Detection of Emergency Vehicle using Combination of HSV Color Space and RGB Color Space Technique for Intelligent Traffic Light System

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Abstract

One of the factors of traffic congested in a busiest town is due to a traffic light at a road intersection. Normally, current traffic light has been programmed with fixed timer whereby it is not consider the situation of vehicle intensity at the intersection. It do not have intelligent sensor to self-learn the road condition and number of vehicle so that the controller will react based on the information of traffic at the intersection. Furthermore, for an emergency case such as ambulance, fire truck and cop cars, they are also facing a problem whenever reach at a traffic light. It is hard to those emergency vehicles to bypass the traffic congested at a traffic light due to unsmarts traffic light system. On top of that, a smart traffic light controller for emergency vehicles is required to overcome a problem of traffic congested at an intersection. In this paper, our general objective is to develop a system that can control a traffic light for any emergency vehicle to pass through a road intersection smoothly. We are focusing our study on the emergency vehicle detection using image processing techniques. HSV color space and RGB color has been used to analyse the light of emergency vehicle and it become a features for the classification. With combination of morphological approach to select region of interest, we found that the algorithm given a promising result as we presented it the analysis part. We achieved 89% efficiency detection of emergency light for emergency vehicles

Keywords - Intelligent traffic light, vision sensor, HSV, RGB

1. Introduction

The traffic lights are signalling devices positioned at road intersections, pedestrian crossings and other locations to control competing flows of traffic [1]. Most of the traffic congested at an intersection is due to the traffic light. The current traffic light installed in cities in Malaysia is fixed by timer where a sensor is used just to determine the existence of vehicle at an intersection. The problem of congested at traffic light become more severe whenever an emergency vehicle pass by at the intersection. The drivers need to getspace from other users to pass through the traffic light in a case where the junction is in red light. This situation wills danger the driver as they need to pass by the traffic light although at that time the traffic light is not turn to green. An intelligent traffic light is required to solve the problem facing by emergency vehicles. As the limitation of sensor technology, vision sensor can be used to detect emergency vehicles and can be used to control the traffic light. In designing an intelligent traffic lights control using vision system, the most important thing to consider is to prevent any traffic disturbance and make emergency vehicles pass by the traffic light smoothly. To achieve these objectives, a smart system needed which use vision sensor to take data, identify the appearance of emergency vehicles, process the data and send signal to make the system activated. This system is used to decrease time taken for emergency vehicles reach their destination.

Most countries in the world come out with the incident management systems, traffic monitoring and control system and so on to move emergency vehicles to the scene of the accident quickly and safely as well as to relieve traffic congestion by reducing response time (the running time to the scene). In

image processing analysis, the methodology consists of data acquisition, pre-processing, feature extraction and classification need to be choose in order to get accurate and efficient detection [1].

Jae Bong Yoo, Jihie Kim and Chan Young Park stated that in their paper, in order to reduce additional cost and time for rescue and guarantee the safety of emergency vehicles, the idea is to allow emergency vehicles to reserve a road on a freeway for arriving to the scene of the accident quickly and safely using ubiquitous sensor networks [2]. New idea comes out from the research paper which is to reserve one lane from three lanes of road which has low density of car for the emergency vehicles when emergency cases happen.

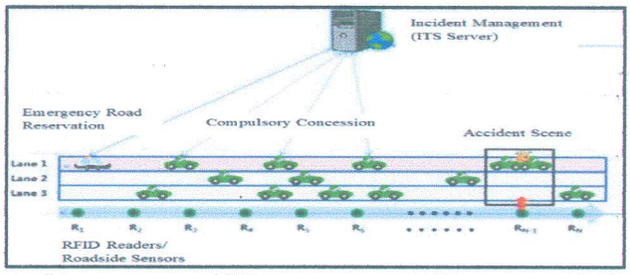


Figure 1: View of the Intelligent Transportation System [2]

Incident detection module in the incident management server is executed to detect a traffic incident by analysing the information received from roadside sensors. After that, the incident management server finds out the lowest density lane for emergency vehicles based on traffic statistic information, and sends other vehicles compulsory concession messages which command all other vehicles on the lowest density lane to yield to emergency vehicles. Next, emergency vehicles which function from combination of the emergency lights and the siren are more effective. But there still need a communication system which can full communicate between emergency vehicles and the drivers of other vehicles. So the emergency vehicles can communicate and send the warning messages to neighbouring vehicles periodically to inform them about its current position and speed. This system is discussed by Andreas Buchenscheit, Florian Schaub, Frank Kargl, and Michael Weber [3].

Masters, Lam and Kam Wong proposed two incident detection algorithms namely the All Purpose Incident Detection (APID) algorithm and the Double Exponential Smoothing (DES) algorithm [4]. These algorithms are developed for Advanced Traffic Management Systems (ATMS) to detect incident early. Then, ATMS will provide the means for local transportation officials to monitor traffic conditions, adjust traffic operations, and respond to accidents.

Most of the system such as 'Intelligent Transportation System', incident management system, traffic monitoring and control system are function to make the emergency vehicle reach at the incident scene in a short period of time. All the systems are required a huge investment for the implementation because it's involved a few parties to install, monitor and implement it. As for advancement of imaging analysis and potential of implementation vision sensor in relevant applications, CCTV might become a solution to emergency vehicle for a problem of congested at traffic light. Since the cost of CCTV is quite low and the implementation are not involve so many parties, it is a practical way to use imaging processing technique to detect emergency vehicle to control a traffic light.

Emergency vehicle are distinguish by it flash lamp and siren. The features of emergency vehicle are based on the lamp light colur. Colour detection is a main approach of imaging analysis to detect, recognize and classify an object. As work demonstrate in [5, 6], colour technique has been used to detect weed and face recognition. In image processing part, Samir K. Bandyopadhyay and Sunita Roy described a new algorithm based on the combination of RGB and HSV algorithms to detect multiple human faces in an image. There are three algorithms which are HSV, RGB and YCbCr and the algorithms work very well under the condition that there is only one face is present in the image. In case of multiple face images it will result some false detection (segmenting some region which do not

contain a face). So, the proposed algorithm by using combination of RGB and HSV will give better result with higher accuracy. Experimental results are shown that the proposed method is good enough to achieve 90% accuracy to localize a face in both single and multiple face images. [7]

In pre-processing process, Haoliang Li and Tao Qin proposed a novel algorithm based on combination of multi-component in the HSI color space. The HSI color space decouples the intensity component from the color-carrying information in a color image, with the hue, saturation and intensity to represent the color. Therefore for the development of image processing algorithms, the HSI color model is an ideal tool. By using HSI color space analysis, sobel edge detector, and morphology technique, the plate region of the vehicles are located accurately. The percentage of accuracy positioning result from the experimental test is high and the processing time for the detection of region plate also short. [8]

2. Methodology

In this study, the main part of analysis mostly involve with image processing technique. The overall methodology is depicted in a block diagram as shown in Figure 2. The research will started with collecting of emergency vehicle image. We collaborate with KlinikKesihatan UMP Pekan to get a recorded video of emergency vehicles. The real data has been taken in a heavy traffic flow at a main road in Pekan town. The duration of video is about 30 minutes with 5 samples of 6 minutes for each video. This data will be used for the whole of this study. Next is to apply pre-processing technique to remove unwanted object in the acquired video. Two approaches have been selected where we use blurring and filtering technique to remove all the unwanted objects such as background of building, trees, bridge etc. This will prepared a good data for our next process of image processing technique. As main characteristics of emergency vehicles specifically the ambulance, the obvious features to distinguish with a normal vehicles is its emergency light. We proposed color processing technique where the image in RGB has been converted to HSV colour space to get better color representation. Then, feature extraction has been implemented to get the feature values to represent the detection in binary format. The binary conversion has been combined with morphology processing to get a clear and accurate detection of object interest. The flow of image processing approach in this study is shown in Figure 2.

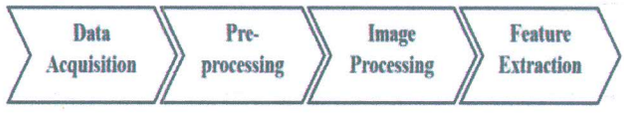


Figure 2: View of the main process in image processing part

The overall detail technique of the study is shown in Figure 3. The proposed technique includes two image processing algorithm as well as a pre-processing step. The method continues with the detection algorithm techniques .The steps of detection are follows,

1. Averaging filtering
2. HSV colour space analysis
3. Colour thresholding
4. Image Multiply
5. Binarization
6. Edge Detection Boundaries

The proposed method is summarized in Figure 3.

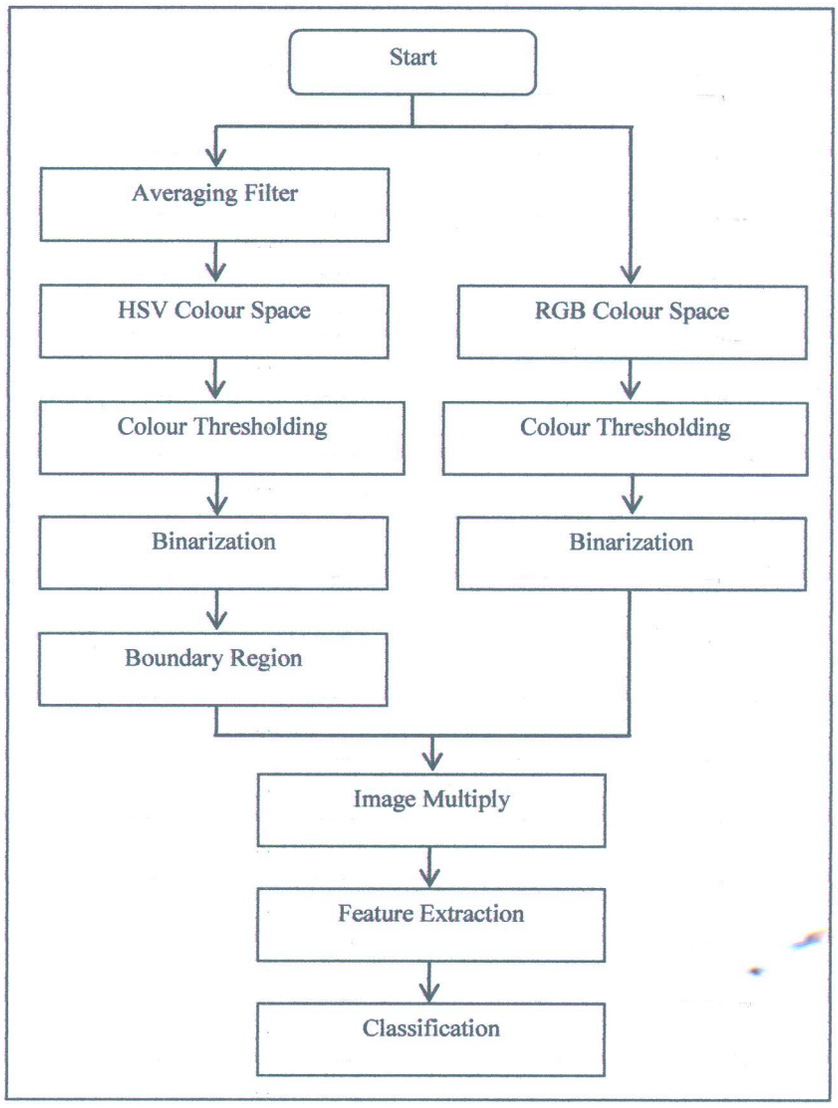


Figure 3: Flow chart of the algorithm

2.1 Pre-processing Technique

The main features of emergency vehicle is its emergency lamp. It is main part of analysis where we apply colour processing technique HSV and RGB to detect the emergency lamp. Before that, a step of noise removal has to be taken where pre-processing blurring technique using averaging filter has been used to remove the unwanted signal in the images. As shown in (7), the blurring processing is similar with the low pass filter where it will remove and transform the higher neighbouring pixel to a low intensity. This wills resultant to a blurring of object in the image. The process of blurring image using [9] is shown in Figure 4. The high frequencies of pixel values has been transform and remove to a low intensity of pixel and the result can be shown in Figure 4(b).

(a) (b)

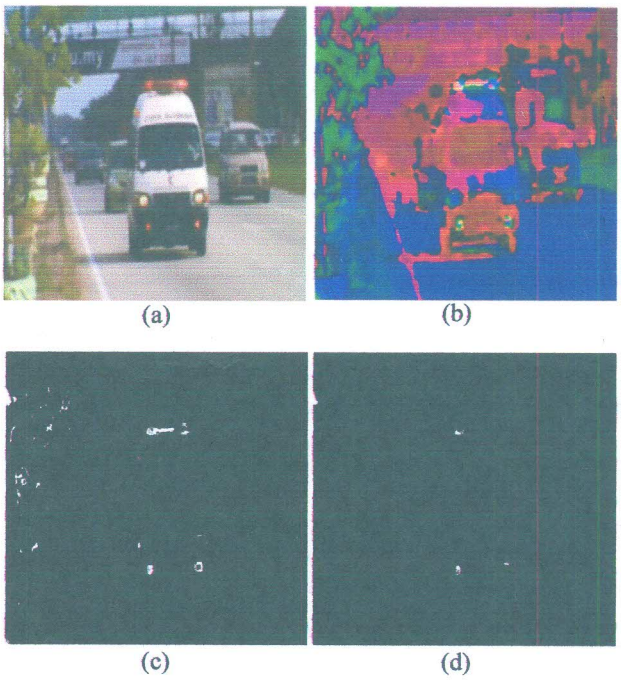
Figure 4: Image Pre-processing (a) original image and (b) Blurring image after averaging filter.

2.2 Image Processing Technique

In the practical of intelligent traffic light, the image that we collect is in real field where it is exposing by direct sun lighting. As one of the challenging in image analysis is source of light, this study also facing the problem of illuminations. By implementing blurring of averaging filter, it was reduced the problem of illumination affected by sunlight. On top of that, in image processing stage, we proposed a color processing technique based on HSV where we do the conversion of RGB format. The detail algorithm of color processing described as follows:

- Convert the image from RGB to HSV
- Determine the H, S and V for red
- Set a threshold value to remove no red intensity
- Apply morphological erosion and dilation with appropriate structuring element
- Select the region of object using boundary properties

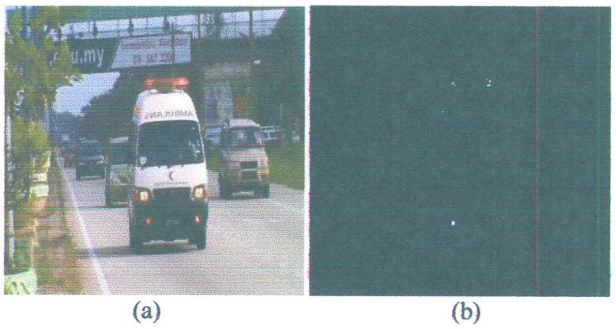
Overall process of the detection is shown in Figure 5. The blurring image in figure 5(a) is in RGB formation and its HSV representation is shown in Figure 5(b). Thresholding values of H, S and V has been selected in applied to the HSV image and we obtained binary formation image as shown in Figure 5(b). Operation to remove the unwanted binary values has been done by implementing morphological erosion and dilation and finally we get the region of interest of emergency light.



(a) (b)

(c) (d)

Figure 5: Image Pre-processing and Image Processing (a) filtering image, (b) HSV colour space, (c) morphology and (d) boundary region image



(a) (b)

Figure 6: Image Processing (a) original image (b) thresholding and morphology RGB color space

From the region of interest of emergency light shown in figure 5(c), there are still unwanted object detected. To improve the detection of emergency light, image multiply technique had been used. At the other side of image processing part, the RGB color space thresholding and morphology are applying to the original image in Figure 6 (a) and (b). Then the image will represent the red component from RGB analysis and it will multiply with the image that represent red component from HSV color analysis. The region of interest of emergency light from this technique will make unwanted object remove and increasing the size of pixel emergency light, Figure 7(c). Next is the decision making, total up the threshold value of the image will give the result of this system whether there are emergency vehicles in the image or not, Figure 7(d).

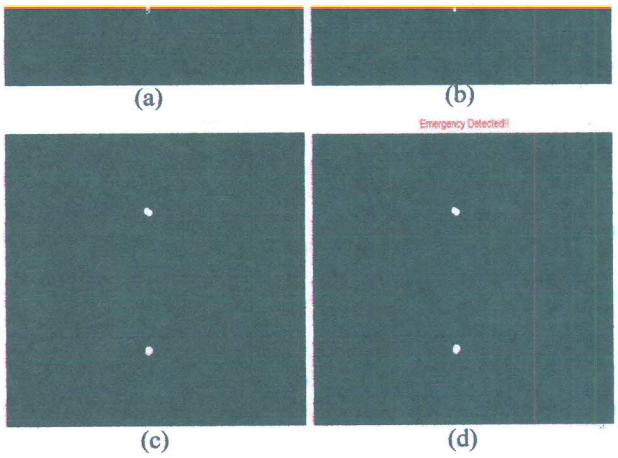


Figure 7: Image processing (a) red component from HSV analysis, (b) red component from RGB colour space, (c) image multiply HSV and RGB (d) detection emergency light

3. Result and Discussion

The main objective of the study is to perform segmentation process to find the object of interest. The best way to measure the efficiency of proposed method is by determine the percentage of classification.

Table 1: Analysis of threshold pixel value for detection of emergency vehicle

Description	**<1 threshold pixel value**		**>1 threshold pixel value**	
	Percentage of success (%)	***Percentage of error (%)***	***Percentage of success (%)***	***Percentage of error (%)***
Efficiency	99	1	89	11
Accuracy	98	2	99	1

For feature extraction, analysis had been done for differentiate images that has emergency vehicles and images that don't have emergency vehicles. From the Table 1, the correct situation is sum of threshold <1 for image doesn't have emergency vehicle and sum of threshold value >1 for image have emergency vehicle. For the features that don't have emergency vehicle in that image is 99% efficient. Different to the image that have emergency vehicles but the threshold value is <1, means the system not detect that emergency vehicles although there is emergency vehicles in that image. It's because, this intelligent system is detected the emergency light on the emergency vehicles and that lamp is blinking. Some of the images have emergency vehicles but the lamp is not blinking on that time, so the system cannot detect that emergency vehicles. As solution, this intelligent system will detect a few of early blinking light from the emergency lamp and will remain until the emergency vehicles pass by

the traffic light means although in between there is no detection of emergency vehicles, the system will remain active because the first detection is the most important to this system.

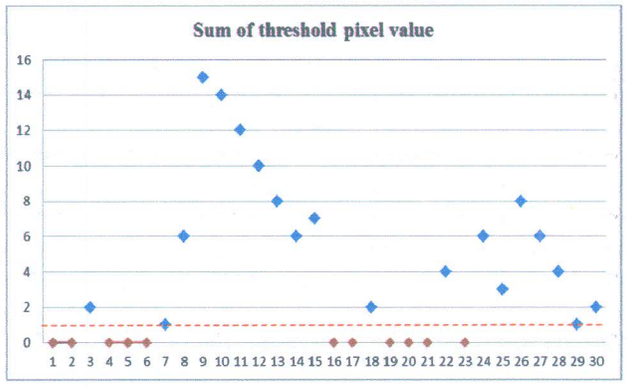


Figure 8: Classification of emergency vehicles detection

Figure 8 shown the classification of emergency vehicles followed the sum of threshold pixel value in the images. If the sum of threshold pixel value is equal or more than one, the decision is there is an emergency vehicle in that image. If the sum of threshold pixel value below than one, the decision is there is no emergency vehicle in the image.

Table 2: Sum of threshold pixel value of image

No. of frame	Sum of threshold pixel value	Decision
1	0	No emergency vehicle
2	0	No emergency vehicle
3	5	Detect emergency vehicle
4	3	Detect emergency vehicle
5	1	Detect emergency vehicle
6	0	No emergency vehicle
7	12	Detect emergency vehicle
8	25	Detect emergency vehicle

From Table 2 it shows that the sum of threshold pixel value of image from frame by frame that gives the decision detection of emergency vehicle. The pixel values which are greater than threshold one and gave the decision as detect the emergency vehicles.

4. Conclusion

Intelligent Traffic Light Control for Emergency Vehicles Using Vision Sensor is a great system that will give important value to all people in this world. This system develop to make the emergency vehicles pass by the traffic light smoothly and indirectly will make the emergency vehicles reach the emergency site faster, hence many lives can be safe. From the video recorded by the video camera, the video will convert to frame by frames of images. From the frames of image, the image processing technique can be applied to detect the emergency vehicles from all the vehicles on the road. The difference of emergency vehicles with other vehicles is the emergency light on those vehicles. Using this feature, image processing will differentiate the emergency vehicles from other vehicles. In this paper, method and technique that has been used for detection of emergency vehicles was presented. The technique is based on pre-processing method followed by image processing method. The analysis of HSV colour space, RGB color space and image multiplying are used to detect the emergency lamp with crowd background and daily light has proven successfully. The technique by combine the two color analysis gives more accurate detection of emergency vehicles. As a future work, we are planning to add other features of emergency vehicles to make the detection more accurate.

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