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Extracting Road Signs using the Color Information

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***Abstract*—**In this paper, we propose a method to extract the road signs. Firstly, the grabbed image is converted into the HSV color space to detect the road signs. Secondly, the morphological operations are used to reduce noise. Finally, extract the road sign using the geometric property. The feature extraction of road sign is done by using the color information. The proposed method has been tested for the real situations. From the experimental results, it is seen that the proposed method can extract the road sign features effectively.

***Keywords*—**Color information, image processing, road sign.

I. Introduction

THE development of an intelligent transportation system grows rapidly today. As the number of vehicles increased, the probability of traffic accident occurred is also growing upward. Therefore, safety driving has become a crucial problem. The development of automatic navigation system and the application of machine vision seem to be one of the answers to this problem. Most of the accident happened due to the less attention of the drivers. This paper intends to propose an automated recognition of the road signs by using machine vision techniques.

Since the road signs are color, therefore some researches extracted the color feature based on their characteristics. Usually, color segmentation depends on the color information and it is implemented on the RGB, YUV, or HSV space [1], [2], [3].

Many methods have been applied in detecting road signs. For example, a template is used to match the image [4], [5]. The template matching method is usually time-consuming. The others used the neural network model detect and recognize objects from an image [6], [7], [8]. This method has higher accuracy and shorter processing time, but it needs a lot of samples in the training process. Besides the samples, sometimes, are difficult to set up its parameter.

Paclik et al. [9] used a Laplace kernel classifier to classify the road signs. A pre-classifying procedure is applied to accelerate the detection. Piccioli et al. [10] proposed a method to detect traffic signs. They first detect the region of interest which may contain a traffic sign.

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Data mining techniques can be used for extracting patterns contained in the data [11], [12]. So it is possible to extract the features of the road signs using the data mining approaches. In this paper, we proposed a method which uses the concept of data mining to extract the road sign features and the features are then used for the road sign recognition.

II. Road Sign Extraction and Recognition

For the recognition of the road signs, the images of road signs captured by digital camera are first converted into the HSV color space. Some image preprocessing procedures are applied to the images and they are illustrated in the following.

A. Image Preprocessing

In this stage, the RGB images will be converted into the HSV color space. The HSV space contains hue, saturation, and value. The color transformation is done by the following equation:

$$H = \begin{cases} H', & \text{if } B \le G \\ 360 - H', & \text{otherwise} \end{cases}, \quad (1)$$

$$S = \frac{\text{Max}(R,G,B) - \text{Min}(R,G,B)}{\text{Max}(R,G,B)},$$

and $V = \frac{\text{Max}(R,G,B)}{255}$,

where $H' = \cos^{-1}\left\{ \frac{0.5[(R-G)+(R-B)]}{\sqrt{(R-G)^2 + (R-B)(G-B)}} \right\}$.

Three main colors for road signs are red, blue, and orange. Since, the orange road signs will be red in the HSV color space, we can identify them as the red or blue color in the HSV space. However, the images usually contain noise due to light, shadow, or dust, etc. The mathematical morphological operations (dilation and erosion) can be used to remove the noise.

B. Road Sign Detection

In order to identify the road signs in the images, we should isolate the red and blue objects using the image labeling method. It consists of three steps. Firstly, it scans the pixels which are red or blue as shown in Fig. 1(a). Secondly, it uses the 3×3 mask to replace the nine pixels with the minimum number as in Fig. 1(b). Finally, the pixels with the same number would be considered as an object as Fig. 1(c).

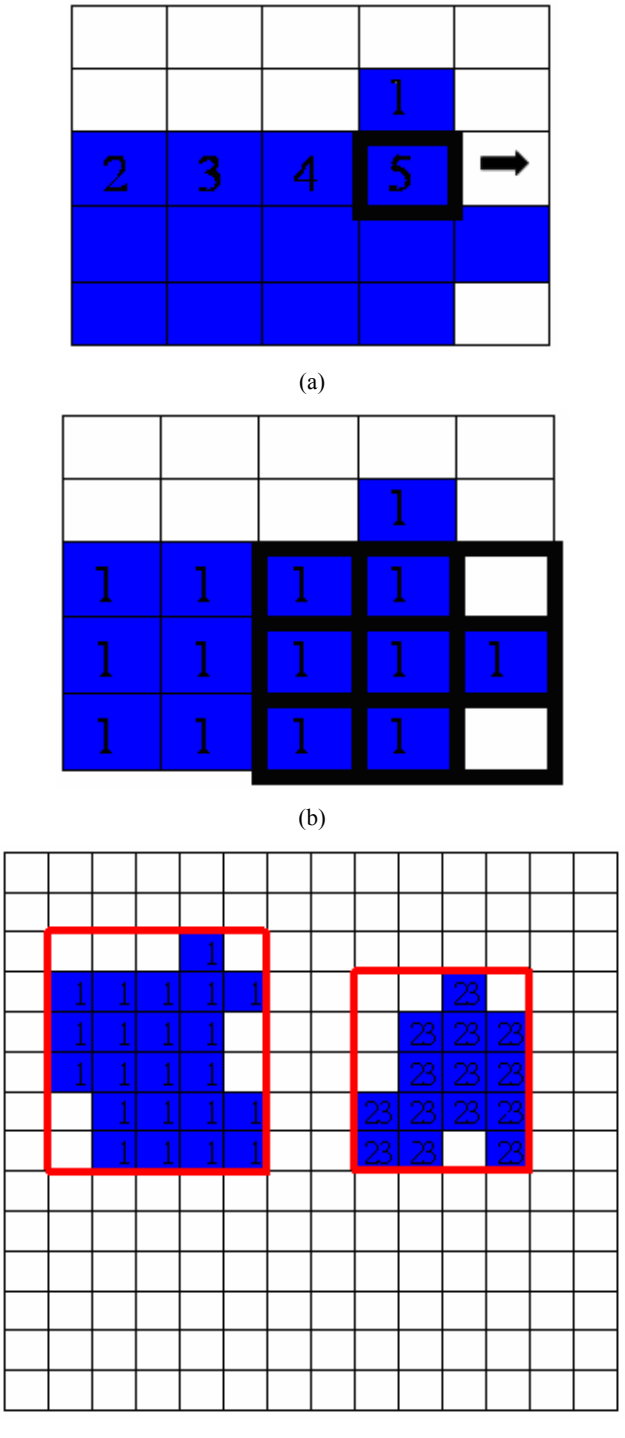


Fig. 1 Labeling: (a) scan and assign codes, (b) reassign the object with the minimum number, and (c) take the collective pixels for an intact object

After labeled the objects, the road signs can be screened using the ratio between height and width as the criterion. From the experience, the ratio between height and width is about 0.91 to 1.2 for the red triangular road signs, The ratio of rectangle road sign is about 0.95 to 2.15 (see Fig. 2). Further, the area is also an important criterion for the road sign. The road sign will contain about 2,000 to 6,000 pixels. The ratio and the area are both used for identifying the road signs.

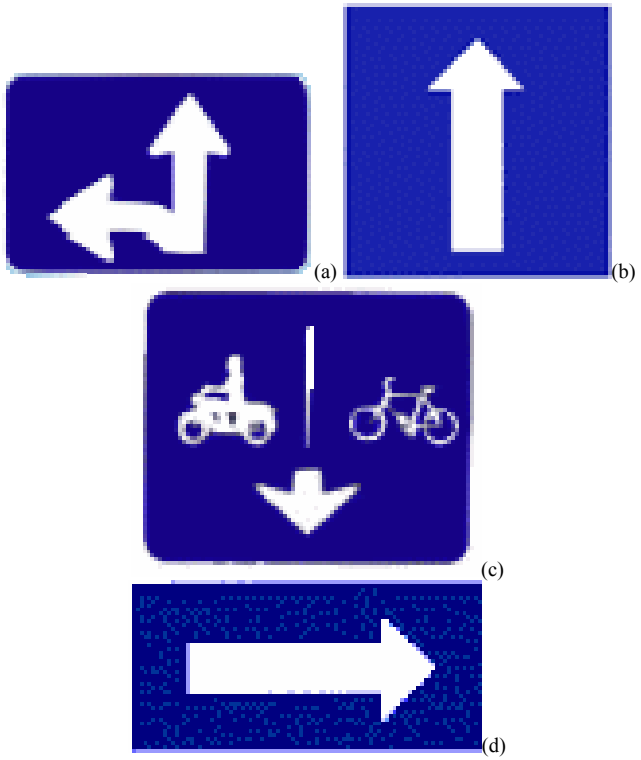


Fig. 2 The ratio between height and width: (a) 1.45, (b) 1, (c) 1.2, (d) 2.1.

C. *Feature Extraction*

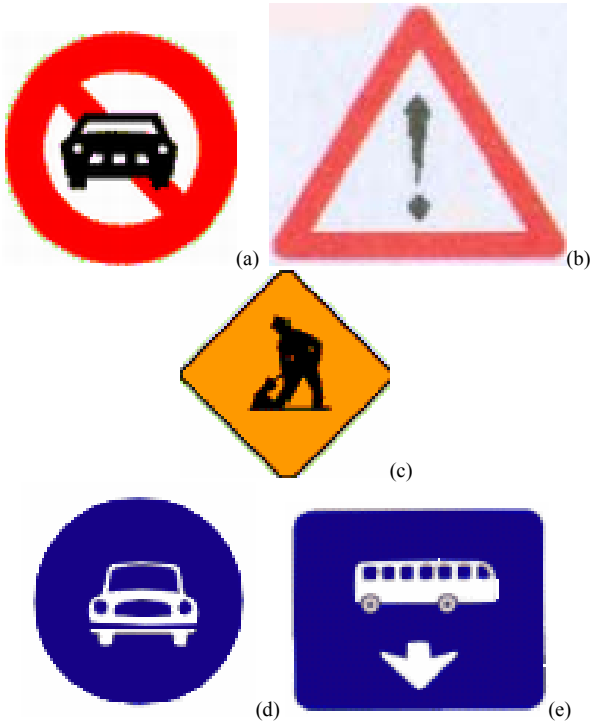


Fig. 3 Some examples of the road signs

As seen in Fig. 3, the road signs are roughly classified as red circle, red triangle, orange rhombus, blue round, and blue rectangle. In order to classify the road signs into the above categories, the detected area of the road sign is divided into a 3×3 region. The positions of the vertices can be used as the feature for classifying the road signs into the triangular, rectangular, circular, and rhombus road signs (see Fig. 4).

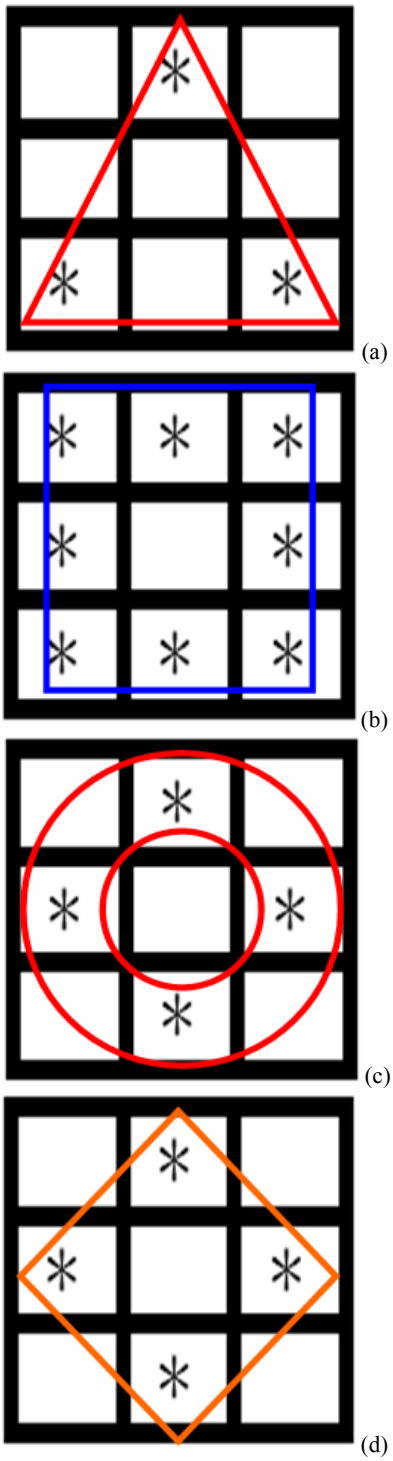


Fig. 4 Positions of the vertices: (a) triangle, (c) rectangle, (c) circle, (d) rhombus

In order to classify the road signs for the same categories, the X and Y axis projections of the inner object and the number of objects are used as the feature. The projections are divided into 3 parts. The peaks of these two projections are used as the features. For example, Fig. 5(a) shows the right turn sign, the X-projections and Y-projections are shown in Fig. 5(b) and Fig. 5(c), respectively. The first two features of the right turn are 1 and 1 as both of the peaks occurred in the first partition. In addition, the number of the right turn is 1; therefore the code of the right turn is (1, 1, 1).

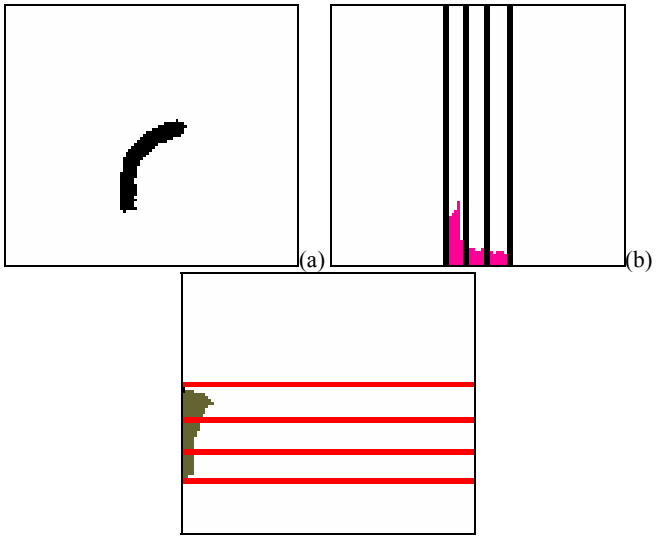


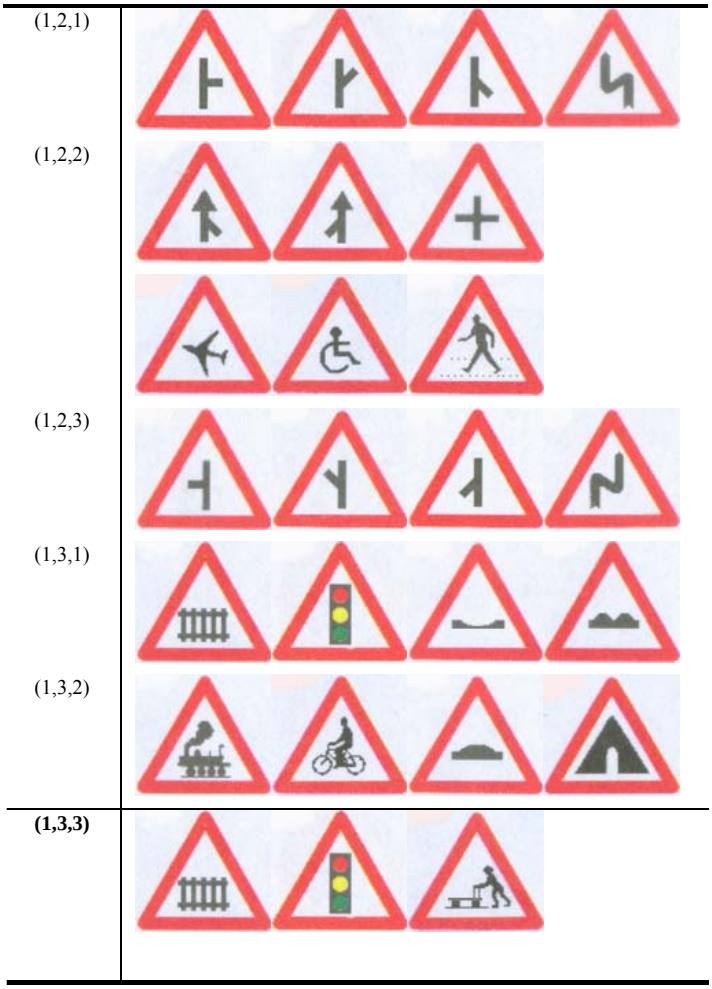
Fig. 5 (a) Right turn sign, (b) X projection, and (c) Y projection.

Since the road signs may contain visual information in the image. As we have known that it is important to include humans in the data exploring stage for data mining. Visual data exploration often consists of a three-step process: Overview first, zoom and filter, and then details on demand [13]. We use the method illustrated by Keima et al. to perform the visual data mining for developing the features of the road signs [12].

D. Classification

TABLE I
EXAMPLES OF RED TRIANGULAR ROAD SIGNS WITH SINGLE OBJECT

Feature	*Road Signs*
(1,1,1)	
(1,1,2)	
(1,1,3)	



After using the coding method described as in Fig. 5, we can develop a rule to classify the load sign. For example, Table I shows the classification rule for the red triangular road signs. The other road signs can be classified by the similar rule.

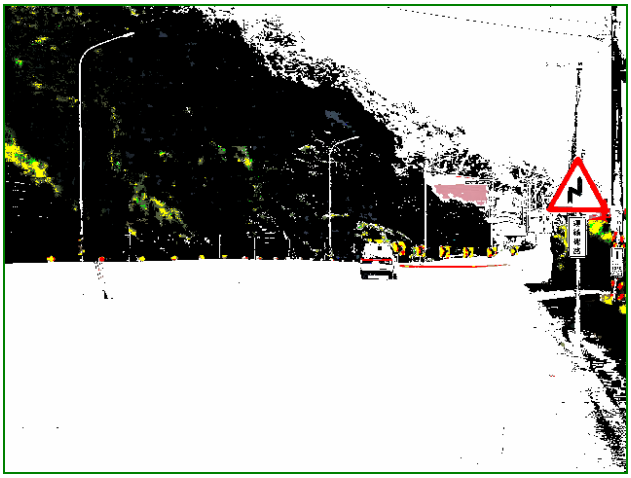
It is seen that there maybe two or more road signs that have the same code. Using the visual data mining technique, the road signs have the same code can be further classified.

III. Experimental Results

To test the proposed method, we have tested 200 images with 640 × 480 resolution. Fig. 6 shows one of the testing images. The images were first converted from the RGB color space into the HSV color space as shown in Fig. 6(b).

Next, the pixels with red and blue colors are extracted for the candidates of road signs as shown in Fig. 7(a). Fig. 7(b) shows the image after removed the noise using the dilation and erosion operations.

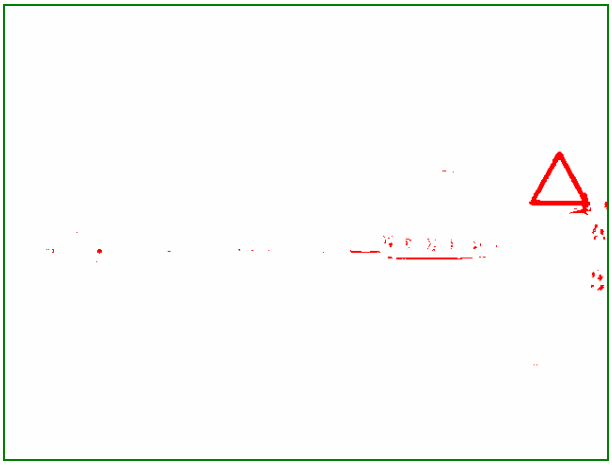
(a)



(b)

Fig. 6 (a) Original image contains the road sign, and (b) converted into the HSV color space

From the experiment, there are 196 images can be recognized correctly. One of the reasons for failure detection is due to the occlusion of two road signs such as in Fig. 8(a). Fig. 8(b) shows another reason that is caused by the color fading.



(a)

(b)

Fig. 7 An example shows the process of the recognition: (a) red color image, (b) after remove noise

(a)

(b)

Fig. 8 Examples of failure: (a) occluded two road signs, (b) color fading

IV. Conclusion

A method for recognizing the road signs has been proposed in this paper. Some image processing techniques have been applied to extract the road signs. Both of the color information and the geometric property of the road signs are used to classify the detected road signs. From the experimental results, it is shown that the proposed method can recognize the road signs effectively.

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