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Method of Traffic Signs Segmentation based on Color-Standardization*

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***Abstract* - The drawbacks of commonly applied color treatment based on the HSI space model have been identified as being the additional computation load for color model conversion, which results in compromising the real-time traffic sign detection. The relevant analysis shows that the major factor adversely affecting the segmentation of traffic signs is closely associated with the color complexity. To reduce the computational complexity in the scene image processing, a new solution based on the color standardization, as defined in this work, is proposed. The scene image is mapped to a simple standardized image consisting of standard color of eight categories, among which five colors related to traffic signs are extracted to form the standardized traffic signs region. The experimental results show that the proposed approach simplifies the complex color description of the scene image, and achieves the traffic signs segmentation with sufficiently high processing speed and satisfactory accuracy.**

Keywords* - *Traffic sign segmentation; Color-Standardization; RGB component thresholding; Scene images

I. INTRODUCTION

The efficiency and accuracy of a transportation system can be boosted by combining Intelligent Transportation System (ITS) with numerous factors, among which are advanced information processing, communications, automation, Geographic Information System (GIS), positioning technology and so on, to build an efficient, safe, environmental friendly integrated transport system. Traffic sign recognition (TSR) is an important part of the field of ITS research, including: ⑴Traffic sign detection, consisting of the pre-processing for scene image and locating signs in the image; ⑵Traffic sign classification, constituting extraction of the kernel of signs and classification [1]. In regard the road safety regulations in China, the traffic signs cover three categories, that is, prohibition signs, warning signs and directional signs, all of which contain special image-related information such as color and shape. Accurately extracting the traffic signs is carried out based on the successful of the prerequisite for traffic signs classification. However, the segmentation of a traffic sign, for its posterior classification, presents the same difficulties as object recognition in natural environments [2]:

1) Lighting conditions are changeable and not controllable. Lighting is different from time to time in a normal day, season, and influenced by cloudiness and other weather conditions, etc..

2) The presence of other objects makes the detection more challenging. Except the simple case as of on highways, other objects often surround traffic signs. This produces partial occlusions, shadows, etc..

3) It is not possible to generate off-line models for all the possibilities of the sign's appearance due to the almost infinite degrees of freedom. The object size varies in accordance with the distance to the camera; the scale for each axis changes given the camera optic axis being not perpendicular to the sign, resulting with an aspect modification; besides, physical condition of a sign is not consistent depending on its duration of use, etc..

To improve the accuracy of traffic sign recognition, it is necessary to achieve the pre-processing of complex color information for traffic sign detection. Nowadays, the method of signs detection is incorporated into processing the color information of traffic signs, and the implementation of color feature extraction through the color model conversion, for example, RGB color model convert to HSI color model. However, this method involves cumbersome calculation of the color conversion, and it is not an efficient way to extract the signs quickly.

Therefore, to address these difficult issues, this paper proposes a fast method of pre-processing for traffic sign segmentation base on the complex color information, called color-standardization as defined in this work. Its essence lies in the non-linear mapping from a scene image of complex color information to a standardized image consisting of standard color of eight categories with consideration of the color composition of traffic signs. Five colors of interest are selected to simplify the color space, and achieve the high quality of traffic signs segmentation with high processing speed and accuracy..

II. IMAGE PRE-PROCESSING

A. Image Pre-processing for Traffic Sign Detection

To correctly classify the traffic signs, the key question is how to tackle the traffic signs segmentation. Among them, the image pre-processing is the most important, since the success of the detection depends on the effectiveness of image pre-processing. The implementation of image pre-procession of

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traffic sign detection is generally based on a priori information, the main issues are color extraction, de-noising, filtering and so on. Image segmentation based on color information is one of the most commonly used methods. However, nowadays, color information extraction is usually carried out under the HSI color model [3-5]. For a scene image, using the traditional method is required to carry out the model conversation from RGB to HSI to get the corresponding HSI component value. But the conversation process takes a lot of computation time which influences a follow-up traffic detection in the real-time effects. To avoid the cumbersome calculation of the conversation, reference [6] proposed traffic signs segmentation based on RGB color model which extracted color information throughout looking for the relationship between RGB components. However, with the increase of the detection samples, the detection accuracy may be compromised. In this study the method is proposed for scene image pre-processing based on color standardization, although it is also based on the RGB model, the basis of the calibration value is primarily on the RGB component thresholding, thus simplifying the color information complexion of traffic sign scenes in order to improve the accuracy of detection.

B. *Image Pre-processing based on Color Standardization*

RGB color space is the most common applications for the display device. For a static image, RGB values of the component can most directly display the information of scene image. The RGB three-dimensional color space will be divided into eight color sub-spaces, as shown in Fig. 1. Each sub-space is a small cube with the edge length of 128, so eight ones as of this make up of the RGB color space. And the definition that the eight exterior angle point of RGB space are eight types of standard color points, they are the standard black, red, green, blue, magenta, yellow, cyan and white. The RGB values of these eight standard colors are as shown in Table I.

The purpose of color standardization for traffic signs segmentation is to significantly reduce the complexity of the color information. And in accordance with calibration value, the scene image will be mapped to a standardized image consisting of standard color as mentioned afore. Prior to describing it in detail, some relevant definitions and rules are introduced as follows.

Definition 1: Let Calibration Value (CV) be the segmentation threshold value of RGB three-components, and $CV = (Tr, Tg, Tb)$. Respectively, Tr is the threshold value of red component, Tg the threshold value of green component, and Tb the threshold value of blue component.

Rule 1: Because of the selected image with 24-bit, each of the RGB components is accounted for by 8-bit, which means the range of each component of the pixel value is [0, 255]. Therefore, the values ranging in Tr, Tg and Tb are respectively from 0 to 255. Let (r, g, b) be a pixel, the segmentation rules are as follows:

if $(r > Tr)$ $r = 255$; else $r = 0$

if $(g > Tg)$ $g = 255$; else $g = 0$

if $(b > Tb)$ $b = 255$; else $b = 0$

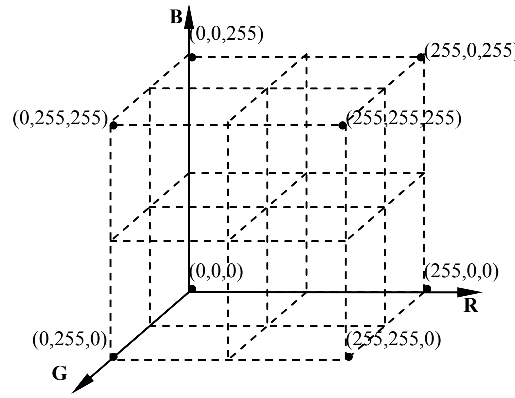


Figure 1. RGB three-dimensional space model

TABLE I. RGB VALUES OF STANDARD COLOR OF EIGHT CATEGORIES

No.	Color	Space Model			No.	Color	Space Model		
		R	G	B			R	G	B
1	Red	255	0	0	5	Magenta	255	0	255
2	Green	0	255	0	6	Yellow	255	255	0
3	Blue	0	0	255	7	Cyan	0	255	255
4	White	255	255	255	8	Black	0	0	0

Definition 2: Let $P_i = (r_i, g_i, b_i)$ be the RGB component values of all pixels in a image. i is a subscripted variable, *WIDTH* the pixels of the width of a image, and *HEIGHT* the pixels of the height of a image. Therefore, $i \in [0, (WIDTH - 1)\times(HEIGHT - 1)]$.

Definition 3: Let *PixNm* be a variable as the number in Table I, $PixNm \in [1, 8]$. The value of *PixNm* is defined by the following rules:

Rule 2: if $(r_i > Tr$ and $g_i < Tg$ and $b_i < Tb)$ $PixNm = 1$
if $(r_i < Tr$ and $g_i > Tg$ and $b_i < Tb)$ $PixNm = 2$
if $(r_i < Tr$ and $g_i < Tg$ and $b_i > Tb)$ $PixNm = 3$
if $(r_i > Tr$ and $g_i > Tg$ and $b_i > Tb)$ $PixNm = 4$
if $(r_i > Tr$ and $g_i < Tg$ and $b_i > Tb)$ $PixNm = 5$
if $(r_i > Tr$ and $g_i > Tg$ and $b_i < Tb)$ $PixNm = 6$
if $(r_i < Tr$ and $g_i > Tg$ and $b_i > Tb)$ $PixNm = 7$
if $(r_i < Tr$ and $g_i < Tg$ and $b_i < Tb)$ $PixNm = 8$

III. METHOD OF COLOR-STANDARDIZATION

In China, there are 116 kinds of traffic signs divided into three categories which are directly related to road safety (excluding consequentially derived signs). By observing and analysing the 116 kinds of traffic signs, it can be noted that traffic sings mainly consist of five basic constituted colors: red, blue, yellow, black, and white. The frame color of the three types of traffic signs has a fixed relationship with these colors: the frame color of prohibition signs is mainly red, but another two ones is black; the frame color of directional signs is mainly blue; the frame color of warning signs is mainly black, and the kernel is in yellow and black. Therefore, for a scene image, by extracting red, blue or black the corresponding frame of traffic signs from background can be separated. Based on these findings, and considering the similarity identified in colors, five colors of interested (COI) are selected: red, magenta, blue, cyan, and black. Magenta and cyan of which will be separately classified as red and blue, then they compose the standard colors library (SCL) and optional colors library (OCL) of traffic signs, as shown in Table II. After color mapping of the scene image, extracting the COI becomes possible with implementation of traffic signs segmentation at high speed. The arithmetic steps are briefly reviewed as follows:

step 1: Calibration Value (*Tr, Tg, Tb*) selection;

step 2: RGB components thresholding by the selected CV;

step 3: Achieve color standardization by mapping from 24-bit scene image to standardized image consisting of standard color of eight categories;

step 4: According to the SCL and OCL, extracting the COI based on RGB space model (see Table II);

step 5: Filtering out the redundancy region on standardized images, and then detect shape by Hough transform to achieve the traffic signs segmentation.

TABLE II. COI OF TRAFFIC SIGNS

Color	SCL			Optional Color	OCL		
	R	G	B		R	G	B
Red	255	0	0	Magenta	255	0	255
Blue	0	0	255	Cyan	0	255	255
Black	0	0	0				

A. CV Selection

Selecting the accurate CV is the key of successful implementation of color standardization. However, in real life, the scene image will always be affected by the impact of weather, light and other factors, usually causing the color components of the image distorted. In addition, the colors contain a variety of "impurities" noises. Because of these unwanted factors, it is difficult to determine the selection of CV with sufficient accuracy. For example, when the RGB values of a red pixel under the visual effect is (116,27,25), according to the *rule 1* and *rule 2* as regulated above, there would be some undesired results due to the different CV as follows:

if *CV* = (100,30,30), mapped to (255,0,0) which is a standard red pixel;

if *CV* = (128,50,20), mapped to (0,0,255) which is a standard blue pixel;

if *CV* = (128,128,128), mapped to (0,0,0) which is a standard black pixel.

Therefore, the CV selection is more important to the results of color standardization. However, the brightness varies a lot between the images. To be able to find signs in either light or dark images, the pixel values have to be made darker or lighter, respectively. This become a necessity if the average pixel value in an image is less than 100 (too dark image) or above 180 (too light image) [7]. Combination of the illumination factors, the three rules of the CV selection may be summarized as follows through a vast number of experiments conducted (take the red circle signs as an example):

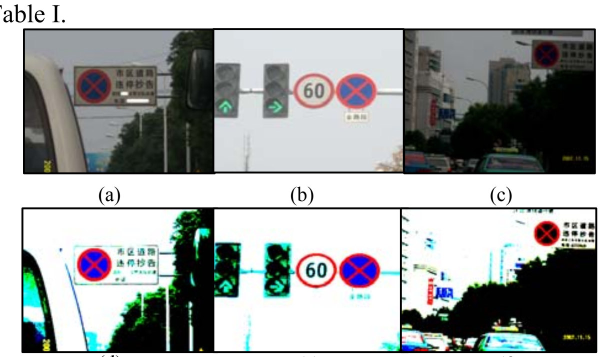
Rule 3: In the normal brightness, we found that the average of R-component values of red pixels is from 70 to 180, while G-component values is less than 75, and B-component values is less than 60 (see Fig. 2(a)). Therefore, we select the CV = (70,75,60) may be selected to achieve standardization of the red pixel in this case;

Rule 4: In too light images, it is noted that the average of R-component values of red pixels is generally more than 180, while G-component values is less than 130, and so is the B-component values (see Fig. 2(b)). Therefore, we select the CV = (180,130,130) may be the premier selection for this case;

Rule 5: In too dark images, it is noticeable that the average of R-component values of red pixels is from 40 to 80, while the values of G-component and B-component are nearly equal to zero. Therefore, selecting CV = (40,30,30) may be optimal in this case.

B. Color Mapping

According to the rules of CV selection, and color segmentation rules as *Rule 1* and *2*, and using the results of RGB components thresholding, we achieve the color mapping of the images can be achieved under different brightness as shown in Fig. 2. Respectively, Fig. 2(d) shows the result of color mapping of Fig. 2(a), Fig. 2(e) comes up with the result of color mapping of Fig. 2(b), and Fig. 2(f) is the result of color mapping of Fig. 2(c). It can be seen that the scene images is mapped to simplified standardized images consisting of standard color of only eight categories, and the RGB component values of colors are separately shown in Table I.



(a) (b) (c)

(d) (e) (f)

Figure 2. Color mapping under different brightness
(a) Normal brightness (b) Too light image (c) Too dark image
(d) Mapping of (a) (e) Mapping of (b) (f) Mapping of (c)

C. Traffic Signs Segmentation

The last part of the method is traffic signs segmentation based on the standardized images, which includes extracting the COI, filtering out the redundancy region, and detecting shape by Hough transform. In view of the SCL and OCL in Table II, we give the new definition and rule on COI extracting rules by *Rule 2* are given as follows:

Definition 4: Let $Q_i = (R_i, G_i, B_i)$ be the RGB component values of all pixels in a standardized image, so the values of R_i, G_i, B_i are equal to 0 or 255. And let *PixColor* be a variable as the color in Table II. Because of the definition of OCL, the value of *PixColor* is defined by the following rules:

Rule 6: if ($R_i = 255$ and $G_i = 0$) *PixColor* = Red
if ($R_i = 0$ and $B_i = 255$) *PixColor* = Blue
if ($R_i = 0$ and $G_i = 0$ and $B_i = 0$) *PixColor* = Black

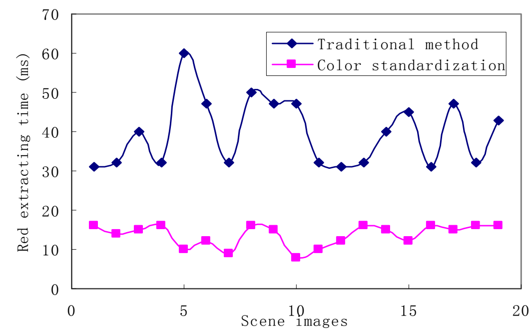
According to all the definitions and rules as stated above, Fig. 3 gives the results of traffic signs segmentation by applying the proposed method to the scene images. It suggests that the signs after color standardization are clear and in favor of further processing of classification.

(a) (b)

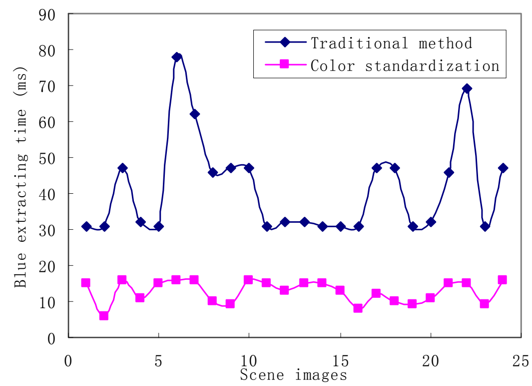
Figure 3. Color standardization for traffic signs segmentation

IV. Experimental Results

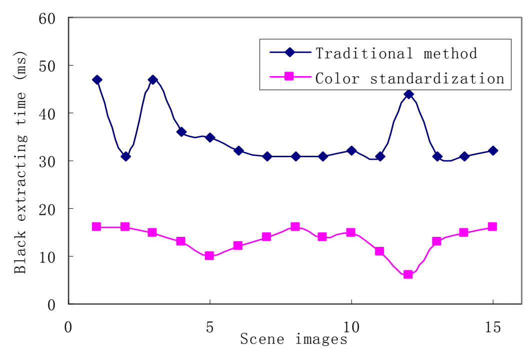
To further verify the effectiveness of the proposed method, simulation is first made based on 58 scene images of traffic signs taken in the normal brightness (there are 19 ones with prohibition signs, 24 ones with directional signs, and others with warning signs), followed by comparing the proposed method with the traditional one (the traffic sign detection based on HSI color model). The simulation is completed on a PC with the Windows XP system, and the experiment result is based on the programming environment of Microsoft Visual C++ 6.0. From the results shown in Table III, it can be noted that the proposed method's performance turns out to be superior, especially the time-saving in computation is significant. In addition, the segmentation method based on the color standardization is much better in terms of the accuracy and extraction color time (see Fig. 4), and the segmentation effectiveness is also improved. Furthermore, when the color extracted based on the standardization, the region of interest can be easily distinguished from other noise regions. Compared with the normal color extraction method, the new algorithm's noise



(a) Comparison of red extraction time



(b) Comparison of blue extraction time



(c) Comparison of black extraction time

Figure 4. Comparison of color extraction time

TABLE III. THE COMPARISON OF TWO METHODS

	Color standardization			Traditional method (HSI model)		
	Prohibition Signs	Directional Signs	Warning Signs	Prohibition Signs	Directional Signs	Warning Signs
Images number	19	24	15	19	24	15
Detection success number	19	23	14	14	15	10
Detection success rate(%)	100	95.8	93.3	73.7	62.5	66.7
Color extracting average time (ms)	13.8	12.3	11.9	39.7	42.2	36.4
Total detection average time (ms)	201.5	311.2	284.4	342.6	546.9	369.1

regions are much reduced, making operating speed for filtering out the redundancy region improved. Therefore, the method of traffic sign segmentation based on color standardization's total computation time is thus saved significantly.

V. CONCLUSIONS

In this research report, a color standardization based method of traffic signs segmentation is proposed, which is achieved using the CV of the RGB three-components thresholding, mapping complex color image into the images composed of eight types of standard colors. On the basis of the COI, five kinds of interest colors are extracted which are associated with traffic signs, followed by detecting the corresponding traffic signs after the pre-processing. Compared with the traditional HSI color model based method, it skips the model conversion from RGB to HSI, which saves significant amount of computation time required for conversion, and the real-time effects in traffic signs segmentation is as a result enhanced.

However, this paper mainly provides a method that is meant to extract the color of traffic signs based on signs detection, and the value of CV in this work is obtained from the empirical experiments, the algorithm is still unable to achieve selecting the CV dynamically under variant brightness. Therefore, if this pre-processing method is to be applied for the real-time TSR system, dynamical selection of the CV needs to be further explored.

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