Color identifying of vehicles based on color container and BP network

Jing Fang
The Institute of Intelligent Information Processing and Application
Soochow University
Suzhou, China
Zoe0824fang@sina.com

Hengjun Yue[1], Xiuzhi Li[1], Jian Wu[1,2], Zhiming Cui[1,2]
[1]The Institute of Intelligent Information Processing and Application
Soochow University
Suzhou, China
[2]Jiangsu Yihe Traffic Engineering Co., Ltd.
Suzhou, China
szjianwu@163.com

***Abstract*—On the basis of model building and extracting of moving vehicles, the paper propose a new method to identify the vehicle color based on color container and BP neural network. The method analyze the contribution of three channel of the HSI color space, extract the vehicle features using container, design a special neural network for the experiment. The experimental results show that the accuracy rate of the color identifying is high and the error rate is low using this method, which overcome the shortcomings of the conventional method.**

Keywords- Color, BP network, container.

I. Introduction

For the past few years, with the rapid development of the national economy and the rapid increase of motor vehicles, China's increasingly serious urban transport problems, traffic congestion, traffic accidents occurred frequently. To establish effective intelligent transportation systems (ITS), for effective traffic monitoring, traffic manage and traffic control has become a pressing problem [1]. In addition to license plates, vehicle type and other vehicle features, color is also an important feature. Therefore, the vehicle color recognition as an important vehicle identification aids were valued by the researchers[2]. Automatic identification of the vehicle color management system can overcome the low efficiency of conventional vehicle management system and greatly improve the impact of the automation of vehicle management system.

Most of the current vehicle color recognition algorithms are based on chromatic aberration, where chromatic aberration is the Euclidean distance between two points in the color space. The size of the distance of two points determines the color differences. However, the current research about vehicle color is still in its infancy and there are many unresolved issues. The paper is based on the retrieving and mining system of vehicle in our laboratory, which make use of the type and color features of the vehicle and do searching, tracking, analyzing, understanding of the vehicle appear in the traffic video. Part of the process about the color characteristics is as figure 1.

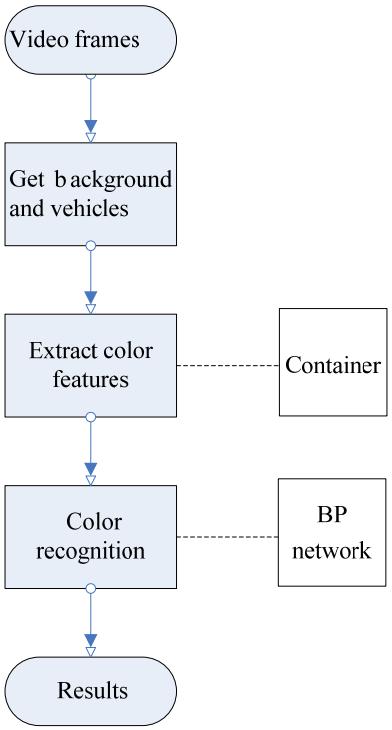

Figure 1. Flow chart of the color recognition

II. Container for Color

A. *color space*

To process color image, we must first select a appropriate color space[3] and it is critical for color recognition to choose a color space which is consistent with the human visual. In a variety of proposed color space, RGB color space is the most practical one. As the earliest and most simple color representation, it uses the principle sum of the three primary colors of red, green and blue, with the RGB values to say the color. But the RGB color space is not a uniform color space, the color difference in the color space is not consistent with the human visual similarity. That is to say, the RGB color space is

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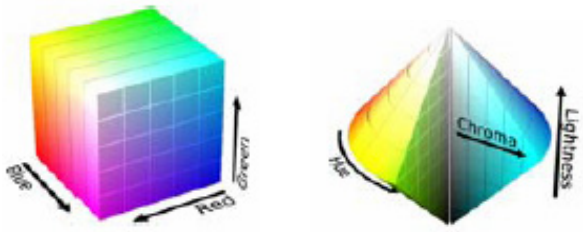
simple but is different from the human visual characteristics.

When dealing with color features, HSI color space is closer to human visual characteristics and do meet the experimental demands. HSI color space is composed of three components of hue, saturation, intensity (or brightness). Where the intensity (I) say the degree of bright or dark and saturation (S) say whether the color is undertone or deep. The three components in this color space is independent and is with linear scalability, the perceived color difference is proportional to the Euclidean distance of the points in the color space

Figure 2 (a) and 2(b) are the color space schemes of RGB and HSI.



(a) RGB (b)HIS

Figure 2. Color space

The HSI color space has the feature that it wipes the relation between the brightness and the color while the definition of saturation is closely related to the way people define the color. The feature mentioned above make HSI color space the ideal one to process images and it is more suitable for us to recognize the color of the vehicles. We get the values of RGB and transform them to the HSI color space using the formula as follows:

$$\begin{cases} I = \dfrac{1}{3}(R+G+B) \\ S = 1 - \dfrac{3}{(R+G+B)}\left[\min(R,G,B)\right] \\ H = \arccos\left\{ \dfrac{2R-G-B}{2\sqrt{(R-G)^2+(R-B)(G-B)}} \right\} \end{cases} \quad (1)$$

According the transformational relation of the RGB and HSI, we can get the values of H,S,I from the values of R,G,B, where the values of R, G, B are the red, green, blue value of the pixels.

B. *Color feature extraction based on container*

There are black, silver and white vehicles as well as the colorful vehicles in the traffic video and we divided the vehicles as seven categories of black, white, silver, red, green, blue and yellow. Many experiments show that it results in low detect results when we only consider the H component of HSI color space, especially for the white, silver and black vehicles.

The values of the three channels we extract from each pixels of the vehicle are the microscopic characteristics of the vehicle and it is hard for us to process them because of its large amount of information. In this paper, we define seven containers as the macro values. We get seven values after classifying each pixel to the seven color categories and the seven values are related to the seven colors but are not linear. We induce the relationship of the values and colors using BP neural network.

After lots of experiments about a variety of traffic video, we find in this article that when we use the HSI color space to process the vehicles object, the three values of the channels contribute to the color in the following specific rules.

1) When the value of brightness is small enough, the pixel is black no matter how much the values of hue and saturation are. While it is white when the value of brightness is big enough.

2) If it doesn't meet the first case, we come to its value of saturation. If the saturation is smaller than some certain value, we can't feel its colorful information no matter what the value of hue is. Then we can classify it to the black, silver or white category.

3) In addition to the foregoing two categories, the pixel is colorful when the value of brightness is moderate and the value of saturation is large enough. Then we can determine the category of the pixel according to the value of hue.

Follow the above rules, we can associate each pixel with one of the seven containers and finally get the value of the containers. The steps to get the container values are shown as figure3.

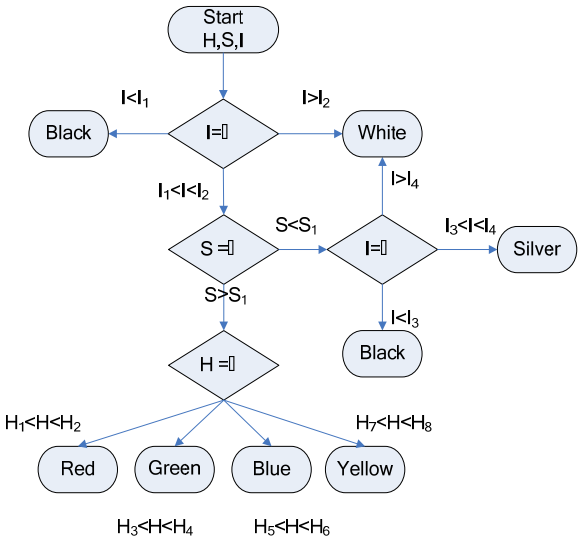


Figure 3. Flow of container calculation

In figure 3, given a pixel with the values of H, S and I, it is classified to black container if the value of I is bigger than I_1 while white smaller than I_2. Then come to the value of S. If it is smaller than S_1, we determine its category by the value of I. Lastly, we assumed it as some colorful container and classify it by the value of H. In the specific test, the thresholds of H, S and I are slightly different.

To recognize the color of the vehicle, we consider not

only the color information of vehicle body, which is talked above, but also the background. For example, there are lots of shadows in the video taken in a glare condition, and the color of the vehicle body will be affected in human eyes. In order to accurately identify the color of the vehicle, the overall brightness information of the video should be taken into account. This paper considers the current frame backgrounds of the vehicles. We extract the relevant value about the brightness of the background and study it in the BP neural network as one of the inputs.

III. BP NETWORK

A. *Introduction for BP network*

Back propagation algorithm is also referred to as BP algorithm[4,5], which successfully solved lots of learning issues about the connection weights of the neurons in hidden layer of the multi-layer network and finally promoted the development of the neural network. In 1899, Robert Hecht-Nielson proved that the BP network with only one hidden layer can approach any continuous function in a closed interval[6]. In another word, a 3-layer BP network can complete any N-dimension to M-dimension mapping. So we usually use the single hidden layer in BP network.

The output of the network is on behalf of the system goal, so it is much easier for us to determine. There are two basic principles to select the inputs of the network. One is the feature should be easily detected or extracted; the other is they each other is irrelevant or has small correlation. Both the way to extract the inputs and the number of output are closely related to the problem to be solved, so the specific selection will be described below.

How many hidden-layer nodes will be the most suitable for the current system is a complex problem and there are no specific theoretical guidance[7]. It is interrelated to the requirements of the problems and the numbers of input and output. If the number of hidden-layer nodes is too small, the network will not be strong enough. While if the number is too big, the study will easily fall into local minimum and not the global optimum. Therefore, the principle to determine the number of the hidden-layer nodes is to meet the accuracy requirements as far as possible under the premise of taking a compact structure, that is to take as few hidden nodes as possible.

The performance of the network is closely related with the training samples. There are two factors we should consider to design a good training set. The first is to determine the number of training samples. In general, the more training samples, the training results more accurately reflect its inherent laws. But there are often many constraints for collecting samples and it is difficult to improve the accuracy of the network when the number of sample is large enough. Thus, we refer to the rule that the samples are the 5 to 10 times of the weights of the network. The second is to select and organize the samples. The inherent law of the network is contained in the samples, which should be representative. The number of samples in each category should be roughly equal and the categories are all covered by the samples.

B. *The design of the network*

The neural network structure is shown in figure 4. For this paper, it contains an input layer, an output layer and one hidden layer.

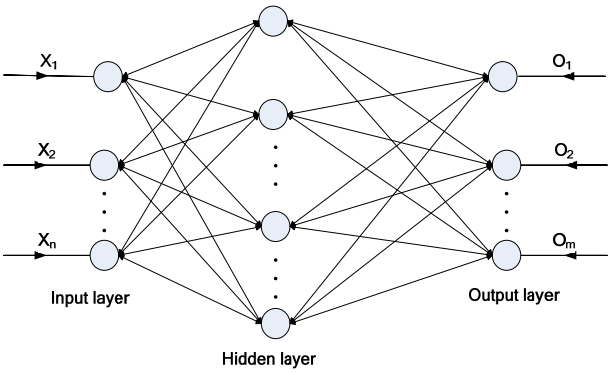


Figure 4. The structure of BP neural network

We divided the vehicles into seven categories of red, green, blue, yellow, black, white, silver. So the number of nodes in output layer is seven. When comes to the number of nodes in hidden layer, the paper conduct the number of the nodes through trial and error.

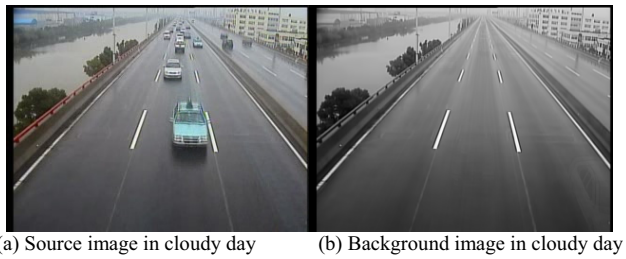
$$s = \sqrt{n+m} + \alpha \tag{2}$$

Where n is the number of nodes in the input layer, m output layer, s hidden layer, while a is an integer between 1 and 10. After repeated trail of the same sample with different hidden layer nodes, we ultimately be sure that when the number of nodes in hidden layer is nine, the performance of the network is the best.

The object to be processed in this experiment is the vehicles in the traffic video. In order to prevent the large errors resulted by the different ways to get samples and test data, we extract all the samples from the traffic videos using the program in this paper and the videos are under various conditions.

IV. EXPERIMENT AND DISCUSSION

Build the model using the Gaussian background model. Take two videos for example, as shown in figure 5, (a) and (c) are the source images of the video in cloudy day and sunny day, while (b) and (d) are the corresponding background images.



(a) Source image in cloudy day (b) Background image in cloudy day

(c) Source image in sunny day (d) Background image in sunny day

Figure 5. Source image and the corresponding background image

The videos for our experiment are from the monitors of the highway and city roads from Suzhou. Extract all sorts of vehicle object in different colors and different shapes from the videos as the samples for the neural network and establish a large sample library as the training samples.

Then we calculate the feature of container following the flow chart of containers and gain a large table of features combined with the feature extract from the background. Train the neural network with the stable as input and get the final value of thresholds and weights of the network. Test the vehicle object in the video using the network which is trained and display the results finally. Figure 6 shows the color identify results of the test in the video.

Figure 6. The results of color identify.

The trained neural network achieves good results in the test of identifying the color of the vehicles in the video. In this paper, we extract and select about 2000 samples from about 50 video in different condition, each video is an average of 5 minutes. The test data are 20 videos which are similar to the training videos. Table 1 is the accuracy rate and error rate.

TABLE I. THE ACCURACY RATE AND THE ERROR RATE

	Black	**White**	**Silver**	**Red**	**Green**	**Blue**	**Yellow**
Accuracy rate	*83.4%*	*92.3%*	*88.9 %*	*97.2 %*	*98.1%*	*97.0 %*	*97.3 %*
Error rate	*7.2%*	*4.2%*	*8.6%*	*1.2 %*	*2.4%*	*0.5%*	*2.1%*

As in the table 1, the accuracy rates of the colorful vehicles are high while the error rates are very low. Because the black, white and silver vehicles usually affect by the lights and weather, the accuracy rate is lower than the colorful vehicles, while the error rate higher. But the results are better than other algorithms.

V. CONCLUSION

On the basis of analyzing the HSI color space, the paper proposed a method of the container to extract the features of the moving vehicles, design a special BP neural network to study the features. The test results are good when using the trained network to identify the vehicle color in the video. The next step is to identify the vehicle color at night or in rainy day, analyze and find the appropriate method.

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