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Road Congestion Level Detection using Image Processing in Matlab

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Abstract: This project proposes a technique to determine the congestion level on the road using the image processing techniques. The image processing algorithm is written and simulated in MATLAB. The image processing techniques that are used in this work are image acquisition, image resizing, background subtraction using region of interest, adaptive thresholding and morphology operations. Pre-processing images that were captured from the traffic light junction are used as the image samples. The image of the road is divided into three regions which are level 1, level 2 and level 3. Experimental results show that the proposed technique is able to determine the level of road congestion accurately.

Keywords: Road Congestion, Image Processing, Regions of Interest

1. Introduction

The rapid development and economic growth in many cities have made an increase of population in the cities. As the population increases, the transportation systems have become more important for people to travel from place to place. An uncontrolled growth in traffic volume can cause many serious problems such as traffic congestion, air pollution, accidents, emergencies, stress and low quality of life. To overcome the problems, the smart traffic light systems have been introduced [1]. Smart traffic light or intelligent traffic light is an intelligent system that controls the traffic lights using an array of sensors and artificial intelligence to regulate the flow of traffics in response to the demand of vehicles and pedestrians. Sensor technology is integrated with the transportation infrastructure to achieve better performance of intelligent traffic light system [2]. The use of sensors is to collect accurate data from the realistic condition on the road and make a corresponding response to the traffic management.

The sensors that are widely used in smart traffic light are inductive loop detector (ILD) [2]. This sensor collects traffic flow vehicle's occupancy, length, and speed. However, it is costly and unreliable to count many vehicles. In order to provide better performance to monitor the traffic conditions, image processing technique is proposed to be used in identifying the congestion level of vehicles for proper traffic management. Image processing is a technique that utilizes images as input and process for better display, analysis and other purposes. In this project we focus on image processing using MATLAB to determine the congestion level on the road for better road safety and traffic management.

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The uncontrolled growth in traffic volume has caused the traffic congestion levels to increase significantly. There are many reasons that can cause traffic congestion, such as obstacles that block the road, high quantity of vehicles or trucks on road, accidents and others. Traffic congestion can cause a lot of man hours to be wasted. Hence, vehicle detection technologies become more important in order to solve the congestion level on the road. Regarding this problem, developing a self adaptive system which can help in better traffic management using the technique of image processing is a necessity [3]. Image processing is a good approach to detect the queue of vehicles on the road but there are difficulties for this technique because of different vehicle types, light intensity problem and surrounding background. It is hard to detect vehicles if the lightning is dim or dark. There is research saying that vehicle detection and algorithms are more accurate during daytime if compare to nighttime. Hence, the techniques used to detect the vehicles can be varied. However, it is a better approach if compare to other sensors from the perspective of cost and efficiency. The quantity of other sensors used to identify the queue of vehicles can be costly because a large number of sensors need to be installed. Image processing sensors have low installation and maintenance costs if compared to other sensors. The sensors can also detect a wide area with no traffic interruption during installation and repairs [4][5]. Hence, image processing has high performance and flexibility. It is suitable to be used to analyze the congestion of road for better traffic management.

The scopes of the project focus on image processing and simulation in MATLAB environment. MATLAB has an image processing toolbox that enables the process of image manipulation to become much easier. The image processing algorithm is used to detect the congestion level of a junction. An image is used as the input for the congestion level detection. The congestion level will be divided into three levels, which are not congested, slightly congested and highly congested levels. Different values of parameters such as regions of interest and boundaries to remove small objects are applied in the algorithm due to different road conditions. The study takes an assumption for the parameters because there is a need to study the traffic flow of a junction before applying the parameters to fulfill the realistic condition. The algorithm is designed for smart traffic controller so that the congestion level of a road can be determined.

2. Methodology

This section describes about the procedures and methods used in developing the algorithms used for congestion level detection. This section also explains in detail on how the result is obtained.

2.1 Project development

This study is carried out according to the flowchart as shown in Figure 3.2. There are several steps to be carried out in order to complete this study. Researches and studies on image processing are required to obtain more details and knowledges on how to develop the algorithm. The relating books or articles which are suitable for the application are filtered and saved so that it is easier to identify the suitable algorithm to be used. The important points of the articles have been highlighted and cited in literature reviews of this study. The researches, books and journal articles that are related to this study has been saved for reference or citation.

Next, the suitable image processing techniques are identified to be applied in obtaining the output. There are several image processing techniques such as image acquisition, image enhancement, noise removal, morphological and so on. It is necessary to understand the techniques so that suitable techniques can be selected and the expected result can be obtained faster and easier. The process of writing code and programming comes after image processing techniques understanding. The algorithm development is carried out using MATLAB software. An image is inputted into MATLAB for enhancing and process. The input image should be the image of a junction or a road. The image is then enhanced and processed using the code to see the output. If the expected outcome is obtained, the outcome is displayed to show the congestion level. Debugging and testing of code are required to get a better outcome if the code does not success.

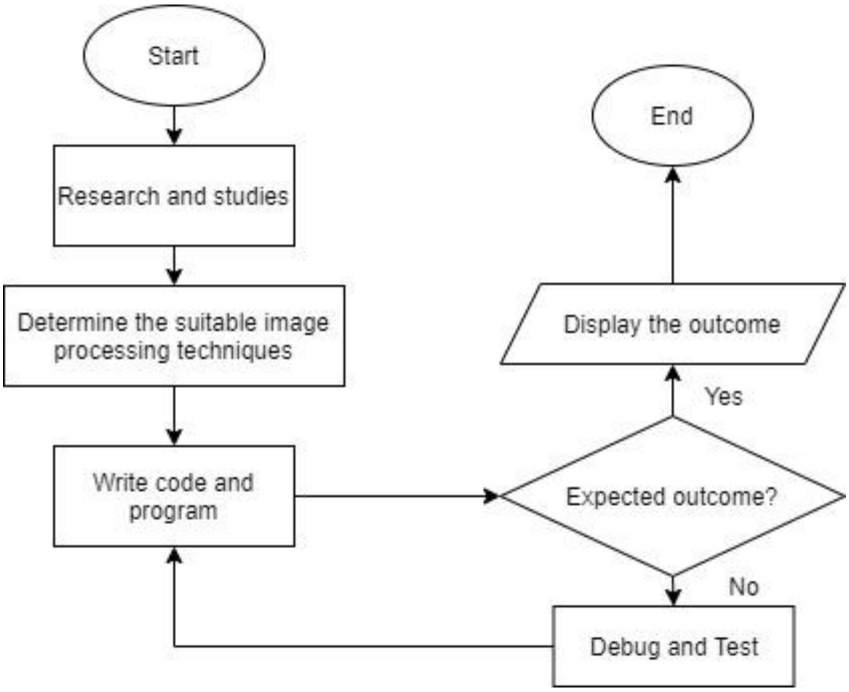


Figure 1 : Flowchart of project development

2.2 Algorithm development

This part explains on how the algorithm for vehicle detection and road congestion level detection can be developed in detail. MATLAB has been used in developing the algorithm to do image processing. A ready input image is used to test and simulate for the algorithm developed. Different images are used to do the comparison for the output. However, different regions of interest need to be defined for different input images. The steps for developing the algorithm have been described using the block diagram as shown in Figure 2.

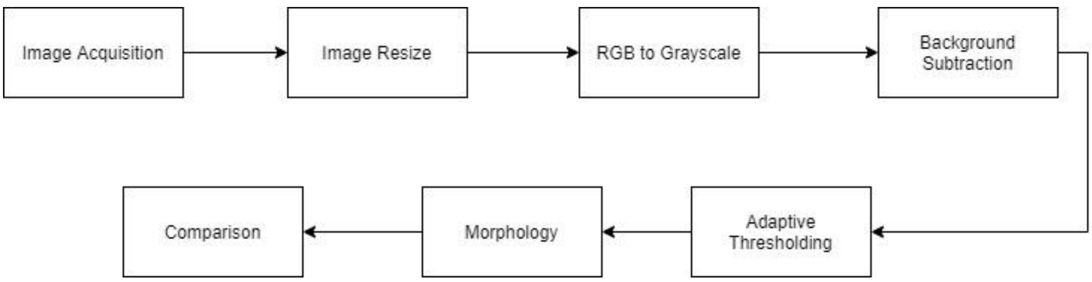


Figure 2 : Block diagram of algorithm development

Figure 3 shows the flow for the algorithm development in this study. First of all, image acquisition is done by inputting the image data into the MATLAB workspace. After that, the image is resized to 256 x 256 pixels. The image is then converted from RGB to grayscale. The algorithm is then divided into three parts for three different regions of interest. Each part will start from defining regions of interest before doing background subtraction. Then adaptive threshold is applied and morphological operations are done. The small objects are removed from the image to avoid shadows to be detected. The counts of vehicle for the three regions are stored in variables called info1, info2 and info3 where info1 is for the not congested region, info2 is for the slightly congested region and info3 is for the high congested region. The variables are compared using decision method to obtain the final result to decide the congestion level of the road.

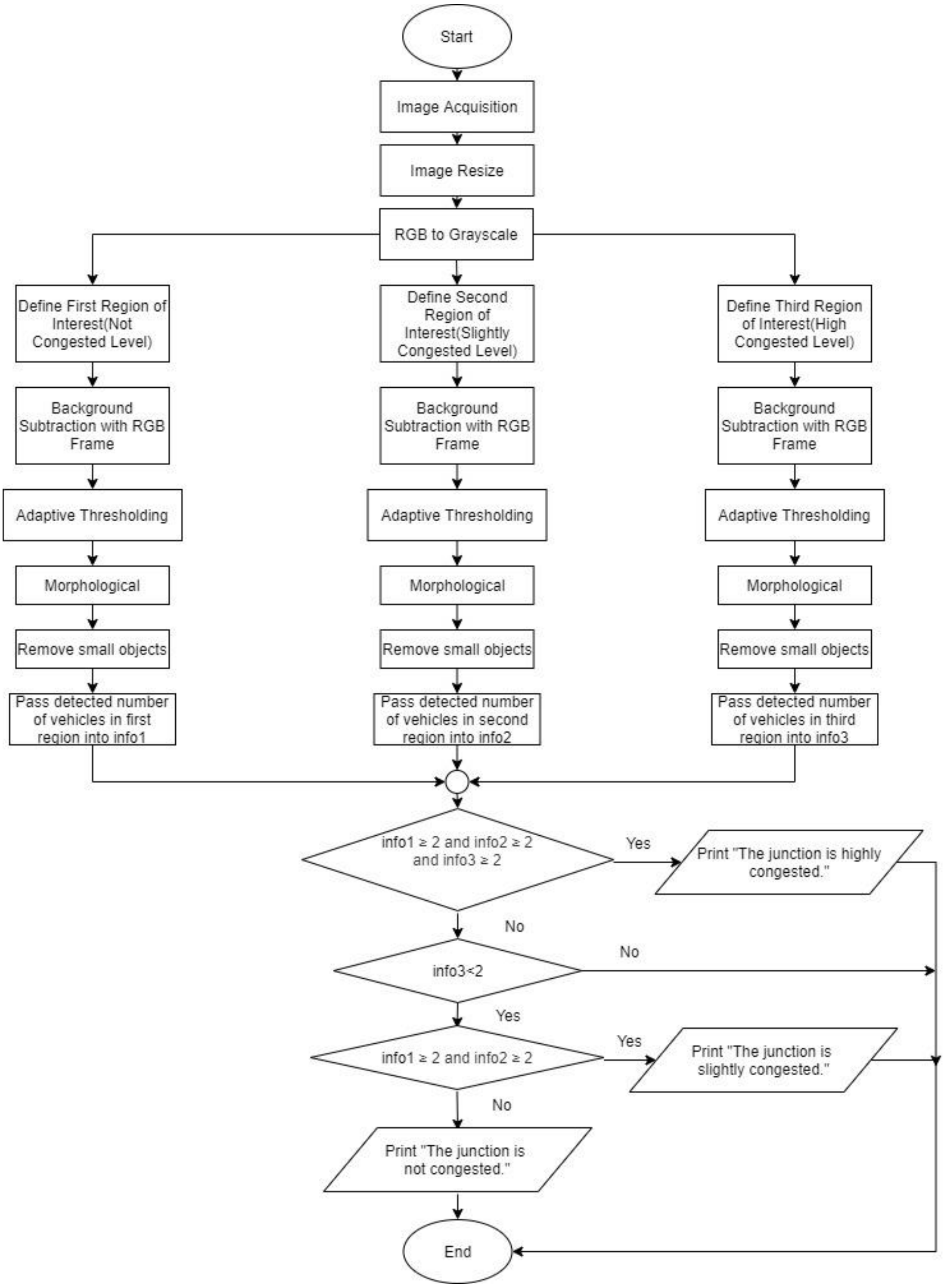


Figure 3 : Flowchart of algorithm development

3. Results and Discussion

This section presents the verification of results, analysis and discussion of the algorithms used for congestion level detection. This section also shows the results obtained in detail.

3.1 Results

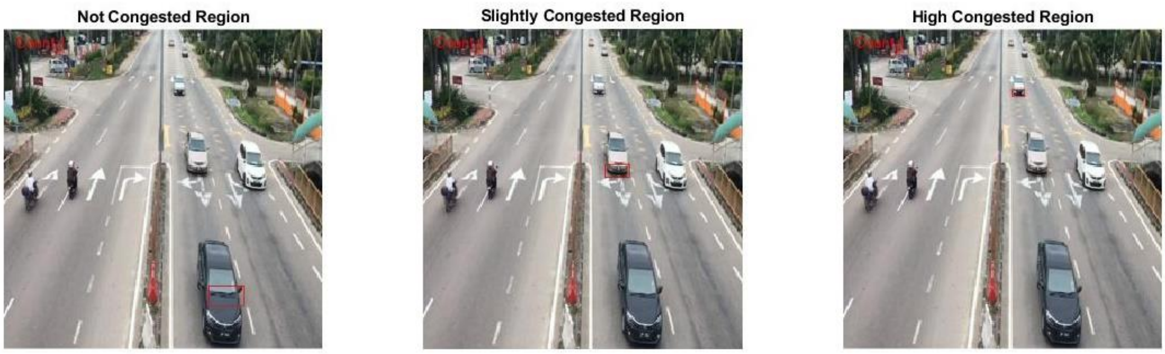
In order to determine whether the junction is not congested, slightly congested or highly congested, the count of vehicles is taken in count to do the comparison. However, to avoid faulty, the region is considered occupied when there are two or more vehicles detected. The congestion level of the junction are determined by comparing the regions and display on the command window in MATLAB. Figure 4-13 show the results of the vehicle detection and the congestion level detection printed in command window.

For Image1 as shown in Figure 4 (a), (b) and (c), there are only one vehicle detected for every region. The junction is considered not congested and hence the command window printed the result as shown in Figure 5. For Image 2 as shown in Figure 6 (a), (b) and (c), there are 6 vehicles detected at not congested region, 5 vehicles detected at slightly congested region and high congested region. It means that both three regions are occupied. The command window printed the junction is highly congested as shown in Figure 7.

Next, for Image 3 as shown in Figure 8 (a), (b) and (c), the counts of the vehicle show a value of 2 for not congested region and slightly congested region.. It means that not first region and second region are occupied. The junction is slightly congested. Hence, the result show that the junction is slightly congested as shown in Figure 9.

For Figure 10 (a), (b), (c), it is clear to see that the junction is highly congested where the not congested region has detected 7 vehicles, slightly congested region has detected 10 vehicles and high congested region has detected 9 vehicles respectively. The command window printed the desired result as shown in Figure 11.

For Image 5 as shown in Figure 12, there is no vehicle detected at not congested region, only one vehicle detected at slightly congested region and 3 vehicles are detected at high congested region. It means that only high congested region is occupied or active. The junction is not considered highly congested when the not congested region and slightly congested region are not occupied. Hence, the result show that the junction is not congested as shown in Figure 13.



(a) (b) (c)

Figure 4 : (a) Vehicle detection at not congested region for image 1 (b) vehicle detection at slightly congested region for image 1 (c) vehicle detection at high congested region for image 1

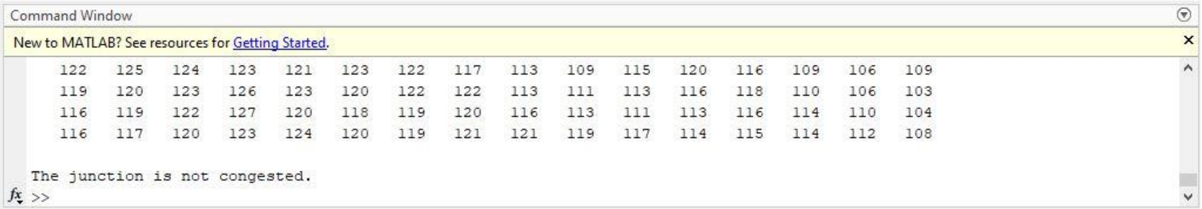


Figure 5 : Congestion level detection for image 1

(a) (b) (c)

Figure 6 : (a) Vehicle detection at not congested region for image 2 (b) vehicle detection at slightly congested region for image 2 (c) vehicle detection at high congested region for image 2

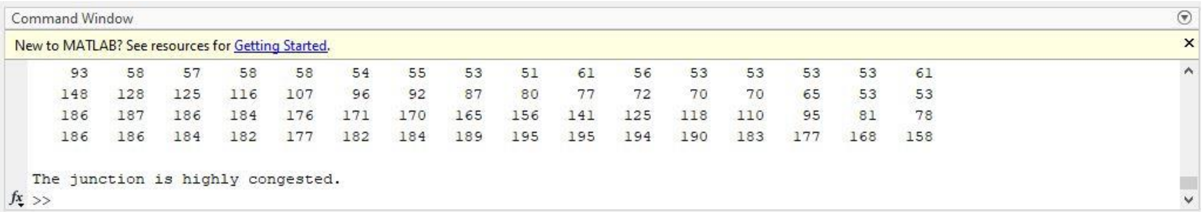
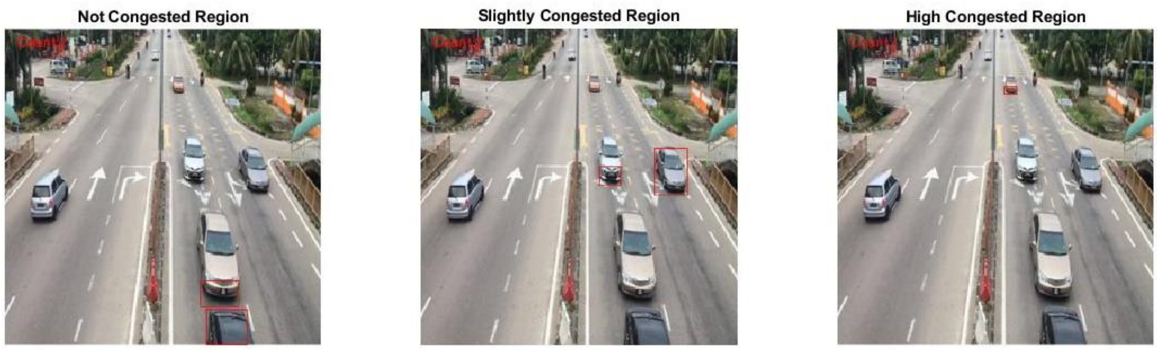
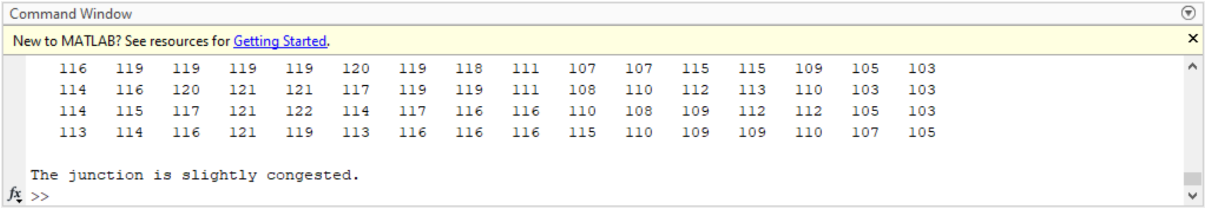


Figure 7 : Congestion level detection for image 2



(a) (b) (c)

Figure 8 : (a) vehicle detection at not congested region for image 3 (b) vehicle detection at slightly congested region for image 3 (c) vehicle detection at high congested region for image 3

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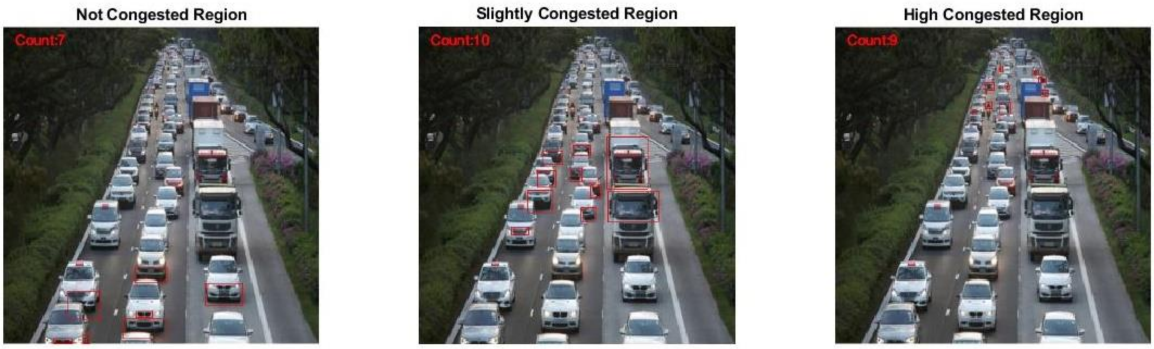
116 119 119 119 119 120 119 118 111 107 107 115 115 109 105 103
114 116 120 121 121 117 119 119 111 108 110 112 113 110 103 103
114 115 117 121 122 114 117 116 116 110 108 109 112 112 105 103
113 114 116 121 119 113 116 116 116 115 110 109 109 110 107 105

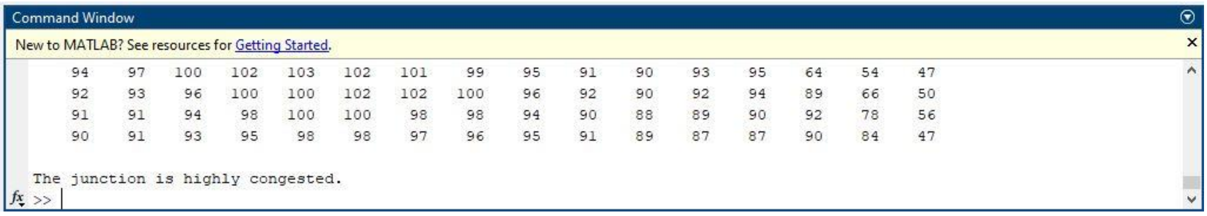
The junction is slightly congested.
>>
```

Figure 9 : Congestion level detection for image 3



(a) (b) (c)

Figure 10 : (a) vehicle detection at not congested region for image 4 (b) vehicle detection at slightly congested region for image 4 (c) vehicle detection at high congested region for image 4

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94  97 100 102 103 102 101  99  95  91  90  93  95  64  54  47
92  93  96 100 100 102 102 100  96  92  90  92  94  89  66  50
91  91  94  98 100 100  98  98  94  90  88  89  90  92  78  56
90  91  93  95  98  98  97  96  95  91  89  87  87  90  84  47

The junction is highly congested.
>>
```
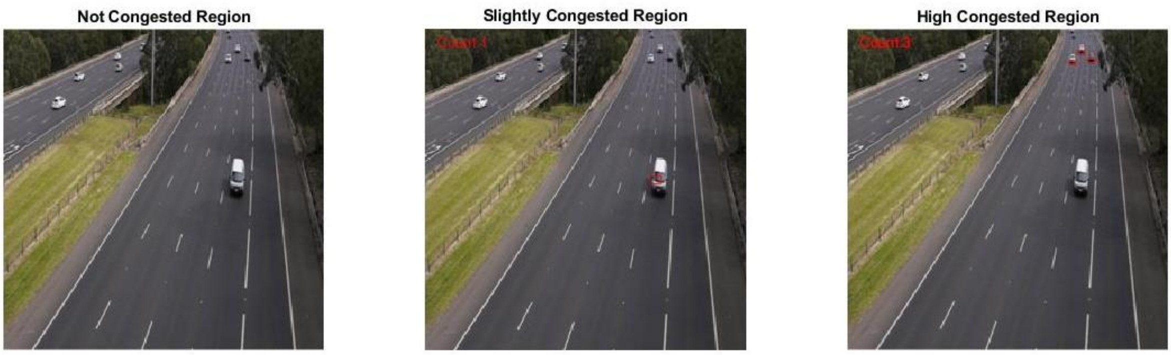

Figure 11 : Congestion level detection for image 4



(a) (b) (c)

Figure 12 : (a) Vehicle detection at not congested region for image 5 (b) vehicle detection at slightly congested region for image 5 (c) vehicle detection at high congested region for image 5

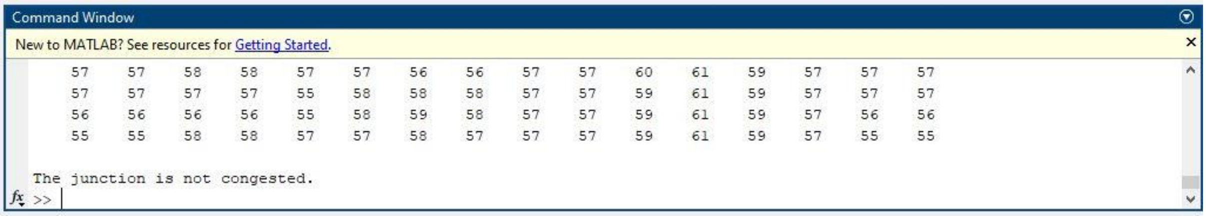


Figure 13 : Congestion level detection for image 5

4. Conclusion

This study was conducted using the real traffic condition and scene on road. The algorithm developed successfully detected vehicles and perform counting of stopping and moving vehicles. The proposed algorithm works according to the objectives. It is difficult to differentiate the vehicles and the background. There is an issue that the algorithm will recognize the vehicles as a background image. Besides that, the region of interest technique is used to avoid counting vehicles at opposite direction. The threshold applied to the image is not strong enough to visualize the shape of the vehicles and hence erosion is used to thicken the shape of the vehicles. The errors of vehicle counting have been reduced when dark regions less than desired pixels are removed. The vehicle detection can perform better and less error using these algorithms. The congestion level detection is successfully done by comparing the counts of vehicle in three regions of interest. The simulation works successfully to detect the road congestion in MATLAB. The accuracy of this algorithm is validated using manual calculation.

References

[1] M. Rath, “Smart Traffic Management System for Traffic Control using Automated Mechanical and Electronic Devices,” IOP Conf. Ser. Mater. Sci. Eng., vol. 377, no. 1, 2018, doi: 10.1088/1757-899X/377/1/012201

[2] J. Guerrero-Ibáñez, S. Zeadally, and J. Contreras-Castillo, “Sensor technologies for intelligent transportation systems,” Sensors (Switzerland), vol. 18, no. 4, pp. 1–24, 2018, doi: 10.3390/s18041212

[3] J. George and H. Thomas, “Traffic Density analysis based on Image Processing.” Available: https://www.academia.edu [Accessed September 24, 2019]

[4] I. Gulati and R. Srinivasan, “Image processing in intelligent traffic management,” Int. J. Recent Technol. Eng., vol. 8, no. 2 Special Issue 4, pp. 213–218, 2019, doi: 10.35940/ijrte.B1040.0782S419

[5] N. Kham, and C. Nwe, Implementation of modem traffic light control system, International Journal of Scientific and Research Publications, Vol. 4, Issue 6, Jun. 2014