Vehicle Color Recognition Based on License Plate Color

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Abstract—As a significant feature of vehicle, the color feature plays an important role in the intelligent transportation systems. However, the color feature is easily affected by the variations of the lighting condition. In this paper, we present a new method for vehicle color recognition, which is based on license plate color. The color of license plate is recognized by the prior knowledge and the recognition result of the license plate, which is not sensitive to the variations of lighting condition. We select the vehicle ROI (region of interest) near the license plate, and convert the color space of the plate image and the vehicle ROI image from RGB to HSV. The vehicle color is identified by the relative location of the ROI color and the plate color in the spectrum. We verify the feasibility of our approach through a comparison experiment. Experiment results show that the color of license plate is helpful to recognize the vehicle color.

Keywords-vehicle color recognition, license plate color, HSV, color space, spectrum

I. INTRODUCTION

Vehicle information recognition has played an important part in ITS (Intelligent Transportation Systems). As a significant feature of vehicle, color has received people's attention in recent years. And extracting vehicle color effectively has become a hot problem. Dule *et al.* [4] used the plate position parameters to determine two kinds of ROIs (smooth hood peace and semi front vehicle), and made feature selection over the determined ROIs. He used three classification methods (K-Nearest Neighbors, Artificial Neural Networks, and Support Vector Machines) to classify vehicles into seven colors: black, gray, white, red, green, blue, and yellow. Li *et al.* [5] used vector matching of template and a color normalization operator to preprocess the images, and applied relative error distance matching algorithm to classify the vehicles into seven colors in HSI color space. Li *et al.* [6] recognized car-body color based on color difference and color normalization. Hu *et al.* [7] removed the useless part of vehicle body, estimated the impact of sunlight on each pixel, and recognized the vehicle color based on specular-free image. Brown *et al.* [8] used spatial features to identify vehicle color with tree-based method, and tested it on publicly available continuous dataset.

In this paper, we present a new method to recognize vehicle color based on license plate color. We extract the license plate region and vehicle ROI near the license plate from vehicle image, and convert the color of the two regions from RGB space into HSV space. Then, we use the relative location of the vehicle ROI color and the license plate color in the spectrum to recognize the vehicle color. The color of license plate can be inferred from the prior knowledge and the recognition result of the plate, which is not sensitive to the variations of lighting condition. Therefore, the color of license plate can be used to recognize the vehicle color.

The remainder part of the paper is organized as follows: color spaces, especially RGB color space and HSV color space are discussed in Section 2. In Section 3, we explain the details of our method. The experiment results are shown in Section 4, and conclusions are presented in section 5.

II. COLOR SPACE

The purpose of a color space (also called color model or color system) is to facilitate the specification of colors in some standard, generally accepted way [2]. Color space can be divided into three categories. First, the color space based on HVS (Human Vision System), which consists of RGB, HSI and Munsell color space, etc. Second, the color space based on specific applications, including YUV (be used in the television system), CMY (K) (be used in the printer system) and YIQ color space. The last one is called CIE color space, such as CIE, XYZ, Lab and Luv color space, etc.

A. RGB Color Space

RGB color space is one of the color standards for the industry, and one of the most commonly used color spaces. It is an additive color space in which red, green, and blue lights are added together in various ways to reproduce a broad array of colors [12]. In this color space, all the colors can be expressed by three components, R, G and B, which mean red, green and blue, respectively. When all the components have full intensity, the color is white, and when all the intensity is zero, the color becomes black. Zero intensity in two components and full intensity in the third component give a primary color of the third component. For example, component blue and green have zero intensity, and red component have the full, then the color is red. The RGB color space is represented by a cube in geometric, as shown in Figure 1.

The RGB color space is device-dependent. The relationships between the composition amounts of the three components are unintuitive, and the resulting colors are not specified as absolute.
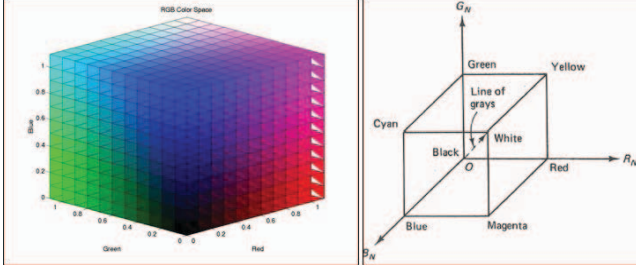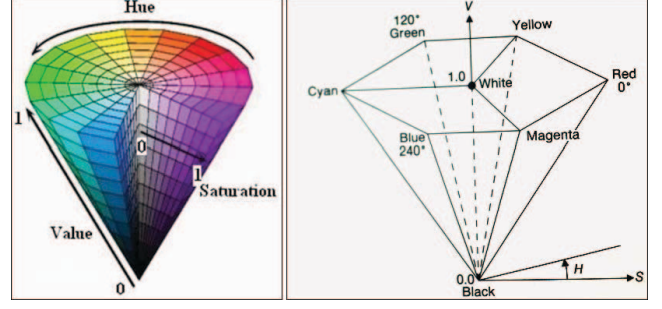
Figure 1.   RGB color model

Figure 2.   HSV color model

B.   HSV Color Space

HSV color space, which also named the "hexcone model", is proposed based on the visual characteristics of color [1] in 1978. This color space has been widely used in scientific research, such as object tracking [9], face detection [10], and object detection [11].

HSV color model divides color into H (hue), S (saturation) and V (value), which apperceives color change independently [3]. It is represented by an inverted cone in geometric, as shown in Figure 2. In the inverted cone, the gray colors comprise the center vertical axis, which ranges from black at value 0 to white at value 1, and the value of the top is 1 while the bottom is 0. The component hue is represented by the angular dimension, which starting from pure red at 0°, across pure yellow at 60°, pure green at 120°, pure blue at 240°, and then turning back to pure red at 360°. The radial dimension of the cone, ranging from 0, the center, to 1, the edge, was labeled as saturation.

HSV color space is more intuitive and perceptually relevant than RGB color space [13]. And the components H, S, and V in the HSV color space are more separating than the components R, G, B in RGB color space.

A color can be converted from RGB color space to HSV color space with the following expressions:

$$S = \frac{\max(R, G, B) - \min(R, G, B)}{\max(R, G, B)}, \qquad (1)$$

$$H = \begin{cases} 0, & S = 0 \\ 60 \times \dfrac{G - B}{S \times V}, & \max(R, G, B) = R \,\&\, G \geq B \\ 60 \times \dfrac{2 + (B - R)}{S \times V}, & \max(R, G, B) = G \\ 60 \times \dfrac{4 + (R - B)}{S \times V}, & \max(R, G, B) = B \\ 60 \times \dfrac{6 + (G - B)}{S \times V}, & \max(R, G, B) = R \,\&\, G < B \end{cases} \qquad (2)$$

$$V = \max(R, G, B), \qquad (3)$$

where R, G and B are respectively the normalized values of the RGB color space. The ranges of components H, S and V are $[0, 360)$, $(0, 1]$ and $[0, 1]$, respectively.

III.   VEHICLE COLOR RECOGNITION

Our color recognition method is based on the color of the license plate. We extract the license plate region and vehicle ROI near the license plate from vehicle image, and convert the color of the two regions from RGB space into HSV space. Then, the relative location of the vehicle ROI color and the license plate color in the spectrum are utilized to recognize the vehicle color.

Generally, the vehicle colors are classified into six categories: white, red, yellow, gray, blue and green. However, since the white and gray are not chromatic colors, we only examine red, yellow, blue, and green in our experiments.

A.   License Plate Processing

From the existing license plate recognition system, we can get the recognition results of the license plate, including the license plate location and the type of the license plate (blue plates with white letters, white plates with black letters, and yellow plates with black letters.).

The color of license plate can be inferred by the recognition results. A military vehicle, *e.g.*, the license plate must be white. And the plate color of a double deck non-military vehicle must be yellow, while the single ones have ordinary plates (blue plates). The blue and yellow plates can be distinguished by whether the letters are lighter or darker than the background. In order to reduce the influence of ambient light, we get the plate color not only by color recognition, but also utilize other information of the plates (for example, the structure of the plate). Some sample plate images are shown in Figure 3.

Figure 3.   Some sample plate images

Figure 4. Some sample vehicles including the license plate, and the rectangles with green color are the selected ROIs

Figure 5. color location in the spectrum

B. Vehicle ROI Processing

In our method, instead of using the whole vehicle for color recognition, we use a region of interest on the vehicle. The ROI we selected is the region near the license plate. On one hand, the neighbor regions have similar lighting conditions. On the other hand, the correspondences between the color information on license plate and the color of ROIs are constructed to improve the accuracy of the vehicle color recognition.

We locate the position of the license plate by utilizing the license plate recognition system, and cut out the vehicle ROI near the vehicle license plate automatically. Then, we select the vehicle ROI from the right side or the left side of the plate.

Before selecting the ROI, we convert the vehicle color image to grayscale image. Then select couples of rectangle regions from the left side and the right side of the plate, calculate the mean values and the variances of those regions. Finally, we select the area with the minimum variance as the vehicle ROI. Some sample vehicles including the license plate are shown in Figure 4, and the rectangles with green color are the selected ROIs.

C. Recognition Process

In HSV color space, the parameter H (Hue) represents the color information, and we can obtain the location of the color in the spectrum according to this value. Hence, we only use the parameter H to recognize the vehicle color.

During the above two parts, License Plate Processing and Vehicle ROI Processing, we have converted the color of the final images from RGB space to HSV space. Thus, the parameters H of both the license plate and the vehicle ROI can be obtained directly. Simultaneously, we can compute the averages of the H values that defined as h_{plate} and h_{ROI}.

Then we utilize the relative location of h_{plate} and h_{ROI} in the spectrum to recognize the vehicle color. For example, in Figure 5, the H value of red color is about 0, and yellow color is about 60, so the location of yellow is at the right side of red, and green is located at the right side of yellow. Suppose $h_{ROI} < h_{plate}$ (h_{ROI} is at the left side of h_{plate}), if the plate color is yellow, then the ROI color must be red, for the reason that the h value ranges between 0 and 360. If the plate color is blue, then the vehicle color may be blue, green, yellow, or red, we can recognize the color by the difference between h_{plate} and h_{ROI}. For instance, if the difference is less than 60° ($60^o = 240^o - 180^o$, we make an assumption that the color value of blue plate is 240°), then the vehicle color is blue. If the difference ranges between 60° and 150° ($240^o - 90^o$), the vehicle color would be green. If the difference ranges between 150° and 210° ($240^o - 30^o$), the vehicle color would be yellow, otherwise, the vehicle color must be red.

IV.   EXPERIMENTAL RESULTS

We implement a comparison experiment to verify the feasibility of our approach. That is, we compare the vehicle color recognition results with and without using the license plate color information.

A. Data Set

The vehicle images in our data set are collected in the real road at different time with different lighting condition. We divide all images into six classes: red, yellow, blue, green, white, and gray. We examine our method on four of them (red, yellow, blue and green), since white and gray are not chromatic color. Figure 6 shows some sample images in the data set. There are 306 images in our data set, and the size of every image is 1600×1280.

B. Results

In the experiment without using the license plate color information, we use the average of H value h_{ROI} to identify the vehicle color. At last, we have an accuracy rate of 0.73 on the red vehicles, 0.93 on the yellow vehicles, 0.90 on the blue, and 0.40 on the green. The average accuracy rate on our data set is 0.69.

We have better results by employing the license plate color information. As shown in TABLE I, the accuracy rate on the red vehicles is 0.73, the yellow is 0.93, the blue is 0.97, and the green is 0.53. The average accuracy rate on the data set is 0.75.

The experiment results show that the accuracy rates on red and yellow vehicle images have not been improved. The reason is that: we use the relative location of the ROI color and the plate color in the spectrum to recognize the vehicle color. However, most vehicles have ordinary plate (blue plate), and the color yellow and red are far away from blue in the spectrum while blue and green are closer. So the plate color is less helpful in the recognitions on red vehicles and yellow vehicles.
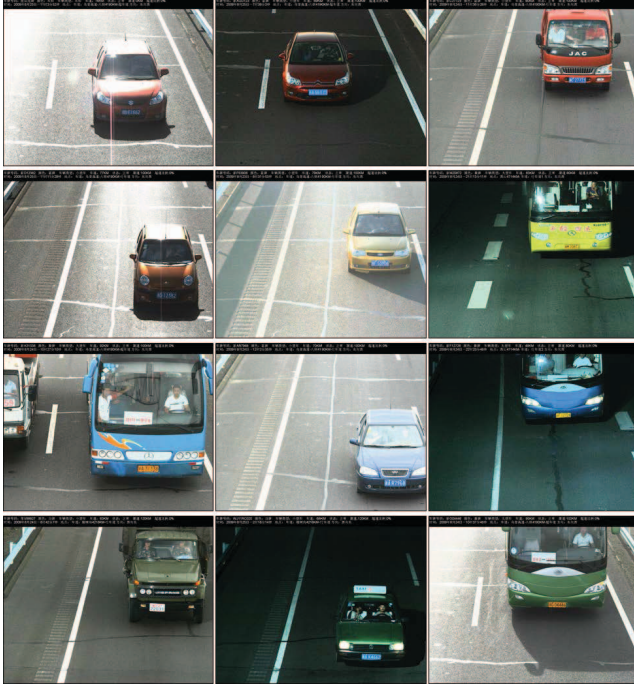
Figure 6.   some sample images in our vehicle images data set, and the size of every image is 1600×1280

TABLE I.   EXPERIMENT RESULTS

Vehicle color	Without plate	Using plate
red	0.73	0.73
yellow	0.93	0.93
blue	0.90	**0.97**
green	0.40	**0.53**
all	0.69	**0.75**

All in all, the results show that our new method of vehicle color recognition based on license plate color is effective.

V.   CONCLUSION

In this paper, we propose a new method for vehicle color recognition based on license plate color. We identify the vehicle color by the relative location of vehicle color and plate color in HSV color space. The experiment results show that our method of vehicle color recognition based on license plate color is effective and robust.

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