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Image Analysis Algorithms for Vehicle Color Recognition

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Abstract— **This work discusses about the implementation of a vehicle color recognition system to be used with the vehicle license plate recognition system. Because of the complexity of Thai alphabet, current license plate recognition system fails in correctly recognizing vehicles that have the same number but different Thai characters. Also the current system cannot identify illegal number plates that are being used. This color recognition system will help to resolve these problems and increase the accuracy of the vehicle recognition system. In addition, this system will provide a wide range of color classification which includes 13 colors including white, silver and gray colors. Color recognition is done by two methods: one with machine learning and one without machine learning. A best accuracy of 87.52% is given when using SVM to classify colors.**

Keywords— ***vehicle color recognition; color histogram; back projection; support vector machines***

I. Introduction

With the development in automobile technology, digital image processing has been implemented in the industry. As a result of this autopilot vehicles have been introduced to the market. Some major automobile companies have implemented an adaptive suspension system with the use of digital image processing.

Digital image processing has also been applied in safety and security systems. A system for vehicle license plate recognition for police vehicles has been developed to recognize vehicle license plate and then with the use of database it can retrieve driver's information. The system helps the police officer to identify the driver details easily.

Vehicle license plate recognition system has been implemented in Thailand. Vehicle color recognition is one of the effective ways of vehicle recognition. Some researchers have proposed a color recognition system using support vector machines (SVM) [1] and convolutional neural network (CNN) [2] which is good in rich colors but there method do not include white and silver color classification. Several well-known detection approaches [3-4] can provide an accurate bounding box for each vehicle.

One of the main reasons to exclude white, silver and gray colors in color classification is that pixel values of those three colors are so close to each other and cannot be classified using single color space. Although there is a high percentage of vehicles designed with white, silver and black colors, the researches conducted have not classified these three major colors for vehicle color recognition.

This work is to implement a vehicle color recognition system which can classify up to 13 colors including white, silver and gray colors to work with the current vehicle license plate recognition system and improve the system's accuracy.

The remaining of this paper is organized as follows: Section II describes the dataset used in this paper. Section III proposes two different methods for vehicle color recognition. Section IV presents and discusses experimental results. Section V concludes the paper.

II. Materials and Preparation

A. Dataset

Image datasets used in this paper were collected using traffic cameras which are mounted on Thailand motor ways. These cameras are used for the current License plate recognition (LPR) systems that have been deployed in Thailand. As a reference license plate information is extracted from the current LPR system to work with the color recognition system. Information about the data set is as follows:

- Dataset size – 7,000 images
- Test Dataset size – 2,500 images
- Image size – 1,920 × 1,080 pixels
- Condition – Day time
- Data source – Highway Traffic Camera

As shown in Table 1, this system has to classify 13 colors, including black, white, silver and gray and other popular vehicle colors in Thailand. This list was prepared with the information received from the vehicle information database at Thailand land transportation department.

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TABLE I. VEHICLE COLOR DISTRIBUION IN DATASET

Color	Number	Percentage (%)
Silver	646	25.84
White	502	20.08
Black	310	12.40
Grey	310	12.40
Sky blue	124	4.96
Red	122	4.88
Blue	118	4.72
Brown	74	2.96
Orange	72	2.88
Pink	62	2.48
Green	58	2.32
Yellow	55	2.20
Purple	47	1.88
Total	**2,500**	**100.00**

B. *The Input*

The information regarding the vehicle plate and the image that is captured will be referenced from LPR system for the color and make recognition system implementation. This is because the current LPR system can accurately detect moving vehicles and localize the vehicle number plate of the image. As shown in Figure 1, the system then captures the frame and stores the license plate information (width and height) as well as the coordinate values of the license plate (top left corner x, y).

C. *Region of Interest*

With the use of the top left corner coordinates of the license plate, the system defines a region of interest (ROI) right above the number plate with the dimension of 50 × 200 pixels as shown in Figure 1.

Figure 1. Selection of ROI

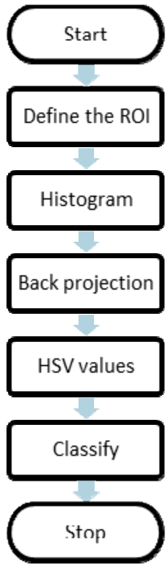

Figure 2. The flowchart of the histogram and back projection based method

III. COLOR RECOGNITION METHODS

As to successfully classify 13 colors, which was mentioned in Table 1, this work has implemented two main methods, as follows:

- Histogram and back projection based method
- Support vector machines (SVM) based method

These two methods use the same data set and same license plate data information. The first method is done without machine learning while the second method is based on machine learning. Each method has its own advantages as well as disadvantages. This work will compare these two methods in the aspect of accuracy.

A. *Method I: Histogram and Back Projection Based Method*

This method was implemented without any machine learning method. The model for each color was found after doing some research on color values of vehicle images. The method can be described by a flowchart, as shown in Figure 3.

As explained earlier, an ROI of size 50 × 200 pixels will be extracted from the hood area of the vehicle (Figure 3). Then the histogram is calculated for the extracted ROI in HSV color space (Figure 4). Then the histogram will be normalized in order to make it accurate and a histogram model is created.

With the use of the histogram model of ROI, histogram back projection is done as shown Figure 5. Back projection is a way of recording how well the pixel of the given image fit the distribution of pixels in the histogram model. In other words, this system calculates the histogram model for ROI and then uses it to find this feature in the entire image.

As shown in Figure 5, back projection will give a mask which contains the same features as the histogram model of

ROI. Therefore this mask will contain a majority of the vehicle color area as shown in Figure 6. This will eliminate the background and windshield of the vehicle which is not useful for the color recognition system.

After extracting the interested colored area of the image then it will be used to classify the color. Each color has a range of predefined values for the classification. So the HSV values for every pixel in the colored area will be voted according to the color. Then the vehicle color is classified as shown in Figure 7. Some examples for vehicle color classification using this method is shown in Figure 8.

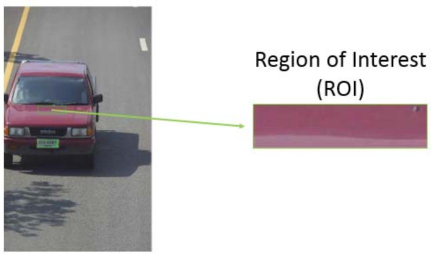

Figure 3. ROI extraction

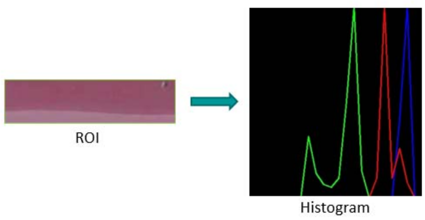

Figure 4. Model of color histogram in ROI

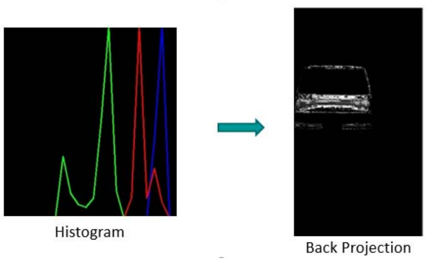

Figure 5. Example result of histogram back projection

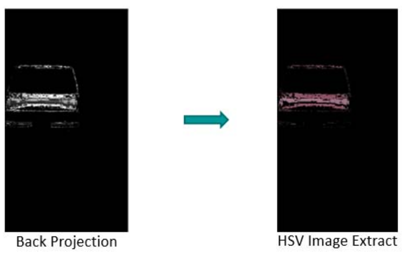

Figure 6. Extracted area

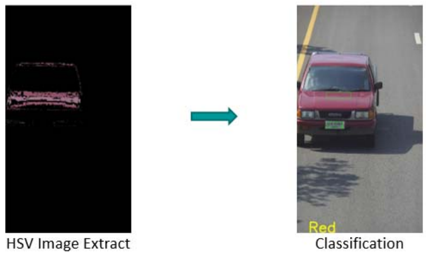

Figure 7. Color classification

Figure 8. Examples of color classificaiton result

B. Method II: SVM Based Method

SVM algorithm is based on finding the hyperplane that gives the largest minimum distance to the training sample. Therefore the optimal separating hyperplane in a feature space maximizes the margin of the training data.

In this method, we used several feature combinations and carried out testing to get the results according to them. In this work, radial basis function (RBF) kernel was used in SVM classification. The same ROI was extracted in order to extract color features from the vehicle. This area will be processed with a sliding window of 10×10 pixels area. This sliding window will extract features from each pixel within its area (Figure 9).

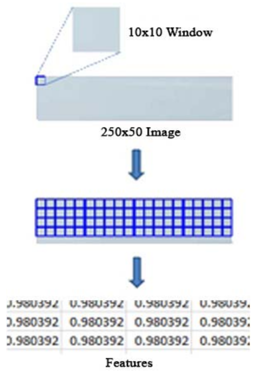

Figure 9. Feature extraction steps

In order to select accurate features for classifying colors some research was done using several features in this work. As the color classes contain with many combinations of primary colors more feature value should be selected. Each color space has its advantages and disadvantages. For an example HSV color space is good with intensity variation but poor in classification on non-colors such as black, white and silver.

BGR is good with non-colors but bad with intensity. Consequently, in this work, the feature vector contains several color spaces in order to compensate errors of the each other color spaces.

In this method different feature combinations were tested in order to reach a good accuracy.

- Four features (R, G, B, V)
- Six features (R, G, B, H, S, V)

These feature vectors are classified using multi-class SVM. RBF has been used as it achieves the best accuracy when comparing with other kernels. Finally, the majority voting scheme is used to classify the final result as the class which has the largest number of votes.

TABLE II. ACCURACY OF METHODS

Color	**The number of vehicles correctly recognized (accuracy)**		
	Histogram Back Projection	***SVM Four features***	***SVM Six features***
Silver	398 (61.61)	406 (62.85)	524 (81.11)
White	322 (64.14)	398 (79.28)	425 (84.66)
Black	297 (95.81)	302 (97.42)	295 (95.16)
Grey	242 (78.06)	235 (75.81)	268 (86.45)
Sky blue	121 (97.58)	108 (87.10)	108 (87.10)
Red	121 (99.18)	112 (91.80)	115 (94.26)
Blue	113 (95.76)	105 (88.98)	111 (94.07)
Brown	72 (97.30)	71 (95.95)	72 (97.30)
Orange	68 (94.44)	66 (91.67)	65 (90.28)
Pink	57 (91.94)	57 (91.94)	57 (91.94)
Green	54 (93.10)	53 (91.38)	53 (91.38)
Yellow	53 (96.39)	50 (90.91)	51 (92.73)
Purple	43 (91.49)	42 (89.36)	44 (93.62)
Total	**1,961 (78.44)**	**2,005 (80.20)**	**2,188 (87.52)**

IV. RESULTS AND DISCUSSION

For each method various tests were done by varying its parameters and data sizes. Each and every test had its advantages and disadvantages.

In method I, histogram model with 32 bins in the range of 0-255 is used to create a mask that will then extract the colored metallic areas of the vehicle. This method is called back projection. In this method the image is compared with the ROI histogram model. When comparing this, Otsu's thresholding method [5] is used to automatically perform clustering-based image thresholding to maximize the extracted area acutely.

In this method I, it will extract the area which matches the histogram model from the ROI. So the extracted area will contain similar features as the give histogram model.

As shown in table II, the method I, is good in recognizing colors other than gray, silver and white. The reason for low accuracy is that gray, silver and white it has a small difference in pixel values in HSV color space.

In method II, SVM was used to classify each color. Experimental results are shown in Table II. In this method best accuracy was given when using six features for classification. For the case of using six features, it contains two color spaces and it successfully manages to classify colors with good accuracy for all the colors.

V. CONCLUSION

This paper proposes two methods in vehicle color recognition as well as a method to detect the vehicle metallic area using histogram back projection. SVM based classification method successfully solved the color classification on white, silver and gray color which had low accuracy in other methods that were proposed.

When using back projection method, it gives an accuracy around 78.44%. In this method, it successfully classifies colors when the lighting conditions are good. But when shadow is present on the vehicle this method fails to classify colors acutely.

In SVM maximum accuracy was given when using six features. It managed to give an accuracy of 87.52% and it managed to classify color even when it has shadows on vehicles. Overall SVM method gave the highest accuracy.

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