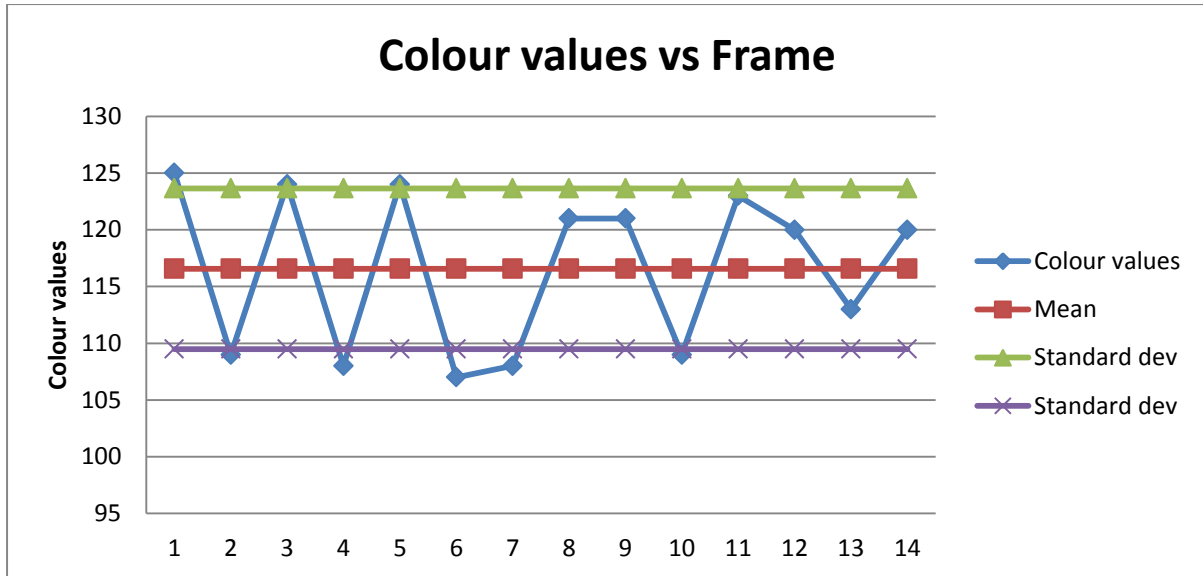


Figure 17: Cr med for second camera

From the data tabulated above,

	First Camera	Second Camera
Total(sum of 14 data)	1756	1632
No. of data	14	14
Mean	125.43	116.57
Variance	5.8	50.11
Standard Deviation	2.41	7.08

Table 16: Calculated value of Cr med

$\sigma_d^2 =$ is the variance of the difference between the means

$\sigma_d =$ the standard deviation of the difference between the means

$$\sigma_d^2 = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2} = \frac{5.8}{14} + \frac{50.11}{14} = 3.99$$

$$\sigma_d = \sqrt{3.99} = 1.99$$

$$t = \frac{Mean_1 + Mean_2}{\sigma_d} = 4.45$$

Entering a t-table (See Appendix 1) at 26 degrees of freedom ($n_1 + n_2 - 2 = 26$) we find a tabulated t value of 2.06 ($p = 0.05$) going up to a tabulated value of 3.71 ($p = 0.001$).

Our calculated $t=4.45$ value exceeds these, so the difference between our means is very highly significant.

Thus, the hypothesis for this set of data (cr med) is rejected.

4.2 DATA ANALYSIS

A significant difference at $p = 0.05$ means that if the hypothesis were correct (i.e. the values from two samples (cameras) is the same) then we would expect to get a t value as great as this on less than 5% of occasions. So we can be reasonably confident that the samples do differ from one another, but we still have nearly a 5% chance of being wrong in reaching this conclusion.

Now compare your calculated t value with tabulated values for higher levels of significance (e.g. $p = 0.01$). These levels tell us the probability of our conclusion being correct. For example, if our calculated t value exceeds the tabulated value for $p = 0.01$, then there is a 99% chance of the means being significantly different (and a 99.9% chance if the calculated t value exceeds the tabulated value for $p = 0.001$). By convention, we say that a difference between means at the 95% level is "significant", a difference at 99% level is "highly significant" and a difference at 99.9% level is "very highly significant".

What does this mean in "real" terms? Statistical tests allow us to make statements with a degree of precision, but cannot actually prove or disprove anything. A significant result at the 95% probability level tells us that our data are good enough to support a conclusion with 95% confidence (but there is a 1 in 20 chance of being wrong).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

In this work, we have proven that colour properties of vehicles can be utilized in vehicle tracking which are used as for general classification of vehicles. Algorithm is developed to enhance the vehicle tracking method. This work also subsequently demonstrated that two cameras based tracking enhances the tracking performance as compared to the single camera tracking. As conclusion, video surveillance with two cameras extends their capabilities and improves their robustness by employment of algorithms. The accuracy and the robustness of vehicle tracking also improved.

Other expansion to the system to be done in the future includes the vehicles tracking at the road with four junctions, utilizing four cameras. This should be done carefully as the probability of one vehicle entering a new junction is also need to be accounted.

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APPENDIX A

Note 1: A difference between two means is significant (at the given probability level) if the calculated t value is greater than the value given in this table. A probability of $p = 0.05$ (95% probability of making a correct statement) is usually acceptable for biological work, but $p = 0.1$ can be used for a "one-tailed" t-test.

Note 2: When comparing two means, the number of degrees of freedom is $(n_1 + n_2) - 2$, where n_1 is the number of frames of camera 1, and n_2 is the number of frames of camera 2.

Degrees of Freedom	Probability, p			
	0.1	0.05	0.01	0.001
1	6.31	12.71	63.66	636.62
2	2.92	4.30	9.93	31.80
3	2.35	3.18	5.84	12.92
4	2.13	2.78	4.60	8.61
5	2.02	2.57	4.03	6.87
6	1.94	2.45	3.71	5.96
7	1.89	2.37	3.50	5.41
8	1.86	2.31	3.36	5.04
9	1.83	2.26	3.25	4.78
10	1.81	2.23	3.17	4.59
11	1.80	2.20	3.11	4.44
12	1.78	2.18	3.06	4.32
13	1.77	2.16	3.01	4.22
14	1.76	2.14	2.98	4.14
15	1.75	2.13	2.95	4.07
16	1.75	2.12	2.92	4.02
17	1.74	2.11	2.90	3.97
18	1.73	2.10	2.88	3.92
19	1.73	2.09	2.86	3.88
20	1.72	2.09	2.85	3.85
21	1.72	2.08	2.83	3.82
22	1.72	2.07	2.82	3.79
23	1.71	2.07	2.82	3.77
24	1.71	2.06	2.80	3.75
25	1.71	2.06	2.79	3.73
26	1.71	2.06	2.78	3.71
27	1.70	2.05	2.77	3.69
28	1.70	2.05	2.76	3.67
29	1.70	2.05	2.76	3.66
30	1.70	2.04	2.75	3.65

APPENDIX B

```

clear;
position=[]; %variable to store track coordinates
nr_groups=6;
track=[];
reg=[];line_c=[];line_s=[];
testy=[];tester=[];testers=[];
display=2; %variable to control display onscreen
vector=zeros(10,1); % line to store calculated vector
angles=zeros(10,1); % line to store angle of vector
vec_m=[];ang_m=[];vector_m=[];
vecs=[]; % variable for determining the number of
vectors
stored=[];lined=[];
car_cb_mean=[];car_cr_mean=[];
car_cb_med=[];car_cr_med=[];

%display=nr_groups+1;

sName='cut1'; % video file read
fInfo=aviinfo(sName); % get information from video file
d=aviread(sName,1); % get video first frame
h=mexCvBSLib(d.cdata); %Initialize or first background image
initial_f=d.cdata;
mexCvBSLib(d.cdata,h,[0.01 14*14 1 0.1]); %set parameters
figure(1);

[m,n]=size(initial_f(:,:,1));
for loop=1:nr_groups
    mask1(:,:,loop)=zeros(m,n);
    % mask2(:,:,loop)=zeros(m,n);
end

blank=zeros(m,n); %blank template for empty frames
msk1=zeros(m,n);
msk2=zeros(m,n);
msk3=zeros(m,n);
msk4=zeros(m,n);
msk5=zeros(m,n);
msk6=zeros(m,n);

se=strel('diamond',4);
se2=strel('square',4);
bands=[0:1:255];
time=0; %variable for running correlation
result1=[0:.01:1]';

for i=1:fInfo.NumFrames

    d=aviread(sName,i); %read in from video file
    snap=d.cdata; %snapshot of video file
    imMask=mexCvBSLib(snap,h); %to get masked image
    snap1=rgb2ycbcr(snap);
    snap1cb=snap1(:,:,2); %this is to get the Cb layer alone
    snap1cr=snap1(:,:,3);
    %% section on getting a masked image
    imMask=im2bw(imMask,graythresh(imMask));
    %imMask=imclose(imMask,se);
    imMask=imopen(imMask,se);

    imMask=bwareaopen(imMask,150); %remove speckles from image
    %imMask(end-1:end,:)=0; %add line at bottom of image

```

```

    imMask(1:20,:)=0; %add line at bottom of image
    imMask=imclearborder(imMask,8); %to get image not connected to left
and right edges
    imMask=imfill(imMask,'holes'); %to fill holes in images

    LMask=imMask; %logical image LMask and imMask
    %LMask1=cat(3,imMask,imMask,imMask);

    %ycbcr_masked=immultiply(LMask1,snap1);

    labelled=bwlabel(LMask); % label the area in a mask
    stats=regionprops(labelled,'basic'); % getting basic information
    addstats=regionprops(labelled,'PixelIdxList'); %getting pixel location
    identity=find([stats.Area]>500); % getting area of identity of
area larger than 500 pixels
    identity=identity';

    % section to box the selected areas
    hold on;
    subplot(1,display,1);
    imshow(snap);
    drawnow;
    hold on;
%       for blocks = 1:size(stats,1)
           for blocks = 1:size(identity,1)

rectangle('Position',stats(identity(blocks)).BoundingBox,'EdgeColor',[1 0 0],
'LineWidth',1.5);%need to change to reg %1 0 0 is red
%rectangle('Position',[reg(blocks).Centroid 5
5], 'Curvature',[1,1], 'Facecolor','r'); %centroid
%plot(reg(blocks).Centroid(1),reg(blocks).Centroid(2),'+r');
car_colorcb=snap1cb(addstats(identity(blocks)).PixelIdxList);
car_colorcr=snap1cr(addstats(identity(blocks)).PixelIdxList);
car_cb_mean=[car_cb_mean,mean(car_colorcb)];
car_cr_mean=[car_cr_mean,mean(car_colorcr)];
car_cb_med=[car_cb_med,median(car_colorcb)];
car_cr_med=[car_cr_med,median(car_colorcr)];

txt=text(stats(identity(blocks)).BoundingBox(1),stats(identity(blocks)).BoundingBox
(2), strcat('car:', num2str(identity(blocks))));
%set(txt, 'FontName', 'Arial', 'FontWeight', 'bold', 'FontSize',
12, 'Color', 'black');

%plot(bc(1),bc(2), '-m+')
%a=text(bc(1)+15,bc(2), strcat('X: ', num2str(round(bc(1))), '
Y: ', num2str(round(bc(2))));
%set(a, 'FontName', 'Arial', 'FontWeight', 'bold', 'FontSize',
12, 'Color', 'yellow');
drawnow;
%section to store coordinates
%line_c=[line_c; reg(blocks).Centroid(1) reg(blocks).Centroid(2)
testy(blocks)];%line to save coordinates of lines
%stored=[stored;i reg(blocks).Centroid(1) reg(blocks).Centroid(2)
testy(blocks)];
end

car_colorcb=[];
car_colorcr=[];

%% section to display input inmage
%subplot(1,display,1);
%subplot(1,2,1);
%imshow(snap);
drawnow;
hold off;
subplot(1,display,2);

```

```
imshow(imMask);  
drawnow;  
  
end;  
  
mexCvBSLib(h); %Release memory
```