Traffic Congestion System

by

Dini Amalia

A dissertation submitted
in partial fulfillment of the requirement for the
Bachelor Of Technology (Hons)
(Business Information System)
JULY 2007

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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

____

(Rozana Kasbon)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
July 2007

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.

DINI AMALIA

ACKNOWLEDGEMENTS

I am glad that after gone through all the hardship in the making of 'Traffic Congestion System', I have successfully completed the whole requirement in Final Year Project. I would like to take this opportunity to give acknowledgement and recognition to people who helped me throughout the past two semesters.

First of all, I would like to thank to the Al Mighty, Allah SWT, for giving me the strength and patience gone through this project. I would also like to thank my parents for endless support that they gave me. My beloved siblings: Hero Adela and Erika Firdausi Amalia who always cherish me when I was down.

Sincere thank goes to the author's supervisor, Mrs. Rozana Kasbon for her guidance in finishing the project on time. The advice has given me a motivation in pursuing my project.

A higher appreciation given to the people mentioned below for the inspiration and motivation. Sri Krisna Wisnu Wardhana, a person who always be there for me. Thank you for your assistance, guidance, patience, support, and understanding in helping me completing this project. Dani Ihtahto, a person who assist me as well in this project. My best friends: Hernanti Agustina, Hestie Primasari, and Retno Palupi. My course mate, UTP student batch July 2003, PSP IPB batch 2002 for the support. Last but not least Indonesian Student Association (PPI UTP).

ABSTRACT

Traffic jam is a common issue faced by every capital city in the world. A lot of system has been made in order to improve the traffic. One of them is ITIS that initiated by City Hall Kuala Lumpur. By using operator in monitor and analyze the traffic, ITIS has a high human dependency. The system itself has not maximized the utilization of the latest technology. Due to the problem mentioned earlier, the author proposed a new solution that provide more detailed information and reduce the human dependency greatly on processing the traffic information. To automate the system provided by MATLAB algorithm in order to improve the current-technology in handling the traffic. To complete the project, four phases has been gone through: planning, analyzing, designing and testing, and implementation. MATLAB has been chosen to analyze the traffic and to create the user interface for traffic congestion system. A web camera used to support the system acquiring the traffic data. The data gathering then done by using the road prototype. After the testing, the author analyzed there are three main factors has influenced Traffic Congestion System: camera, object/vehicles, and lighting. The angle and position of camera has contribution in defining the Region of Interest (ROI) and number of pixels that will be analyzed. Number and color of the object have a huge impact to the traffic congestion. And lighting holds important role in Traffic Congestion System. It is where extra lights will be needed in order to examine traffic in night mode since it only works on the same light intensity.

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ABBREVIATIONS

AID	Automatic Incident System
ATIS	Advance Traveler Information System
ATMS	Advanced Traffic Management System
AVLS	Automatic Vehicle Location System
CCTV	Closed-circuit television
CHKL	City Hall Kuala Lumpur
CPU	Central Processing Unit
GIS	Geographic Information System
GUI	Graphical User Interface
ITIS	Integrated Transport Information System
RGB	Red Green Blue
ROI	Region Of Interest
TMC	Transport Management Center
VMS	Virtual Memory System

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Number of population in the world is increasing rapidly every year, and it has been followed by the usage of vehicles. This kind of situation has leads to creation of traffic jam and starting to affect environment. Cases such as pollution and stress increase tremendously.

Government, as the institution that responsible for public service, has made several attempts to reduce the number of traffic jam. They have added number of police high way patrol, CCTV to monitor the traffic, and construct a bridge or underpass. Yet, it has improved the traffic condition for small percentage. In Malaysia, one of the state governments has created a system to improve the traffic.

A system called ITIS has been developed and implemented by CHKL. This system involves acquiring raw information, gathering the raw information, analyzing and processing, and also delivering useful-traffic-information to the user.

ITIS are using CCTV camera, AID system, and AVLS as their media. With the integration of these three systems, that will form Advanced Traffic Management System (ATMS), ITIS acquired the data. The traffic image, as the raw data, sends to Transport Management Center (TMC) to be processed and analyze by the expertise. The result then sent to Advance Traveler Information System (ATIS) to be broadcasted [1].

1.2 Problem Statement

The author would like to highlight one component of ITIS, the usage of expertise in analyzing the traffic image. ITIS as a system considers having a high dependency toward expertise. Cost, speed and accuracy will affect the system running effectively.

In a common sense, the cost of expertise itself is quite high compared to ordinary employee. Human limitation could make less accuracy and more delay in delivering the information.

In current system, ITIS is not maximizing the utilization of the latest technology. It might reduce the user satisfaction in using the system. An improvement is needed to deliver more sufficient information.

1.3 Problem Solution

To improve the problem that has been mentioned previously, ITIS should construct an algorithm replacing the expertise task. So, the new system later on will have function of capturing, processing, and delivering the information. Meanwhile, third party only involved in requesting the information.

The algorithm will be used to compare the image: base image and current image. Base image is road image with the surrounding only. Meanwhile current image is the image capture initiated by user. The algorithm will calculate the percentage of similarities between those two images. High percentage means current image occupied less area. Meanwhile low percentage can be interpreted as congested. Training data is conducted for the author studies the trend and result.

1.4 Objectives and Scope of Study

1.4.1 Objectives

The objectives of this project are:

- To propose a new solution that provides more detailed information and reduce the human dependency greatly on processing the traffic information.
- To improve the current-technology in handling the traffic by using automation system provided by MATLAB algorithm. This can assist people to avoid traffic jam

1.4.2 Scope of study

This project concentrates on determining the area being occupied by the vehicles. Study the trend of normal, modest, and congested traffic. And based on those, then the author set the range of congestion.

The author has to explore on how to use MATLAB in image processing as well as in creating an interface. It is because this programming language is quite new for the author.

The hardware being utilized is web camera and CPU. The author also made road prototype for the purpose of analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Traffic in Malaysia

Due to the increasing of population has effect the number of vehicle being registered. It has been shown from the figure below; number of vehicle in Malaysia is swelling every year. Government need to be more concerned with this issues, since it will affect the environment condition and effect to the human wellbeing.

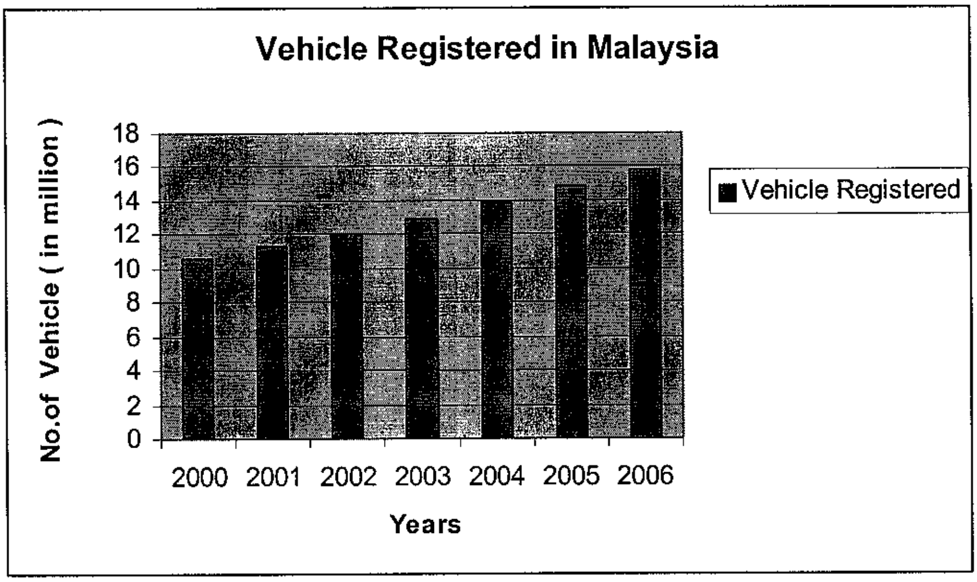

Figure 2.1 Vehicle Registered in Malaysia

Several attempts have been made by the government as the most responsible institution for this issue. Building a bridge, adding more police high way patrol, and making a new road as alternative are the solution that they have created. But it seems not sufficient enough. The government has to develop more effective solution that might simplifies the process of managing the traffic. City Hall Kuala Lumpur has answered this problem with forming a system called ITIS.

2.2 Current System

CCTV has been used to monitor the traffic. The data then gathered and publish using website. ITIS, integrated transport information system, is one of the examples. The project that initiated by CHKL provides a real-time traffic and flood information. [1].ITIS divide the system three major areas: monitoring, managing and distributing the information.

In monitoring the traffic situation, ITIS used three devices: CCTV, AID system, and AVLS. CCTV will be used to monitor the traffic situation happening in the road. Meanwhile AID system detects traffic congestion on the roads and the AVLS provides real time travel database. Information gathered using those three devices then send to TMC to analyze and to evaluate.

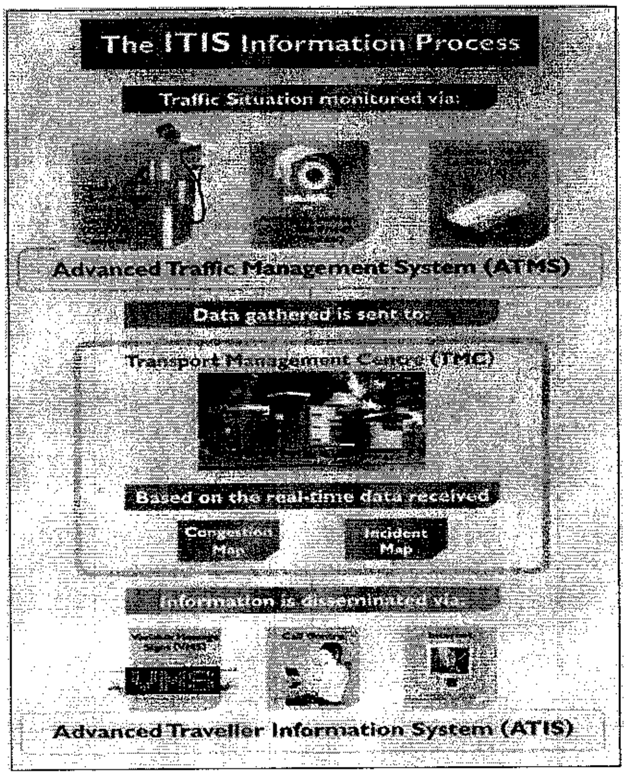

Figure 2.2 ITIS Information Process

In TMC, the operator will analyze and evaluate the data. Information that has been processed then disseminated via VMS, call center and internet.

ITIS has a dependency in human usage. In this system, human play a major role in order to create useful traffic information. To make the system more efficient, it needs to create a system to replace the function of human in analyzing and evaluating the data.

2.3 3D Urban Traffic System Simulation based on Geo-Data

This method has been introduced in London University. A traffic simulation has been created in order to study the 3D traffic system based on geo-data. [2] In the system, every car will have ability to make a decision. In this method it involves the simulation environment and traffic model. The simulation environment is a virtual environment generated by GIS database. Meanwhile, the traffic model used in the simulation system is a modified car-following model based on UK traffic rules.

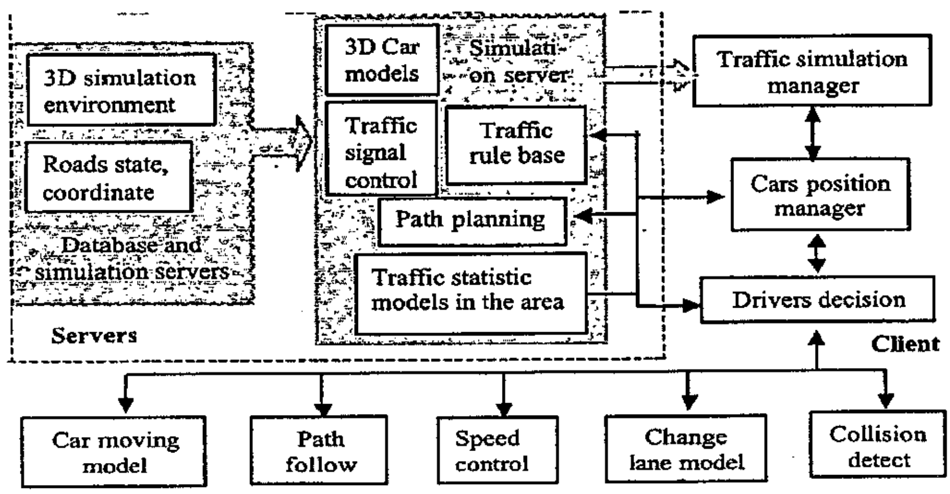

Figure 2.3 3D Urban Traffic System Simulation based on Geo-Data

From the figure above, there are a lot of component needs to be considered in order to implement this method. This method introduces two cars modeling. Car- modeling 1 is where the car moving model divided into cells of equal length, where the cell can contain one car or no car. Each cell is being created in order to blocked the car and treated it as not moving object. Car- modeling 2 is where the speed and time take as one of the consideration in traffic system simulation.

2.4 MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. [3].

Array is the basic data structured used in MATLAB. It is suitable for represents the images, and real valued ordered sets of color or intensity data. Here, most of the images will be stored in two dimensional arrays where each element of the matrix will be corresponding with a single pixel in the image. A pixel is the single value of intersection between row and column in the image. MATLAB also allow the conversion of images. It is possible to convert: RGB to gray scale image, RGB to HIS, RGB to index and etc.

2.4.1 Types of Images

MATLAB supported four types of image: indexed images, intensity images, binary images and RGB images.

Indexed images stores two kind of information: colormap matrix and map. Colormap matrix is an m-by-3 array of class double containing floating point values in the range of [0,1]. Meanwhile map is to describe the color component in each pixel : red, green, blue. For example the first value in the colormap matrix has the color component intensity in the first value in the map.

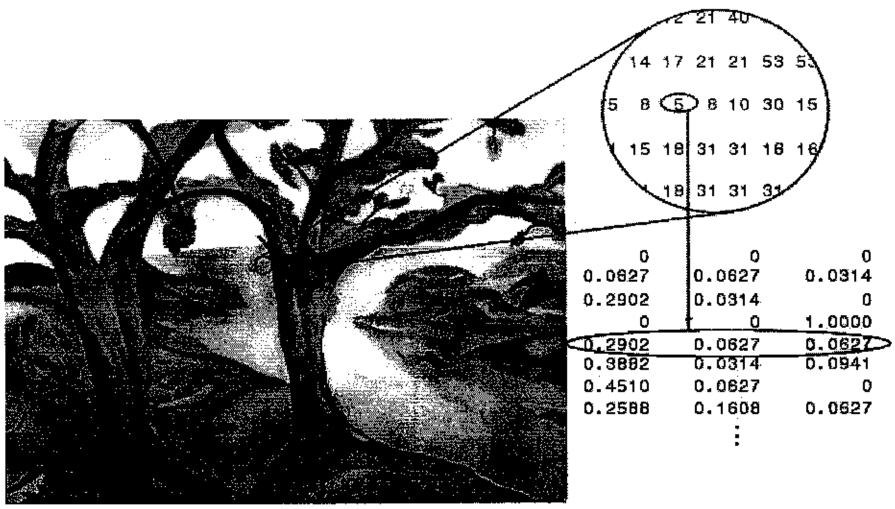

Figure 2.4 Indexed Image

Intensity image is the image matrix which value represents intensities within some range. The difference with the previous type is there is no color component being assigned. Only single matrix represents one image pixel. The intensity will be range from 0 that represents black and 1, 255, or 65535 that represent full intensity or white.

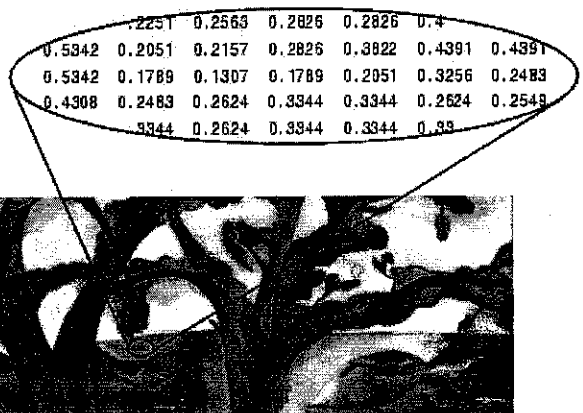

Figure 2.5 Intensity Image

Each pixel in binary image assumes ones of only two discrete values. The values will correspond to on and off. Where array with 0's values will be an off pixel meanwhile 1's will be considered as on pixel.

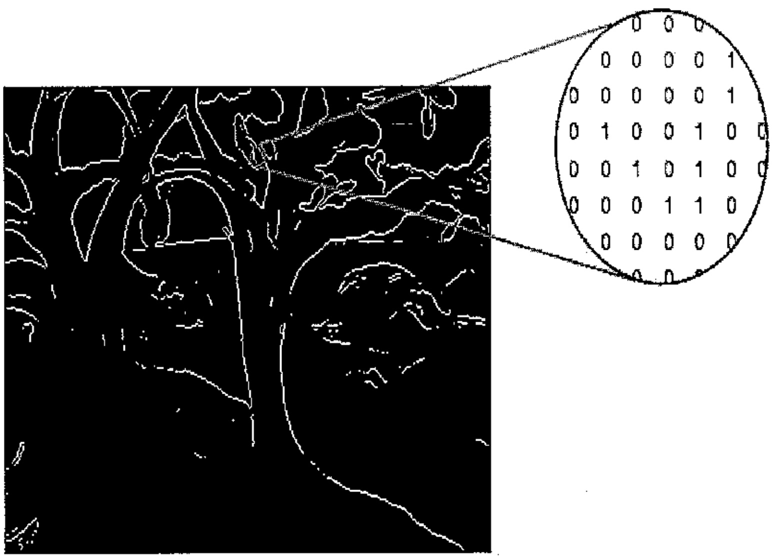

Figure 2.6 Binary Image

RGB image is a three dimensional images where each pixel is stored in an m-by-n-bu-3 data array that defines red, green, and blue color components. Each component is treated as one plane. The color of each pixel is determined by the combination of red, green, and blue intensities in each color plane. Graphics file formats will store the RGB images as 24-bit images, where the red, green, and blue components are 8 bits each. A pixel whose color components are (0,0,0) is displayed as black, and a pixel whose color components are (1,1,1) is displayed as white. The three color components for each pixel are stored along the third dimension of the data array. For example, the red, green, and blue color components of the pixel (10,5) are stored in RGB(10,5,1), RGB(10,5,2), and RGB(10,5,3), respectively.

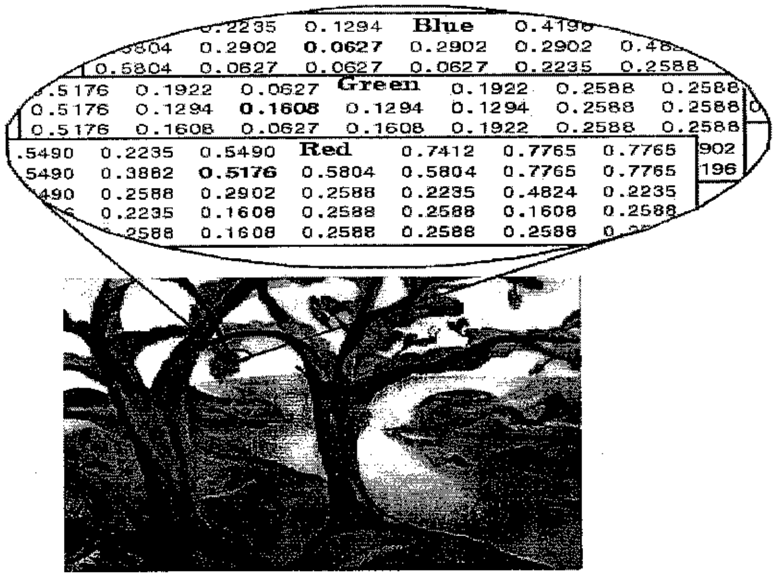

Figure 2.7 RGB Image

2.5 Optimum Statistical Classifier using Bayesian

Bayesian classifier studies conditional probability for mask in training data [4]. It can be used to compute the property that an example x belongs to class ωi. The computer implementation is facilitated using the multivariate normal density function, which is entirely defined by two parameters: the mean μi and covariance matrix Σi.[5]. To classify that the new element x as one of the the ωi classes, we take the highest value of the gi functions as the corresponding true class.

In optimum statistical classifier, it used bayes recognition frequently for automatically classifying regions in multispectral imagery. Four images will be needed (three visual bands and one infrared band). Bayes classification applied to different classes of region of interest.

The optimum statistical started with reading the multispectral images. After specifying each region of interest (binary mask image), the area cut by using roipoly function. The multispectral images then concatenated along with three dimensions to obtain image stack.

To create the different classes (binary mask image) , the method use roipoly function to determine the region of interest. The multispectral images being concatenated along with the third dimension to obtain image stack. The vector in ROI will be subtracted by using imastack2vectors function [3]. And the covariance and the mean vector will be calculated in order to find the pattern of the image. The data then have to be trained in order to acquire desired result.

CHAPTER 3

METHODOLOGY

To achieve objective mentioned earlier, a throwaway prototyping development-based Methodology has been implemented. With this methodology, the author has relatively thorough analysis phase to gather information and to develop idea for the system concept. Each issue will be scrutinized by analyzing, designing, and building a design prototype.

The function of the prototype in this project is for the author retrieves the data and analyzes the traffic condition. The result then will be used as standard of the system and apply in the system.

This methodology has a longer time to deliver compared to prototyping-based methodology. But it has advantages in producing more stable and reliable system.

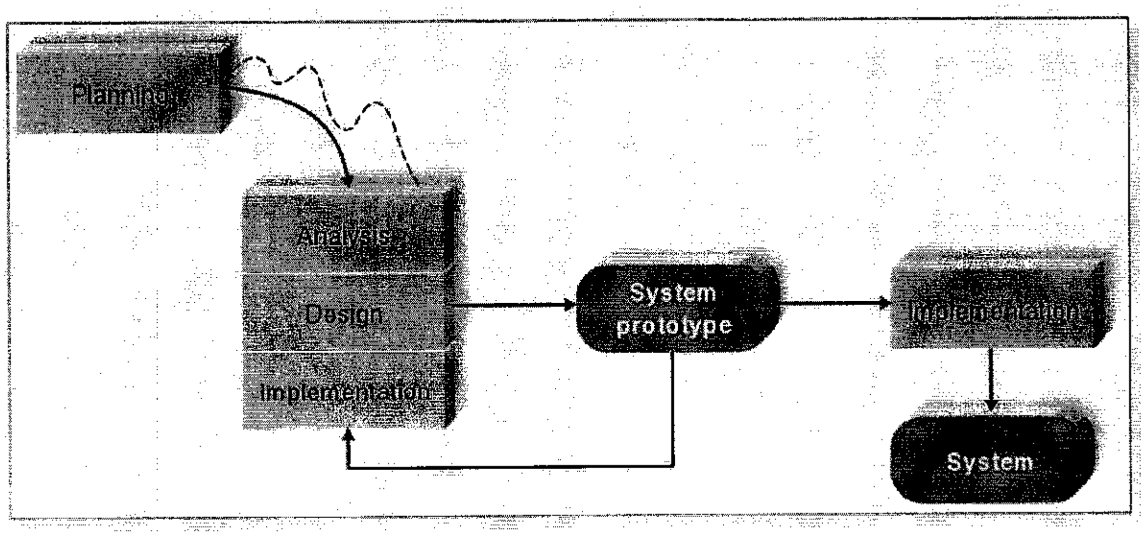

Figure 3.1 A Throwaway Prototyping-based Methodology

3.1 Planning Phase

In every system made, planning is the essential process of understanding the importance of building the system. In this phase, the author has determined there were unnecessary cost and neglected component occur in the previous system (ITIS) expertise cost and speed component.

Based on those two reasons, the author suggested a solution. The function of expertise in analyzing the data need to be substituted with a system that calculate the percentage of area being occupied by the variables such as cars, motor, etc. This solution has advantages on reducing human dependency and cutting the cost of the system.

3.2 Analysis Phase

ITIS provides the traffic solution by capturing the data and sending it to TMC in order for the expertise to analyze. Later on, the data being process and the result being upload to the database within five minutes gap.

From that process, the author sees the opportunities to improve the system by creating an algorithm that can automatically calculate the congested traffic automatically without involving the expertise. To accomplish this objective the author need to create a prototype. Data gathering then will be conducted by capturing the image. Collecting numerous of data is needed in order to get sufficient result. In this phase as well, the author also see the importance of setting the angle and placing the camera.

3.3 Design Phase and Testing

Design phase is where the blue print is drawn for building the system [6]. Every detail should be laid out before generation. In this phase, the author will define how the system will operate in terms of hardware, software, and the process of data gathering.

There are two images the system need in order to analyze the traffic: base image and current. Base image is the initial image that captured where there are no variables (car, motor, etc) and being stored in the system. The camera will capture the current image, initiate by the user, and send it to the system to be process. In the system, current image will be compared with the base image. If the value between those two images is same, so it means the traffic is normal. But if there is a huge difference between both images, so it will determine as congested. The information then delivered to the user.

3.3.1 Hardware Requirements

There are two hardware requirements needed and used:

- Web Camera
- PC as the server

3.3.2 Software Requirements

The software required:

- MATLAB

  It is used to construct algorithm for capturing and analyzing the data. User interface also created using this software.

In order to analyze the traffic situation, the author created road prototype. It is where there are four junctions in the area and the web camera capture the traffic image. Examining the pattern of traffic and using the result as the standard to define the congestion.

An interface will be created in order for user to initiate the image to be captured and to analyze the image. The result then will be informed to the user in the range of congested, moderate, and normal traffic.

3.4 Implementation Phase

This is the phase where the system and the interface that develop separately in previous phase being integrated. It is to make sure that the system working properly and giving the sufficient result.

3.4.1 Traffic Congestion System

Traffic congestion systems that will be created use a physical architecture. The architecture itself divided into two layers: transportation layer and communication layer [7]. Refer to figure 2.

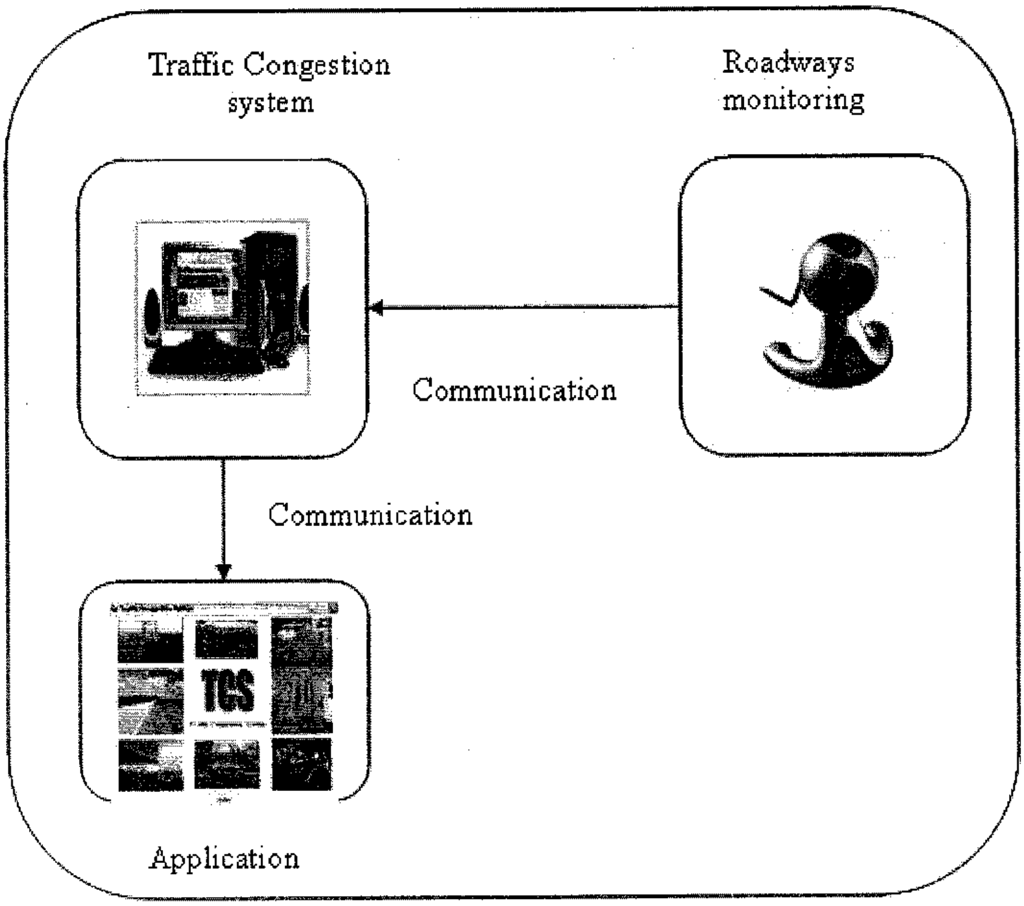

Figure 3.2 TCS Architecture

In transportation layer, it shows the relationship among the transportation management related elements [7]. Traffic congestion system has two layers of transportation: Roadways monitoring, traffic congestion management system, and website. Road ways monitoring only include the web camera in order to observe the traffic. Traffic congestion management system will include the server in order to analyze the data. Meanwhile website is included in transportation layer in order to inform the user about the traffic situation.

Communication layer of the physical architecture will provides the communication service that connects the transportation layer components.

In this project the concentration more on the traffic congestion system. It is where the system processes the analyzing image into meaningful information. Important factors need to be considered in analyzing the data. There is camera modeling, correlation as method to analyzing the data, and time interval.

Camera Modeling

In traffic congestion system, camera will be used to capture the image. To get required image, the angle of the camera could not be 90 degrees. To determine camera position and orientation perspective camera model will be used [8].

Perspective camera model is a model which has a correspondence to an ideal pinhole of the camera. By using the formula below, the position of the camera determined. The following is the illustration and factors used.

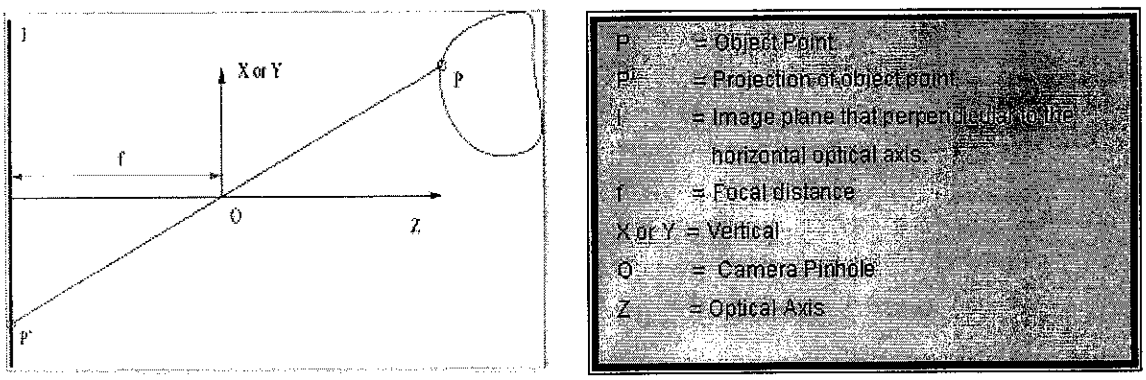

Figure 3.3 Perspective Camera Model

$$\vec{x} = \begin{cases} x = f\frac{X}{Z} \\ y = f\frac{Y}{Z} \end{cases}$$

(1)

The perspective camera model that explained previously then implemented in the real world. A model called modeling real camera implemented using the basic idea of perspective camera model. Comparing with the perspective camera model, there are two additional components added in modeling real camera. Since pixels are never exactly square in a real camera, two factors being added. There are k and l that expressed in pixels/cm. Here are the formulas that can used to calculate the angle

$$\vec{x} = \begin{cases} x = kf\frac{X}{Z} \\ y = lf\frac{Y}{Z} \end{cases}$$

(2)

$$\vec{x} = \begin{cases} x = f_x\frac{X}{Z} + u_0 \\ y = f_y\frac{Y}{Z} + v_0 \end{cases}$$

(3)

The formula can be used either (a) or (b). In formula (b) additional factor being added, u_0 and v_0 . These two factors are used to translate the principle point to the right location.

CHAPTER 4

RESULT AND DISCUSSION

This project has used a prototype that illustrates the road condition. The author then analyzes the traffic congestion based on this prototype. This chapter will be divided into four sub sections: road recognition, data images and analysis, traffic congestion result, and GUI.

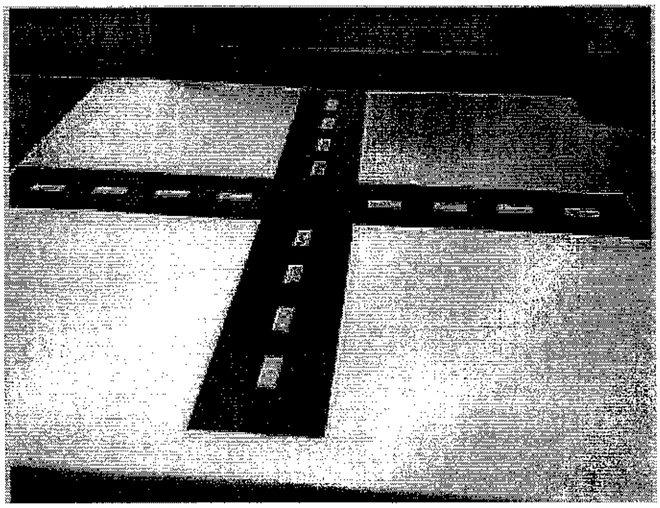

Figure 4.1 Road Prototype

4.1 Road Recognition

The main target for this project is the picture of the road only. The environment surrounding will be neglected. To reach that target, the author has to set two things: camera and mask.

4.1.1 Camera

The author has found that camera has influenced the next process of analyzing the data. Different position of the camera will impact to the setting of region of interest in mask. It also contributes in producing the bright intensity of the image that later on will affect to the pixel value.

The camera has to be set steady. It should not move since the region of interest (ROI) need to be assigned constantly in every image captured. It also required placing the camera at the highest building or at least higher place where nothing can distract the camera to capture the full ROI of road.

4.1.2 Mask

Mask is defined as region of interest. As mentioned earlier, the ROI is only the road. Another variable such as building and trees should not be included. The author has to determined point of interest that displays the road. The other area that not included in ROI will be neglected and it shown by making it in black color.

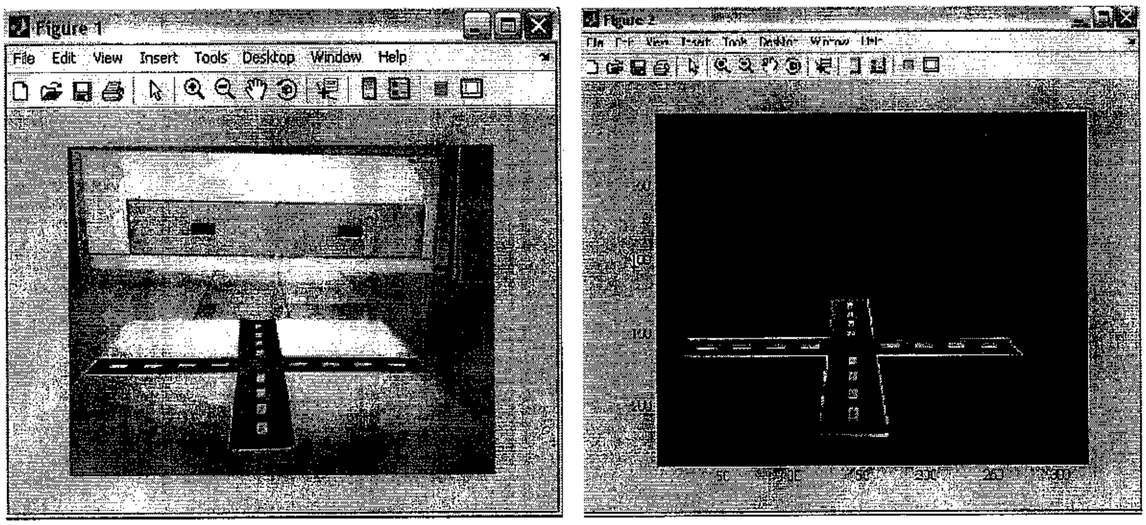

Figure 4.2 Road Mask

After defining the ROI for the road, the author has to set the mask for each street name. It is where a street will be treated as one ROI and the other area including the other three junctions will be disregard (Refer to figure 4.3)

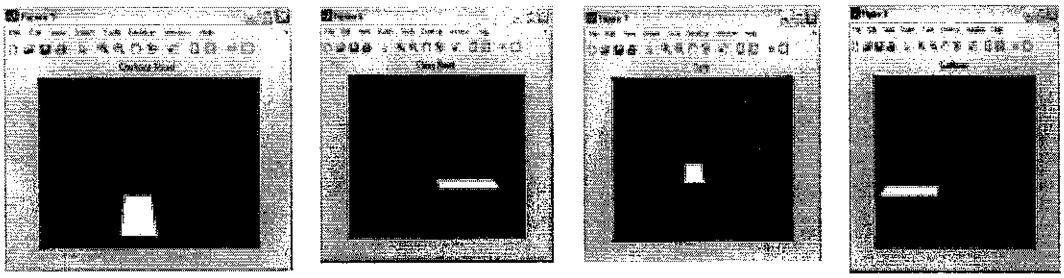

Figure 4.3 Junction Mask

By setting the mask, it means the system specify the area of the image need to be analyze. It only concentrated and calculated a part of the picture that directly affect to the speed of image analysis.

4.2 Data Gathering and Analysis

4.2.1 Traffic Images

Two images will be needed in analyzing the traffic: base image and current image. Base image is the image where it only displays the empty road without any variables such as car, motor, etc. The base image is stored in the system as the comparison. Meanwhile current image is the captured image initiated by the user. Current image will reflect the current condition of the road.

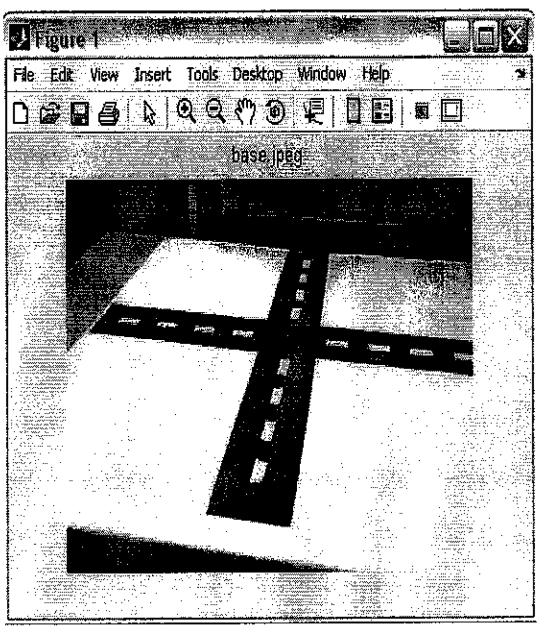

Figure 4.4 Base Image

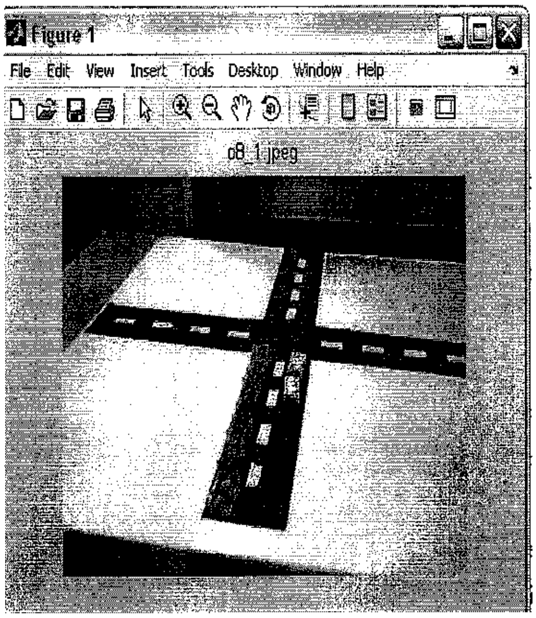

Figure 4.5 Current Image

4.2.2 Analysis

The image analysis done by acquired a lot of samples of current image. Different number of objects was located in the prototype. For each number of objects, there are 20 until 30 different position of the object taken. It also involves different color of objects to see the impact to the analysis.

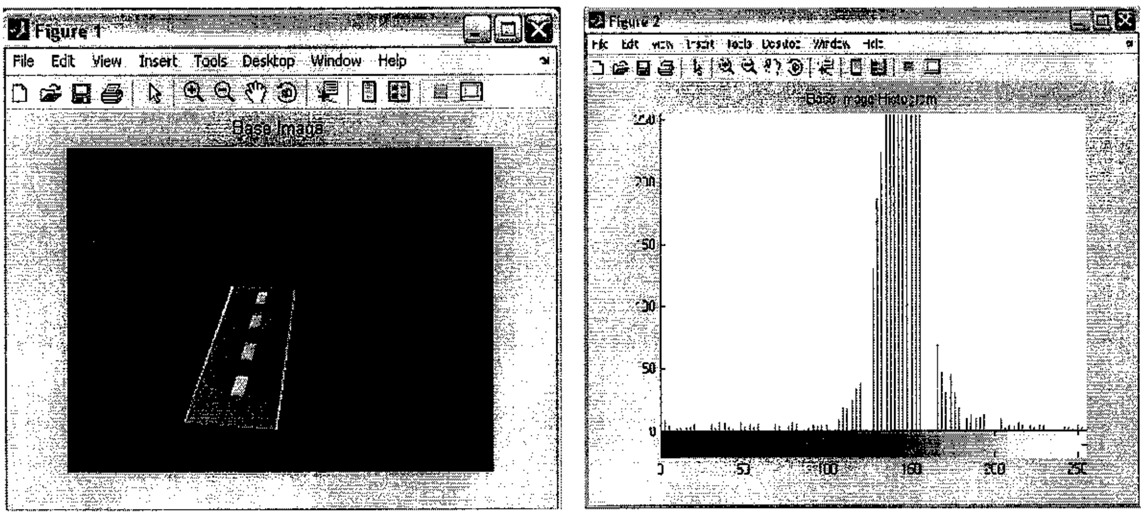

Figure 4.6 Base Image Analysis

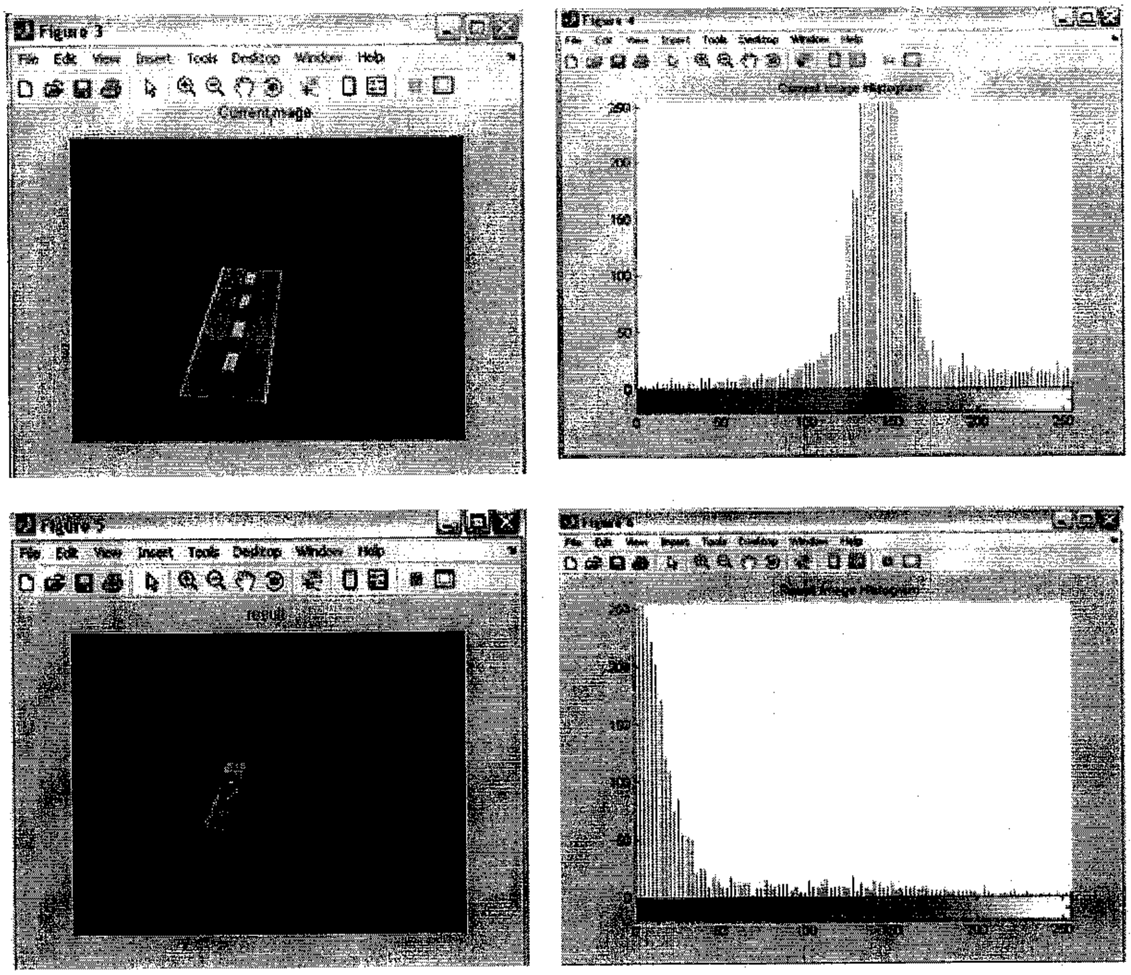

Figure 4.7 Current Image Analysis and Result

The first thing that the system will do after obtain current image is to convert the RGB image into gray scale. If all RGB components images are identical, the result will be a gray-scale image[3]. The process then continues with converting the base image to gray scale format.

The pixel value in current image will be compared with the one in base image. If the result is the same, zero pixel value will be appeared. A zero pixel value being assigned to the area outside the ROI, in order to speed up the analysis process. The result will be calculated by comparing the value in the region of interest only. (refer to figure 4.7.

Congestion area is defined as the percentage of the object occupied the ROI. Number of object in the current image is the main factor that used to determine the congestion. The author has done some data gathering regarding to this issue. In the process, the image has classified into 8 classes. Each class represents number of object in the current image. As predicted, the percentage of the object occupied the ROI is decreasing successively. It can be seen from the figure 4.8. But sometimes the changes between one classes to another class is not much. So, later on the author need to define the range of congested area.

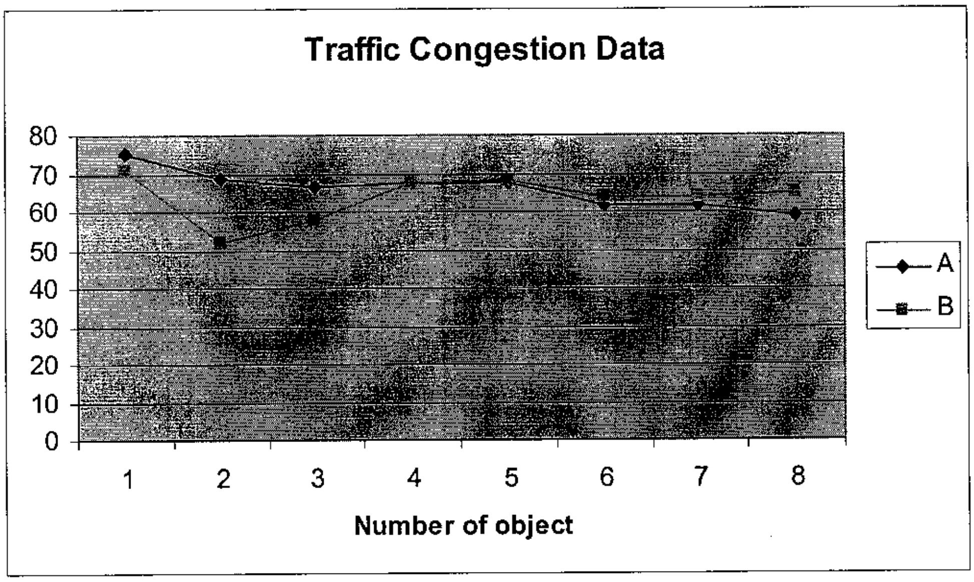

Figure 4.8 Traffic Data

Note :

A: Traffic congestion result with color object

B: Traffic congestion result with mixed color object

In the beginning, the author has assumed if the number of object is the same in the ROI so the percentage of congestion will remain the same. But it is totally wrong. Based on the data acquire, the position of the object also impact to the percentage. In each number of objects with different position, the percentage is diverse. The result will be fluctuated within a range. The author rarely sees the same percentage of congestion with different position in a group. Figure 4.9 displays the difference of congestion percentage within one class but different position.

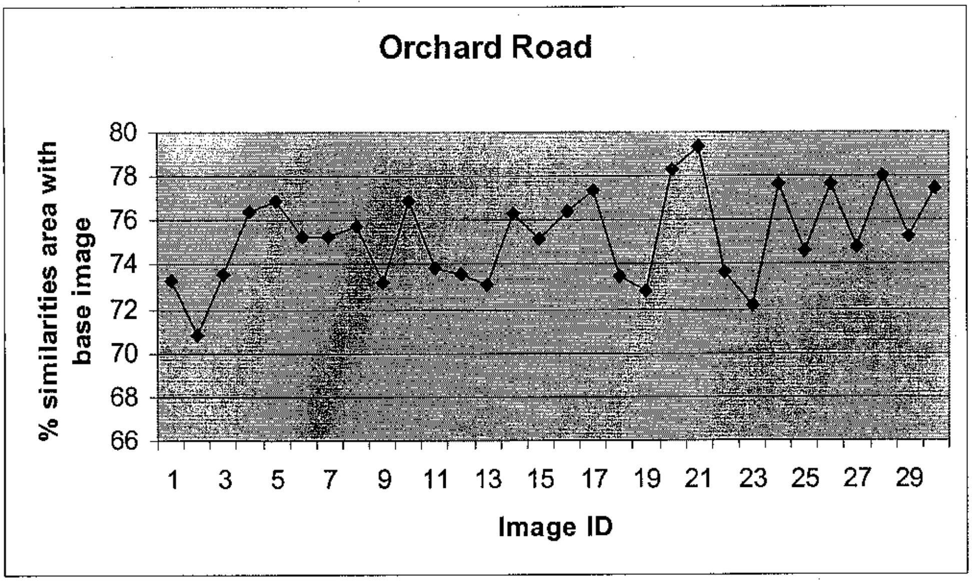

Figure 4.9 One Object in the Road with Different Position

Object color also holds an important role. As refer to figure 4.8, there are major difference between the color object and the mixed color object. Especially in class number 2. It decreased the value from 68.90531 to 52.05583. The reason behind this issue is the road pixel value is higher that the pixel of the object. So when the system subtracts the current image with the base, the result will be zero pixels. Meanwhile in order to calculate the percentage of congestion area, the system will calculate the pixel with zero value. If that is the case, the darker object will be defined as the factor that has contributed more to congestion. This false assumption can be solved by creating the range as mention earlier.

Angle and position of the camera affect to the number of pixel that will be analyze. The author tried to alter the position of the camera in capturing the second group of images. There will be difference in term of number of pixels being analyzed in one ROI. In the first group, only one object in ROI, 8961 number of pixel being analyzed. (Refer to appendix different pixel) Meanwhile in second group there were 9135 pixels were involved in the analysis process. From this point, the author sees the importance of making the camera in steady position and setting the angle. Moving the camera to another location will require to reset the point of ROI and to verify the number of pixel required to be analyzed.

The intensity of lights has influence the value of the pixel being produced. Since the image will be converted to the gray scale, the result of the conversion will be darker. It is hard for the system to recognize the road and the object inside the road. An additional light will be needed in order to support the camera to capture the desired image.

The current image pixel value will be subtracted with the base image to find the congestion result. Problem occurs if the value of current image is lesser than the base image. Zero value will be assign as the pixel result. Meanwhile, the congestion area is being calculated by counting the zero, since the author assumed that zero pixel means equal to the base image. This problem can be solved by having a training data and setting the range for congestion.

4.3 Traffic Congestion Range

After collecting the data (refer to the appendix), the author has came out with the range of congestion area. The information that the user will be given is the traffic status as well as the result image histogram.

Table 0-1 Traffic Congested Range

Range	Traffic Status
0.00%-55.00%	Congested
55.01%-71.00%	Modest
71.01% -100%	Normal

4.4 Graphical User Interface

GUI is needed for user to interact with the system. Basically the interface created will launch with welcoming page and follow by the main page. Both of the pages then saved as M-function file.

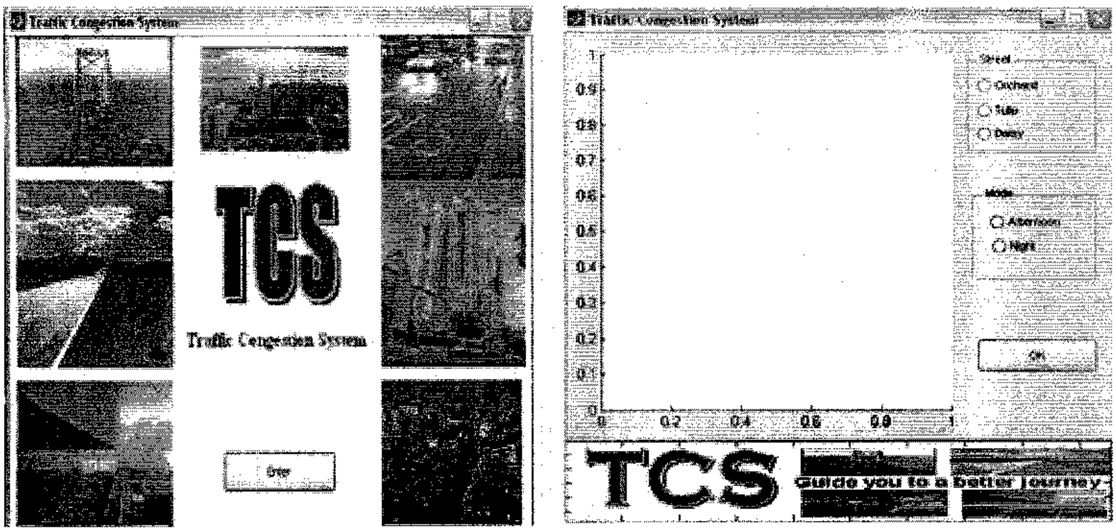

Figure 4.10Welcome and Main Page

The user needs to initiate the analyzing process by choosing the street name and the mode. Defining the street name is to concentrate on area that should be examined. The purpose is for the system itself to fasten the analyzing process. Concentrate on one area is more effective than analyzing the whole traffic image. The mode option is used for the user to identify the road atmosphere. An additional analysis will be made for the system to examine the data. The axis in the lefts side of street panel will show the result of the traffic in the histogram form.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The project is basically to recognize whether the congested traffic by analyzing several circumstances. The objective of this project has been full filled where the system can identify the object in the road. It decreases the level of human dependency by replacing the expertise function with the system. User can access the information by accessing the application.

For the purpose of this project, the author has concentrated on several factors to identify the image: ROI, light intensity, camera angle and position, and object color intensity. Region of interest is where the author identifies each region to be examined that later on will be chosen by the user. Light intensity has influence the value of the pixel. Camera angle and position helps the author to identify the ROI. And object color intensity influence the pixel value being produced.

A future enhancement needs to be made by conducting the research in the real condition. It is where the image being capture in the real road or subway area. Other factors also need to be included such as speed and distance of the object as well as the time difference when each object moves. Another method such as calculating the number of object on the road might be used in order to get more accurate traffic information.

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APPENDICES

APPENDIX A- Orchard Road Data

ORCHARD ROAD DATA
1 OBJECT ON THE ROAD

Color object	
Image Id.	**Percentage**
01_1	73.2786
01_2	70.7827
01_3	73.607
01_4	76.3985
01_5	76.9239
01_6	75.2819
01_7	75.3147
01_8	75.7745
01_9	73.202
01_10	76.8692
01_11	73.8692
01_12	73.5523
01_13	73.0487
01_14	76.2999
01_15	75.1396
01_16	76.3875
01_17	77.329
01_18	73.4647
01_19	72.775
01_20	78.3361
01_21	79.2994
01_22	73.6836
01_23	72.1949
01_24	77.6355
01_25	74.647
01_26	77.6574
01_27	74.7783
01_28	77.9967
01_29	75.249
01_30	77.4713
SUM	2258.2481
AVG	75.2749367
MIN	70.7827
MAX	79.2994

Dark/Mixed Object	
Image Id.	**Percentage**
01_1	71.4614
01_2	71.4833
01_3	69.8084
01_4	73.171
01_5	68.4401
01_6	71.4286
01_7	67.1593
01_8	66.0646
01_9	68.5167
01_10	70.6951
01_11	69.3815
01_12	72.9283
01_13	72.8845
01_14	69.9617
01_15	68.8232
01_16	66.4696
01_17	71.8008
01_18	73.9901
01_19	68.8779
01_20	71.8227
01_21	69.3049
01_22	70.2354
01_23	69.1845
01_24	69.0531
01_25	70.8901
01_26	70.717
01_27	73.7493
01_28	73.3443
01_29	72.2824
01_30	74.4718
SUM	2118.4016
AVG	70.6133867
MIN	66.0646
MAX	74.4718

ORCHARD ROAD DATA
2 OBJECTS ON THE ROAD

Color objects	
Image Id.	Percentage
o2_1	67.3454
o2_2	65.156
o2_3	65.6158
o2_4	65.8456
o2_5	69.3158
o2_6	68.0569
o2_7	67.4877
o2_8	65.2545
o2_9	71.2206
o2_10	69.272
o2_11	69.1297
o2_12	67.1483
o2_13	70.2791
o2_14	68.1117
o2_15	67.9475
o2_16	67.0279
o2_17	69.4143
o2_18	67.9475
o2_19	66.3054
o2_20	68.6152
o2_21	72.1949
o2_22	67.8599
o2_23	70.301
o2_24	72.37
o2_25	72.7313
o2_26	70.4215
o2_27	72.0854
o2_28	72.8298
o2_29	70.6404
o2_30	69.2282
SUM	2067.1593
AVG	68.90531
MIN	65.156
MAX	72.8298

Dark/Mixed Objec	
Image Id.	Percentage
o2_1	72.0197
o2_2	67.7833
o2_3	70.9469
o2_4	70.1478
o2_5	66.6886
o2_6	68.2649
o2_7	68.7466
o2_8	48.3196
o2_9	46.9841
o2_10	45.7252
o2_11	45.988
o2_12	47.619
o2_13	50.7608
o2_14	46.0865
o2_15	46.6995
o2_16	44.8495
o2_17	46.6667
o2_18	45.8456
o2_19	45.0137
o2_20	48.8889
o2_21	44.1708
o2_22	45.769
o2_23	47.5205
o2_24	47.9912
o2_25	43.6782
o2_26	48.046
o2_27	46.1303
o2_28	46.3273
o2_29	50.301
o2_30	47.6957
SUM	1561.6749
AVG	52.05583
MIN	43.6782
MAX	72.0197

ORCHARD ROAD DATA
3 OBJECTS ON THE ROAD

Color object		Dark/Mixed Object	
Image Id.	Percentage	Image Id.	Percentage
o3_1	69.6333	o3_1	66.8499175
o3_2	64.5977	o3_2	62.7047828
o3_3	66.8637	o3_3	62.8367235
o3_4	64.4335	o3_4	60.8026388
o3_5	64.3131	o3_5	59.0434305
o3_6	68.4072	o3_6	59.4282573
o3_7	66.9841	o3_7	59.4282573
o3_8	62.6163	o3_8	55.3380979
o3_9	67.5753	o3_9	56.9763606
o3_10	66.6995	o3_10	55.9868059
o3_11	69.2501	o3_11	61.0995052
o3_12	65.8128	o3_12	56.9983507
o3_13	68.0241	o3_13	62.6168224
o3_14	63.7767	o3_14	59.0544255
o3_15	65.6486	o3_15	53.4909291
o3_16	68.0679	o3_16	53.5678944
o3_17	75.5118	o3_17	60.5717427
o3_18	66.7105	o3_18	57.3391974
o3_19	68.67	o3_19	57.7899945
o3_20	66.7871	o3_20	59.6041781
o3_21	67.504	o3_21	53.8647609
o3_22	68.1226	o3_22	54.6014294
o3_23	63.4483	o3_23	59.7031336
o3_24	63.6015	o3_24	59.5052226
o3_25	61.2808	o3_25	55.1401869
o3_26	69.0859	o3_26	51.3029137
o3_27	67.8051	o3_27	54.5684442
o3_28	64.6415	o3_28	54.1506322
o3_29	70.093	o3_29	52.4463991
o3_30	63.7219	o3_30	54.3925234
SUM	1999.6879	SUM	1731.20396
AVG	66.6562633	AVG	57.7067986
MIN	61.2808	MIN	51.3029137
MAX	75.5118	MAX	66.8499175

ORCHARD ROAD DATA
4 OBJECTS ON THE ROAD

Color object	
Image Id.	**Percentage**
o4_1	71.2206
o4_2	66.7542
o4_3	68.1554
o4_4	70.0493
o4_5	66.8966
o4_6	66.6776
o4_7	65.78
o4_8	69.272
o4_9	68.5276
o4_10	67.1264
o4_11	65.8785
o4_12	67.3892
o4_13	70.3558
o4_14	69.272
o4_15	65.7909
o4_16	65.2107
o4_17	66.5681
o4_18	66.0755
o4_19	67.2797
o4_20	62.9995
o4_21	71.0126
o4_22	71.2425
o4_23	67.63
o4_24	69.075
o4_25	69.5238
o4_26	67.827
o4_27	68.6371
o4_28	69.3815
o4_29	65.5829
o4_30	67.619
SUM	2034.811
AVG	67.8270333
MIN	62.9995
MAX	71.2425

Dark/Mixed Object	
Image Id.	**Percentage**
o4_1	69.7636064
o4_2	66.9158879
o4_3	67.2897196
o4_4	68.2682793
o4_5	68.2902694
o4_6	66.3001649
o4_7	66.0252886
o4_8	65.5305113
o4_9	68.2242991
o4_10	70.0384827
o4_11	68.1913139
o4_12	68.5101704
o4_13	71.1379879
o4_14	67.4326553
o4_15	67.1687741
o4_16	64.6948873
o4_17	67.2677295
o4_18	64.9917537
o4_19	66.8169324
o4_20	69.1258933
o4_21	67.8174821
o4_22	67.8174821
o4_23	68.0153931
o4_24	66.113249
o4_25	67.8064871
o4_26	64.4969764
o4_27	68.7630566
o4_28	68.1583288
o4_29	67.575591
o4_30	67.3117097
SUM	2025.86036
AVG	67.5286788
MIN	64.4969764
MAX	71.1379879

ORCHARD ROAD DATA
5 OBJECTS ON THE ROAD

Color object		Dark/Mixed Object	
Image Id.	**Percentage**	**Image Id.**	**Percentage**
o5_1	68.856	o5_1	68.5101704
o5_2	63.9628	o5_2	67.4766355
o5_3	66.2288	o5_3	65.904343
o5_4	63.5359	o5_4	66.3991204
o5_5	70.7499	o5_5	64.2550852
o5_6	67.7723	o5_6	70.4672897
o5_7	71.8008	o5_7	69.1258933
o5_8	64.0722	o5_8	70.0824629
o5_9	66.8637	o5_9	67.3556899
o5_10	68.3306	o5_10	71.8966465
o5_11	68.4401	o5_11	71.7427158
o5_12	69.3268	o5_12	70.9730621
o5_13	65.752	o5_13	69.3347993
o5_14	69.2501	o5_14	70.4013194
o5_15	64.6962	o5_15	72.6772952
o5_16	69.7756	o5_16	59.7691039
o5_17	63.1746	o5_17	64.1451347
o5_18	63.2293	o5_18	71.3358988
o5_19	65.3311	o5_19	66.1352391
o5_20	66.6338	o5_20	65.2446399
o5_21	72.0307	o5_21	62.5838373
o5_22	69.7646	o5_22	67.1357889
o5_23	68.1883	o5_23	67.3556899
o5_24	64.5868	o5_24	68.7960418
o5_25	69.3049	o5_25	68.3892248
o5_26	64.2474	o5_26	67.7185267
o5_27	71.6913	o5_27	69.6536559
o5_28	69.8413	o5_28	67.3446949
o5_29	70.312	o5_29	66.6849918
o5_30	66.3273	o5_30	69.8185816
SUM	2024.0772	SUM	2038.71358
AVG	67.46924	AVG	67.9571193
MIN	63.1746	MIN	59.7691039
MAX	72.0307	MAX	72.6772952

ORCHARD ROAD DATA
6 OBJECTS ON THE ROAD

Color object			Dark/Mixed Objects	
Image Id.	Percentage		Image Id.	Percentage
o6_1	61.7625		o6_1	62.6608026
o6_2	60.4269		o6_2	61.4293568
o6_3	62.955		o6_3	65.9263332
o6_4	60.5364		o6_4	66.5970313
o6_5	60.0328		o6_5	65.0797141
o6_6	63.503		o6_6	65.6184717
o6_7	63.503		o6_7	64.4639912
o6_8	61.9157		o6_8	62.9686641
o6_9	58.9491		o6_9	63.1885651
o6_10	60.9305		o6_10	69.1478835
o6_11	58.2594		o6_11	68.8730071
o6_12	59.168		o6_12	66.8389225
o6_13	61.04		o6_13	66.1462342
o6_14	58.6754		o6_14	62.946674
o6_15	60.6568		o6_15	63.4634415
o6_16	61.5107		o6_16	63.6503573
o6_17	64.2474		o6_17	62.3859263
o6_18	59.792		o6_18	63.375481
o6_19	62.1018		o6_19	62.6827927
o6_20	62.6492		o6_20	63.7383178
o6_21	64.127		o6_21	63.7163277
o6_22	65.9004		o6_22	61.253436
o6_23	64.0285		o6_23	63.5404068
o6_24	61.3684		o6_24	59.1423859
o6_25	62.9666		o6_25	65.1126993
o6_26	59.6388		o6_26	65.4865311
o6_27	61.2698		o6_27	63.6393623
o6_28	59.6606		o6_28	60.1209456
o6_29	61.5873		o6_29	58.526663
o6_30	62.1456		o6_30	65.7943925
SUM	1845.3086		SUM	1917.51512
AVG	61.5102867		AVG	63.9171706
MIN	58.2594		MIN	58.526663
MAX	65.9004		MAX	69.1478835

ORCHARD ROAD DATA
7 OBJECTS ON THE ROAD

Color object	
Image Id.	**Percentage**
o7_1	61.1604
o7_2	61.8391
o7_3	63.0432
o7_4	62.1346
o7_5	61.2042
o7_6	58.5112
o7_7	59.3103
o7_8	59.8905
o7_9	60.4379
o7_10	62.2879
o7_11	62.879
o7_12	62.5287
o7_13	61.0509
o7_14	62.5725
o7_15	60.9743
o7_16	58.4346
o7_17	55.3585
o7_18	56.5955
o7_19	59.2994
o7_20	57.9091
o7_21	64.8495
o7_22	67.0389
o7_23	60.3503
o7_24	65.6267
o7_25	65.5391
o7_26	65.0465
o7_27	62.8571
o7_28	65.6048
o7_29	60.832
o7_30	62.0799
SUM	1847.2466
AVG	61.5748867
MIN	55.3585
MAX	67.0389

Dark/Mixed Object	
Image Id.	**Percentage**
o7_1	61.2864211
o7_2	61.0775151
o7_3	62.1550302
o7_4	62.0340847
o7_5	63.1335899
o7_6	61.5612974
o7_7	65.5525014
o7_8	63.991204
o7_9	61.7482133
o7_10	64.2550852
o7_11	64.4090159
o7_12	66.322155
o7_13	65.1456844
o7_14	62.7157779
o7_15	61.5832875
o7_16	65.4095657
o7_17	62.0010995
o7_18	62.7157779
o7_19	55.9868059
o7_20	63.7053326
o7_21	67.4876306
o7_22	62.7487631
o7_23	63.166575
o7_24	63.8262782
o7_25	65.26663
o7_26	68.6970863
o7_27	63.6063771
o7_28	66.6739967
o7_29	67.6525563
o7_30	67.3996701
SUM	1913.31501
AVG	63.7771669
MIN	55.9868059
MAX	68.6970863

ORCHARD ROAD DATA
8 OBJECTS ON THE ROAD

Color object	
Image Id.	Percentage
o8_1	60.7225
o8_2	60.9086
o8_3	58.8396
o8_4	60.6568
o8_5	58.763
o8_6	55.4351
o8_7	55.4023
o8_8	56.1576
o8_9	55.9387
o8_10	56.3328
o8_11	55.052
o8_12	57.7449
o8_13	57.3071
o8_14	57.5151
o8_15	56.6502
o8_16	58.0515
o8_17	57.8435
o8_18	58.9491
o8_19	58.5222
o8_20	60.1533
o8_21	62.8462
o8_22	61.8719
o8_23	64.0175
o8_24	63.2403
o8_25	60.6349
o8_26	58.2594
o8_27	59.3432
o8_28	61.2917
o8_29	59.168
o8_30	66.393
SUM	1774.012
AVG	59.1337333
MIN	55.052
MAX	66.393

Dark/Mixed Object	
Image Id	Percentage
o8_1	64.1451347
o8_2	65.1676745
o8_3	64.8708081
o8_4	67.7185267
o8_5	64.7278725
o8_6	67.1357889
o8_7	68.4332051
o8_8	66.7509621
o8_9	66.7509621
o8_10	68.3232545
o8_11	63.9692139
o8_12	64.2660803
o8_13	65.3985706
o8_14	61.4513469
o8_15	68.4002199
o8_16	61.2424409
o8_17	60.6597031
o8_18	65.4865311
o8_19	66.1792194
o8_20	67.2457394
o8_21	61.9791094
o8_22	59.6811435
o8_23	65.2886201
o8_24	63.8922485
o8_25	67.4876306
o8_26	65.5525014
o8_27	63.5184167
o8_28	66.1352391
o8_29	63.2985157
o8_30	62.308961
SUM	1947.46564
AVG	64.9155213
MIN	59.6811435
MAX	68.4332051

APPENDIX B –Different Pixel

Number of Pixel: 8961

Image Id.	Count 0	Percentage
o1_1	6220	69.41
o1_2	6153	68.66
o1_3	5920	66.06
o1_4	5976	66.69
o1_5	5979	66.72
o1_6	6121	68.31
o1_7	5872	65.53
o1_8	6036	67.36
o1_9	5920	66.06
o1_10	6258	69.84
o1_11	5882	65.64
o1_12	6275	70.03
o1_13	6141	68.53
o1_14	5895	65.79
o1_15	6122	68.32
o1_16	6157	68.71
o1_17	6136	68.47
o1_18	5979	66.72
o1_19	6197	69.16

Number of Pixel: 9135

Image Id.	**Count 0**	**Percentage**
01_1	6694.00	73.28
01_2	6466.00	70.78
01_3	6724.00	73.61
01_4	6979.00	76.40
01_5	7027.00	76.92
01_6	6877.00	75.28
01_7	6880.00	75.31
01_8	6922.00	75.77
01_9	6687.00	73.20
01_10	7022.00	76.87
01_11	6747.95	73.87
01_12	6719.00	73.55
01_13	6673.00	73.05
01_14	6970.00	76.30
01_15	6864.00	75.14
01_16	6978.00	76.39
01_17	7064.00	77.33
01_18	6711.00	73.46
01_19	6648.00	72.78