Evolution in Electrical and Electronic Engineering Vol. 2 No. 2 (2021) 943-950
© Universiti Tun Hussein Onn Malaysia Publisher's Office

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Vision-Based Traffic Density Calculation System Based on Area Detection

Yap Yong Hong[1], Nor Surayahani Suriani[1]*

[1] Department of Electronic Engineering
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2021.02.02.112
Received 05 July 2021; Accepted 17 October 2021; Available online 30 October 2021

Abstract: With the rapid development of times, various intelligent traffic systems are trying to replace the traditional timing traffic system. One type of intelligent traffic system detects the number of vehicles to determine the priority of traffic lights. This kind of traffic control system has some shortcomings, which lead to some errors in the calculation of traffic density. In order to overcome this problem, a vision-based traffic light density calculation system by calculate area of vehicle as traffic density parameter is proposed. The system is developed using image processing technique and a smart traffic density calculation system graphical user interface is built for visualization purposes. As the result of simulation in MATLAB, it shows is more appropriate and logical to calculate the traffic density as the parameter than the number of vehicles. When calculating number of vehicles as a parameter for determining the traffic condition may occur some errors that lead the inaccurate od traffic density. For example, two vehicles are very close distance may cause the system recognize as one vehicle. The final suggestion is that when installing the system of this project, it is recommended to find the appropriate camera angle according to the local road section and adjust some parameters in the system code according to the current environment.

Keywords: Intelligent Traffic Systems, Vision-Based Traffic Light, Image Processing, Traffic Density

1. Introduction

Traffic congestion happens when too many vehicles attempt to utilise a common urban road with limited capacity as a result of the rapid growth of urbanization [1]. Malaysia traffic light system mostly area still using traditional timing system but Malaysia also have use intelligent traffic system that is induction control and adaptive control. Induction system is to set the vehicle detector on the entrance road of an intersection, the intelligent computer calculates and controls the time of the traffic light, and it can be changed at any time according to the traffic flow information detected by the detector [2]-[4].

**Corresponding author: nsuraya@uthm.edu.my*

At present, image processing technology is popular to obtain traffic information [5]-[7]. Detect vehicles and count the number of vehicles on the road [8]. This method also has a disadvantage, in some cases, the calculation and detection of the number of vehicles may give inaccurate results. For example, when the distance between two vehicles is very small and very close, the detection result will give the result of one vehicle. Moreover, vehicles of various sizes are not considered in some methods. Instead of counting the number of vehicles on the road, a method is used to calculate traffic density detected in a video frame, which corresponds to the area occupied by the vehicles on the road. The objective of this project is to design a vision-based traffic light density system by calculate area of vehicle as traffic density parameter and develop a smart traffic density calculator with the aid of graphical user interface (GUI). The smart traffic density calculation system graphical user interface is built for visualization purposes and analyze the effectiveness of the proposed traffic light system in different scenario.

2. Methodology

The method and process used in this project to manufacture a vision-based traffic density calculation system. First, MATLAB software version R2020b Software development is used for image processing and MATLAB APP DESIGNER also is used to develop smart traffic density calculator graphical user interface. The graphical user interface is also to analyze the effectiveness of the proposed traffic light system in a different scenario.

2.1 Project Development

The image processing procedure in this project includes pre-processing, Sobel edge detection, background subtraction, vehicle detection, calculation of vehicle area, and so on. Figure 1 shows the flowchart for the project development in this study.

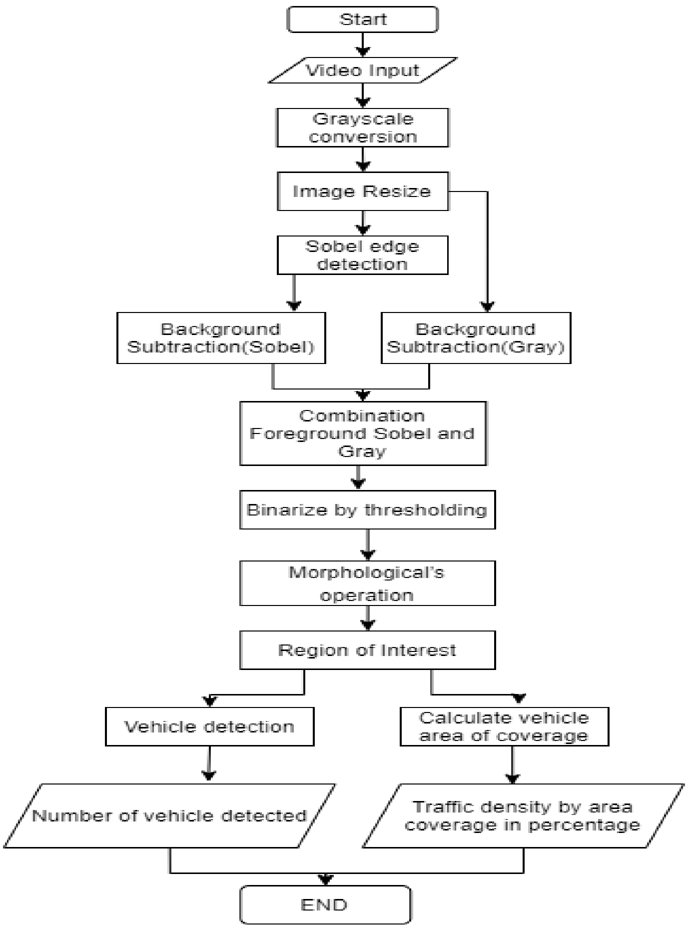

Figure 1: Flowchart of project development

2.1.1 Preprocessing

The preprocessing was included grayscale conversion and image resize. This operation can fix the format of each image source to facilitate the system image processing and reduce the burden on the processor.

2.1.2 Edge Detection

The project edge detection method is use Sobel edge detection. The Sobel operator is mainly used for edge detection and is technically a discrete difference operator that operates on the approximation of the gray scale of the image luminance function. Using this operator at any point in the image will produce either the corresponding grey scale vector or its normal vector. The operator contains two groups of 3x3 matrix Gx and Gy, which are convolved with the image in plane to obtain the difference approximation of brightness respectively. A is the original image. Eq.1 and Eq.2 represents the grayscale values of the images detected by the transverse and longitudinal edges respectively. Horizontal and longitudinal gray values of each pixel of the image can be combined with the Eq.3 formula to calculate the gray size of the point.

$$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -1 \\ +1 & 0 & -1 \end{bmatrix} * A \quad Eq.1$$

$$G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A \quad Eq.2$$

$$G = \sqrt{G_x^2 + G_y^2} \quad Eq.3$$

2.1.3 Background Subtraction

Image subtraction is a method by which one pixel or entire image's digital numeric value is subtracted from another image. The subtraction process is to obtain foreground objects from the background that is vehicle in the frame video. The process is basically subtracting the reference(background) from the current frame image.

There are two background subtractions going on simultaneously, that is the Sobel image background subtraction and Grayscale image background subtraction. The Sobel background subtraction will get the edge of the vehicle while the grayscale background subtraction will get the grayscale area of the vehicle. Both background subtraction methods have their own advantages that the other does not. Later, the two background subtraction methods are combined to obtain an enhanced version of the vehicle foreground image. It has both the edge of the vehicle and the inner area.

2.1.4 Binarize by thresholding

Otsu's method is an adaptive thresholding tool for image processing binarization. It will find the optimal threshold value of the input image by going through all possible threshold values (from 0 to 255). Binarize calculates Otsu thresholds using a 256-bit image histogram. After obtained the threshold value needed to convert the grayscale image into binary image.

2.1.5 Eliminate noise with Morphological's operation.

The processing of morphological images is a series of non-linear operations related to the form or morphology of image features. Morphological techniques detect images using structuring elements that is placed and compared with the corresponding neighborhood of the pixel at all possible locations in the image. Some actions measure whether an element "fits" in a neighboring region, while others test whether it "hits" in a neighboring region or crosses. The morphology process is undergoing convolution, erosion, and dilation.

2.1.6 Extracting Region of Interest

The step is to extract the areas of interest, remove the unwanted areas in video frame, and just focus on the road lane areas. ROI (Region-Of-Interest) method is use in MATLAB to extract the region of interest.

2.2 Vehicle detection

The method of detecting the vehicle in this project is to use the MATLAB native syntax "bwconncomp". The syntax function is to find connected components in binary image. Then choose NumObjects as the output arguments to display number of objects in binary image.

2.3 Traffic density with area coverage

The method for calculating traffic density in this project is to calculate the area of vehicles on the road covering the area of the road, and the area coverage value obtained represents traffic density. In the aspect of image processing, it is to calculate the value of the binaries white pixel and then divide it by the sum of the white pixel and the black pixel.

2.4 Graphical user interface (GUI)

The GUI is develop using MATLAB APP DESIGNER. Figure 2 shows the graphical user interface of the project.

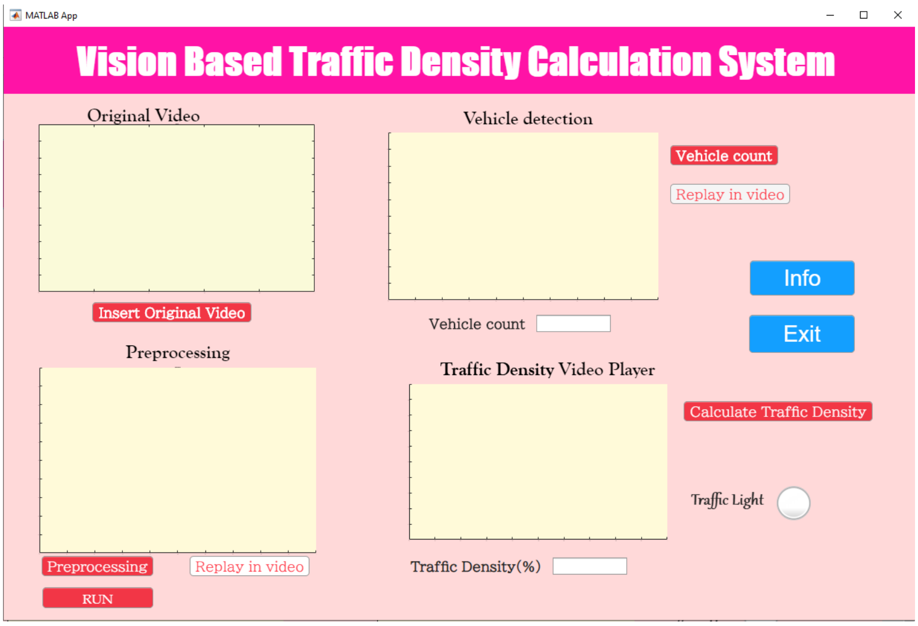

Figure 2: The graphical user interface of the project

3. Results and Discussion

In this section, the vehicle detection result and traffic density result are obtained from the proposed traffic control system simulation. The efficiency and benefits of using area of vehicle as calculate traffic density parameter is discussed.

3.1 Data set

This data set used in this MATLAB simulation is from internet YOUTUBE shared by user Panasonic Security. The location captured of this dataset video is from PTS road, Thailand. Total length of this video is 1 minute and 28 seconds. The frame rate is 30.00 frames per seconds. The frame size of video is 1920x1080 in MKV format. The video is capture using camera Panasonic WV-SFV781L. Figure 3 shows a screenshot from the video.

Figure 3: Sample video

3.2 Result of MATLAB simulation

There is two data result is obtained from the project simulation that is number of vehicle detected and the traffic density calculated by area of the vehicle.

3.2.1 Vehicle detection result

Figure 4 to 7 are the vehicle detection result of the traffic control system. Table 1 shows the comparison detection result with actual number of vehicle.

Figure 4: Video at 2 seconds

Figure 5: Video at 6 seconds

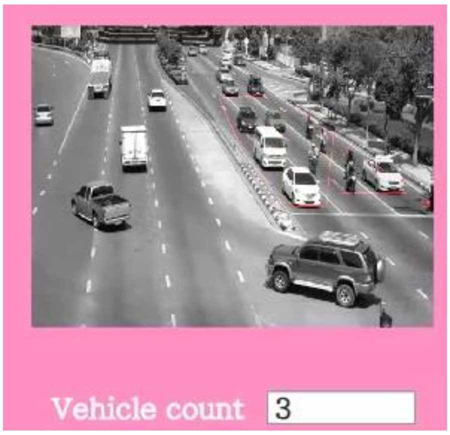

Figure 6: Video at 10 seconds

Figure 7: Video at 22 seconds

Table 1: Comparison detection results with actual number of vehicles

Time(s)	Number of Detected Vehicle	Actual Number of Vehicle
2	3	2
6	5	7
10	3	11
22	2	12

3.2.2 Traffic density result

Figure 8 to 11 are the traffic density result of the traffic control system. Table 2 shows the result traffic density

Figure 8: Dataset video at 2 seconds

Figure 9: Dataset video at 6 seconds

Figure 10: Dataset video at 10 seconds

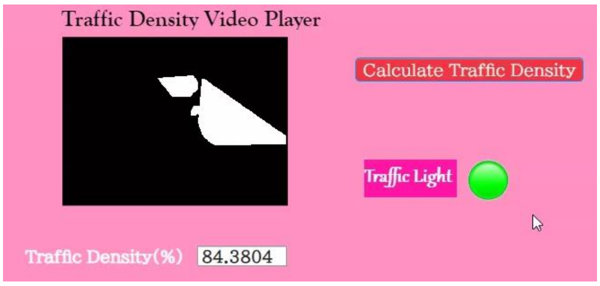

Figure 11: Dataset video at 22 seconds

Table 2: Result traffic density

Time(s)	Traffic Density (%)
2	23.7138
6	34.3412
10	68.3226
22	84.3804

3.3 Discussions

According to Table 1 and 2, the data obtained from the traffic density by coverage area are little inaccurate due to some factors. For example, the distance between motorcycles is not too close or too close to each other will be directly programmed into an area by the system. This results in a higher traffic density when the system calculates traffic density even if there are only a few motorcycles. In the 10 and 22 seconds of the video, there should be a median or high traffic density situation, but the number of vehicles detected is smaller. It is extremely disadvantageous to use the vehicle detection.

Next, the traffic density calculator is built and deployed based on the road condition measurement findings. Second, traffic can be divided into three levels based on the number of area vehicles on the occupied road: high traffic, medium traffic, and low traffic. The function of vehicle detection has a serious problem that when detecting vehicles if they are all close to each other the system will determine that only one vehicle has been detected. Figure 4 is shown that all vehicles are well detected. There are 3 vehicles detected by the system. It can be clearly seen that in this case, each vehicle is keeping a certain distance, so that the system can detect the total number of vehicles at this moment without error. But that's not the case when you have something like the Figure 7 diagram. Visually know that there are more than 8 cars at the current frame but the system tells us there are only 2 vehicles. The result of this situation is that the vehicles described above are very close to each other, causing the system to determine that there is only one object or vehicle. To solve this problem, this project calculates not the number of vehicles, but traffic density, which is the total area of vehicles on a road expressed in total pixels in a single frame of video. In this way, the system can avoid the problem of detecting multiple objects as one, which is different from the number of vehicles detected above.

Conclusion

The conclusion is that the calculation of vehicle area is more suitable as the parameter to calculate traffic density rather than the number of vehicles. Because calculating the area can avoid some of the unfair situation of counting the number of vehicles. For example, the vehicle density of a truck can be the same as that of two mid-size cars, but it is not appropriate to calculate the number of vehicles because mid-size cars and large cars occupy different road areas. Therefore, the calculation of vehicle area is more effective than the number of vehicles method. Not to mention the unfair situation caused by the size of the motorcycle or two vehicles too close to each other is equivalent to a vehicle and other issues.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] L. Y. Deng, N. C. Tang, D. L. Lee, C. T. Wang, and M. C. Lu, “Vision based adaptive traffic signal control system development,” Proc. - Int. Conf. Adv. Inf. Netw. Appl. AINA, vol. 2, pp. 385–388, 2005, doi: 10.1109/AINA.2005.342.

[2] M. M. Hasan, G. Saha, A. Hoque, and M. B. Majumder, “Smart traffic control system with application of image processing techniques,” 2014 Int. Conf. Informatics, Electron. Vision, ICIEV 2014, no. 4, pp. 2–5, 2014, doi: 10.1109/ICIEV.2014.6850751.

[3] Khushi, “Smart Control of Traffic Light System using Image Processing,” Int. Conf. Curr. Trends Comput. Electr. Electron. Commun. CTCEEC 2017, pp. 99–103, 2018, doi: 10.1109/CTCEEC.2017.8454966.

[4] A. H. Akoum, “Automatic Traffic Using Image Processing,” J. Softw. Eng. Appl., vol. 10, no. 09, pp. 765–776, 2017, doi: 10.4236/jsea.2017.109042.

[5] B. Eamthanakul and M. Ketcham, “The Traffic Congestion Investigating System by,” 2017.

[6] W. Phueakjeen, N. Jindapetch, L. Kuburat, and N. Suvanvorn, “A study of the edge detection for road lane,” ECTI-CON 2011 - 8th Electr. Eng. Electron. Comput. Telecommun. Inf. Technol. Assoc. Thail. - Conf. 2011, pp. 995–998, 2011, doi: 10.1109/ECTICON.2011.5948010.

[7] T. Tahmid and E. Hossain, “Density based smart traffic control system using canny edge detection algorithm for congregating traffic information,” 3rd Int. Conf. Electr. Inf. Commun. Technol. EICT 2017, vol. 2018-Janua, no. December, pp. 1–5, 2018, doi: 10.1109/EICT.2017.8275131.

[8] H. Rashid, M. J. F. Ashrafi, M. Azizi, and M. R. Heydarinezhad, “Intelligent traffic light control based on clustering using Vehicular Ad-hoc Networks,” 2015 7th Conf. Inf. Knowl. Technol. IKT 2015, pp. 1–6, 2015, doi: 10.1109/IKT.2015.7288801.