Automatic Traffic Sign Detection

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Abstract—**This work use basic image processing technique to automatically recognize two different traffic signs (stop sign and yield sign) in an image. The image is first thresholded on RBG domain to separate out the regions with red color, which is those traffic signs usually have, then region mapping is done on the remaining regions, the regions that are either too small and too large are removed since they are unlikely to be a traffic sign. Since these two traffic sign is either triangle or octagon in shape, both have the major axis to minor axis ratio close to one, those regions whose ratio is too large is also removed. Finally, the filling ratio of a region is used to separate stop sign from yield sign. This scheme are tested on an total of 65 images with 52 images have stop signs and 13 have yield sign, the overall correct recognition rate is 83%.**

I. INTRODUCTION

Automatica object recognition has long been an interesting research area in image processing, one specific area with practical importance is automatic traffic sign recognition. A robust traffic sign detection algorithm is an essential part of applications like automatic vehicle control, navigation, etc.

Many researches have been done on this topic and have shown promising results [1-4]. As the final project of EE368 image processing class, this work tried to get a first taste of this topic using the image processing techniques introduced in the class. The goal of this project is to detect two different signs: stop sign and yield sign in an image. The properties of color, shape and size of the sign is used to separate them from other part of the image and the filling ratio is used to separate these two sign from each other. Image dilation is also used to connect the possible fragmented region of the traffic sign after thresholding. I collected a total of 65 images with either stop sign and yield sign and divided them into two groups: a training group of 45 images and a testing group of 20 images. Training group is used to select the proper threshold for the algorithm and the testing group is used to test the effectiveness of the algorithm.

II. METHOD

A. Data Collection

All the images are collected by a regular consumer level digital camera from real road, there are a total of 65 images collected, among them 52 images has stop sign and 13 has yield sign. All the images are resized to 640×480. When selecting the images, there is only one image is selected from one traffic sign, so that the detection result won't be biased by the repeated images on similar scenes. Those images are further divided into two group: training group and testing group, which has 45 and 20 images, respectively. Training group are used to select the proper thresholds for the detection algorithm and testing group is used to test its effectiveness. Training group has 37 stop sign images and 8 yield sign image
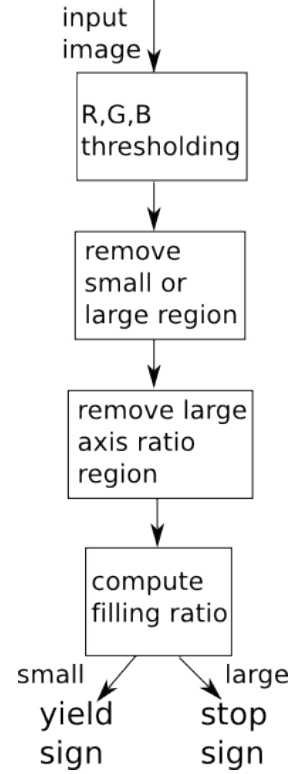

Fig. 1.   procedure to recognize stop and yield sign

while testing group has 15 stop sign images and 5 yield sign images.

B. Detail Algorithms

The overall procedures of this algorithm is shown in Figure 1 and consist of the following steps: first, separate red color region by thresholding in RGB domain, then, remove regions that are either too small or too large, remove region major axis to minor axis ratio is too large, finally, stop sign and yield sign is separated by thresholding on their filling ratio.

Since both stop sign and yield sign are red, they can be separated from background by thresholding in RGB domain using the following scheme, as mentioned in [1]:

$$g(x,y) = k_1 \begin{cases} R_a \le f_r(x,y) \le R_b \\ G_a \le f_g(x,y) \le G_b \\ B_a \le f_b(x,y) \le B_b \end{cases} \quad (1)$$

where $f_r(x,y), f_g(x,y), f_b(x,y)$ is the components in Red, Green and Blue domain, respectively, and $R_a, R_b, G_a, G_b, B_a, B_b$ is the corresponding lower and upper thresholds in those domains, respectively. However, this
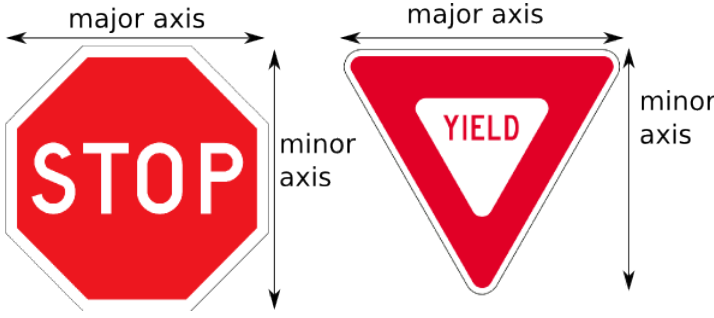
Fig. 2. stop sign and yield sign both have a major/minor axis ratio close to 1

$$\text{filling ratio} = \frac{\text{area of } \blacksquare}{a \times b}$$

Fig. 3. stop sign tend to have a larger filling ratio that yield sign

scheme <mark>has a disadvantage that the thresholds are affected by the lighting condition of the image thus make it difficult to find a universal threshold set that is applicable on images with varying lighting conditions.</mark> As suggested by Arturo et al [1], a slightly modified thresholding scheme is used in this work. Instead of directly thresholding on blue and green domain, the thresholding on these two components is applied on the ratio of the corresponding component to red component, that is:

$$g(x,y) = k_1 \begin{cases} R_a \le f_r(x,y) \le R_b \\ G_a \le \frac{f_g(x,y)}{f_r(x,y)} \le G_b \\ B_a \le \frac{f_b(x,y)}{f_r(x,y)} \le B_b \end{cases} \quad (2)$$

This scheme turns out to be less affected by lighting condition than original scheme and provide better segmentation results.

After thresholding, we need to remove those red regions that are not from a traffic sign, which might come from a car, building or other objects that have similar colors. To do this, we first remove the region that is too small, which might come from noise or small random object. As a result, the traffic sign won't be detected if it is too far way from the observer. The region that is too large is also removed, although this doesn't happen in the images I collected, this step is in participation of some extreme cases such as the image has a large red background. Image dilation is used after this step to connect together the possible fragmented parts of the traffic sign after thresholding. Since both signs has a major to minor axis ratio of close to 1 (as shown in Figure 2), those region whose ratio is too large is considered foreign object and will be removed.

After the above steps, ideally, the remained regions will be either a yield sign or a stop sign, next the filling ratio is used to separate these two signs. A stop sign is a octagon and tend to have a higher filling ratio than that of a yield sign which is triangle and have a empty triangle center, as shown in Figure 3.

III. RESULTS

A. Thresholding choosing

All the thresholds are chosen based on their performance on training images. For each of the image in the testing group, a small area in the traffic sign is manually selected and its red component and the ratio of green to red, and blue to red
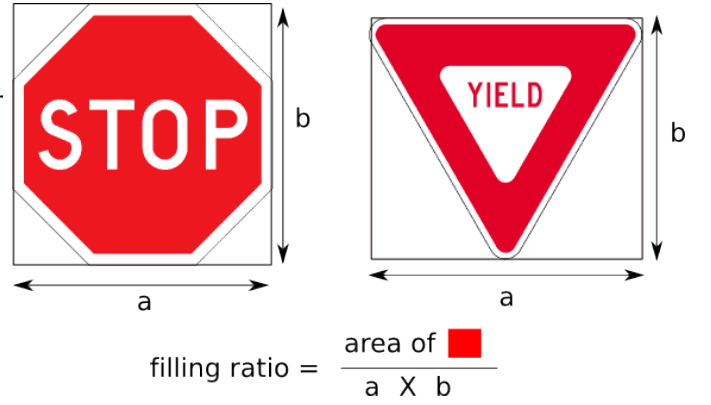
TABLE I. OVERALL DETECTION RATE FOR ALL IMAGES

	Total	Stop Sign	Yield Sign
	65	52	13
Detected	54 (83.0%)	43 (82.7%)	11 (84.6%)
Missed	11(16.9%)	9 (17.3%)	2 (15.4%)
False Detection	10 (15.4%)	8 (15.3%)	2 (15.3%)

in this area ($f_r(x,y)$, $\frac{f_g(x,y)}{f_r(x,y)}$ and $\frac{f_b(x,y)}{f_r(x,y)}$ in Equation 2) are computed. Then, the thresholds are selected based on their distributions across all the images in the training group. The thresholds for size limit and that for filling ratio are chosen based on trial-and-error. The chosen thresholds are as follows: rgb domain threshold, as those defined in Equation 2: $R_a = 65$, $R_b = 255$, $G_a = 0$, $G_b = 0.7$, $B_a = 0$, $B_b = 0.7$; size threshold: lower limit: 40 pixels, upper limit: 400000 pixel; filling ratio threshold: 0.7.

B. Overall Results

The algorithm is applied on all image group and testing image group, the results are as shown in Table I and Table II, respectively, where False Detection means other foreign objects are mistakenly identify as either stop sign and yield sign. The correct detection rate is $> 80\%$ on the selected image group, suggesting that this algorithm, although not in the top-notch performance, can provide some basic recognition capability.

TABLE II. DETECTION RATE FOR TESTING IMAGE GROUP

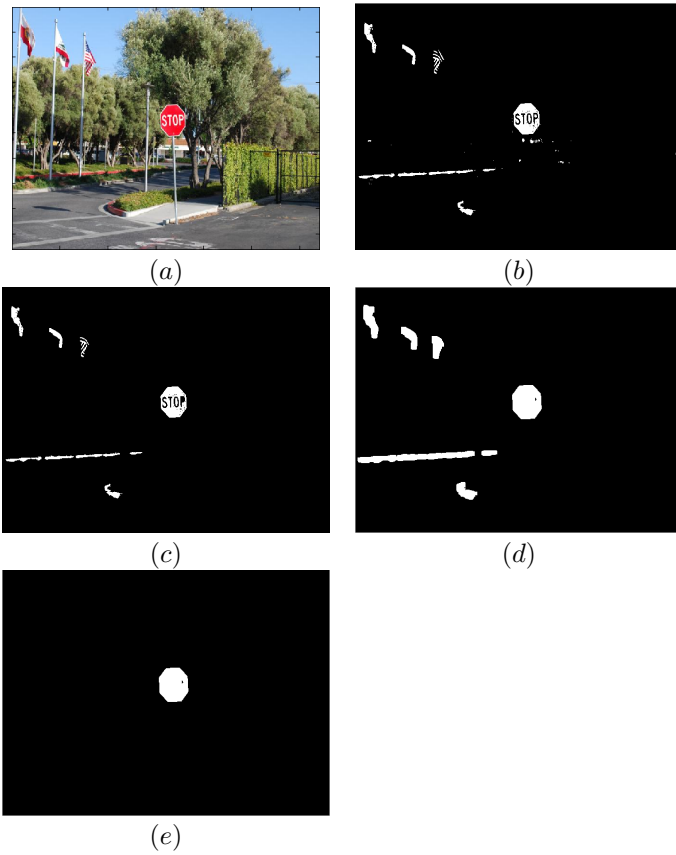|	Total	Stop Sign	Yield Sign
	20	15	5
Detected	16 (80.0%)	13 (86.7%)	3 (60.0%)
Missed	4(20.0%)	2 (13.3%)	2 (40.0%)
False Detection	2 (10.0%)	2 (13.3%)	0 (0%)

(a)

(b)

(c)

(d)

(e)

Fig. 4. (a) original image, (b) image after rgb thresholding, (c) after removing small region, (d) after dilation, (e) after removing region whose axis ratio is too large
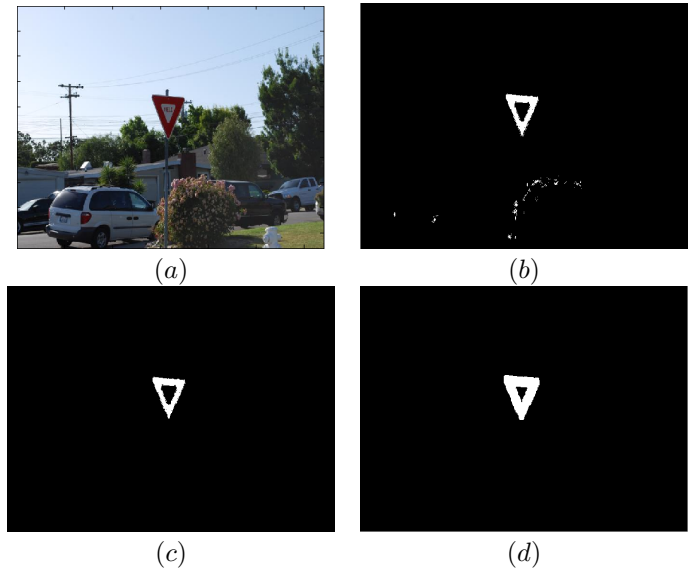

(a)

(b)

(c)

(d)

Fig. 5. (a) original image, (b) image after rgb thresholding, (c) after removing small region, (d) after dilation and removing region whose axis ratio is too large

(a)

(b)

Fig. 6. (a) stop sign is not correctly identified as it was connected with a red pole, (b) stop sign is not detected since it is too dark

C. Examples

One example to identify stop sign is shown in Figure 4. In this example, after thresholding in rgb domain, the stop sign region is segmented out, however, the other red areas such as the red strip in the flag, red road pavement and some other small red regions are also selected (Figure 4 (b)). By removing small region, several small red regions are gone, then by checking their axis ratio, all other red region is removed and only the stop sign region remains (Figure 4). Then by computing its filling ratio, we can correctly identify it as a stop sign since its filling ratio is 0.82, which is greater than the 0.7 threshold.

Another example to identify yield sign is shown in Figure 5, the procedures to segment out the red region and to remove foreign regions are similar to the first example and the yield sign is identified by its filling ratio of 0.60 (<0.7).

IV. LIMITATIONS

Overall, the algorithm works fine on both the training and testing images, however, there are some cases that the algorithm either fail to correctly single out the sign region or falsely remove the sign region. Two examples that the algorithm doesn't work well are shown in Figure 6. In one case (Figure 6 (a)), the stop sign was falsely removed because it is connected to a red pole thus the ratio of major to minor axis is too large; in the other example (Figure 6 (b)) the stop sign is not picked up simply because it is too dark. These two examples shown that there are still much room to improve the algorithm.

Also, this project initially is intended to be an android application, however, due to the time limitation, only the algorithm part is worked on and the integration to droid phone has not finished yet.

V. CONCLUSION

This project tried to develop a basic image processing algorithm to recognize stop sign and yield sign in an image. The

processing methods used in this algorithm include rgb domain thresholding, image dilation, region mapping and thresholding based on region properties, etc. This algorithm is tested on a group of 65 images and get $> 80\%$ overall correct detection rate.

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