# Color Barycenter Hexagon Model Based Road Sign Detection

Qieshi Zhang, Sei-ichiro Kamata and Jun Zhang

***Abstract*—Road sign detection is one of the major concerned topics in the field of driving safety and intelligent vehicle. In this paper, a new method using Color Barycenter Hexagon (CBH) model for road sign detection is proposed. In CBH model, full color images are calculated the color barycenter and get the barycenter region, then select the thresholds to separate the region of interest (ROI) aiming to detect the road sign. Because of the practically image have many noise, and at the existing color space can not separate the ROI ideally, the proposed CBH model can thresholding the principal color of ROI and have high robust. With simple thresholding and operations, road sign on various scene images can be detected.**

***Index Terms*—Road sign detection, Color barycenter hexagon (CBH) model and Thresholding segmentation.**

## I. Introduction

Road sign detection is one of the major research topics which contribute to safety driving assistance systems and intelligent vehicles. The aim of road sign detection is to give caution information to on-board intelligent computing equipments as a major knowledge of driving environment. As a driving assistance system, it is applied in avoiding inattentive sign departure by giving warnings to unaware drivers, offering a safe and comfort driving assistance. Passing analysis the road sign and warning the driver, it will raise the driving safety.

With the technologies development, various methods and techniques are proposed to detection road sign information. GPS system can used to warning some require sign, but it needs the wires network and the information must update regularity. Another alternative [1][2] is by using image sequences captured by digital camera for further analysis. Data obtained with digital eyes are friendly to human sight. However, computers deal with such images in a completely different way than human beings, which is the issue of computer vision.

In this study, we propose a novel method for road sign detection, which is detection the goal region by analysis the color of road scene images in CBH model. Passing CBH model-based analysis, compare with the thresholding result in other color space or models [3]-[5], the result of proposed method have obvious enhance. This paper is organized as follows: in Sec. II introduce what is CBH model and how to set up it. In Sec. III, show the process of detect the road sign in CBH model and in Sec. IV compare proposed algorithm with other color space and show the results.

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Authors are with the Graduate School of Information, Production and Systems, Waseda University, Japan (E-mail: qieshi.zhang@gmail.com, kam@waseda.jp and jjr.zhang@gmail.com).

## II. CBH Model

### A. Model Construction

Usually the image' color can be described in different color space; usually we use RGB, YCbCr, HSV and HSI color space *etc*. In practice, we choice one suitably color space and use 3 channels to reflect it, so the color information must use 3D coordinate to describe. In RGB color space, use 3D coordinate to describe the color characteristic is easy, but use 2D coordinate reflect it and find the relation of colors is not easy. To solve this problem, the color triangle of Fig. 1 is proposed, it use three vectors from origin and alternation $120^\circ$ reciprocally in one plan, every vector's rang is same as the gray value from 0 to 255. Passing this way, RGB values can be reflected in 2D space. For describe this, we choice polar coordinate system and the formulas describe it:

$$\begin{cases} R: r(\varphi_R) = r_R, \ (\varphi_R = 90^\circ \ and \ 0 \le r_R \le 255) \\ G: r(\varphi_G) = r_{G,} \ (\varphi_G = 210^\circ \ and \ 0 \le r_G \le 255) \\ B: r(\varphi_B) = r_B, \ (\varphi_B = 330^\circ \ and \ 0 \le r_B \le 255) \end{cases} \quad (1)$$

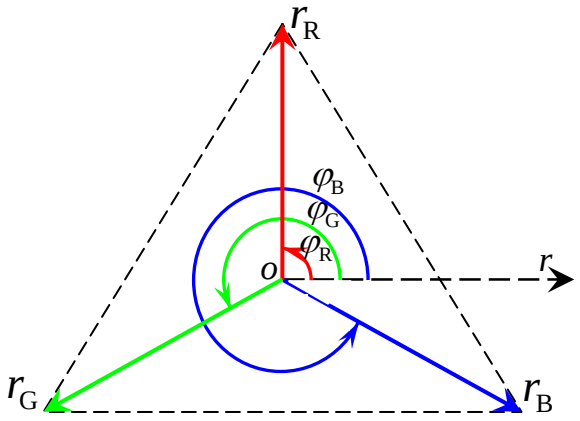



Fig.1 Color Triangle

Connect the three peak of RGB vectors, it can compose a triangle, observing the triangle of Fig. 1, we find that when only change the values of RGB respectively, it can create different shape's triangle and color. The barycenter's position of every triangle can be reflected the characteristic of correspond color. Based on those analyses, it can be find that the aggregate of all barycenter show as hexagon, so the model of Fig. 2 is created. In this color barycenter model, passing segmentation the region of barycenters, the RGB color space's color can be clustering to 7 regions: RGB (Red, Green and Blue), CMY (Cyan, Magenta and Yellow) and W (luminance) regions. In practice application, the proposed model can clustering the image to 2~7 color regions.

To use this method, it needs 7 thresholds to calculate the threshold carves and then use those carves to clustering. The

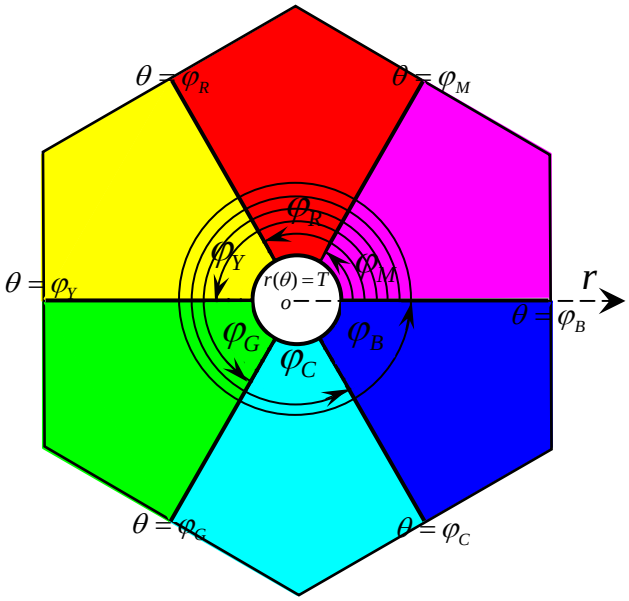



Fig. 2 Color Barycenter Hexagon Model

following section will introduce the thresholds' range and how to get them.

### B. Threshold Selection

Section A introduces how to create the CBH model and the strongpoint; this section will introduce how to get the thresholds and how to use the model.

From Fig. 2 we can see it divided 7 parts, the center part of this model is a circular region, if the RGB values are close, no matter dark or light; it has little color information and only reflects the luminance. So the barycenters of those colors' triangle will in this circular region. Usually those regions are not the goal region and belong to noise, so let $T$ as the threshold, the curve's function is:

$$r(\theta) = T,\ (0 \le T \le 85) \tag{2}$$

If the color has weak color information it will in this region, so threshold $T$ cans thresholding the none-color (weak color) region. Around this circular region it has 6 color blocks can reflect 6 clusters. The follows formulas show the 6 regions:

$$\begin{cases} M: r(\theta) = r_M,\ (\varphi_B \le \theta \le \varphi_M, T < r_M) \\ R: r(\theta) = r_R,\ (\varphi_M \le \theta \le \varphi_R, T < r_R) \\ Y: r(\theta) = r_Y,\ (\varphi_R \le \theta \le \varphi_Y, T < r_Y) \\ G: r(\theta) = r_G,\ (\varphi_Y \le \theta \le \varphi_G, T < r_G) \\ C: r(\theta) = r_C,\ (\varphi_G \le \theta \le \varphi_C, T < r_C) \\ B: r(\theta) = r_B,\ (\varphi_C \le \theta \le \varphi_B, T < r_B) \end{cases} \tag{3}$$

in formula (2) and (3), $T$, $\varphi_M$, $\varphi_R$, $\varphi_Y$, $\varphi_G$, $\varphi_C$ and $\varphi_B$ are the thresholds, and the initial value of them is 5, $60^\circ$, $120^\circ$, $180^\circ$, $240^\circ$, $300^\circ$ and $360^\circ$.

## III. Road Sign Detection Based on CBH Model

### A. System Architecture

A compact overview of the proposed system is show in Fig. 3. The system is carrying out ordinary image analysis; road scene image sequence is captured from camera mounted on host vehicle, having similar perspective of the driver. Every frame is in RGB color space and calculates the color barycenter. After this, use the thresholds with CBH model to distill the goal region with red and blue information. A vertical scan line shown as Fig. 4 is initialized on the 426th line, which is to be left one-third of the width from the right of the image (the image size is 640×480). Because in experiment Country the car is right drive (Japan), so the one-third scene of right is no need for detection goal region and can reduce one-third calculate time. Then noise included goal region can be got, to denoise needless part with open/close operation and connected component labeling (CCL) can be get the final goal region.

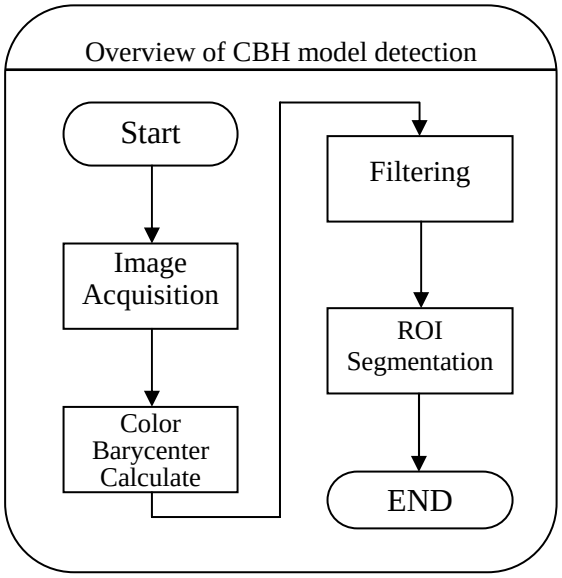



Fig. 3 System Overview

### B. Color Barycenter Calculate in CBH Model

Based on those threshold curves proposed, the key point is how to get the thresholds. For different images and goal objects, the thresholds are different; this paper use CBH model to detection the road sign at complex surroundings. So it needs five thresholds for detection red and blue region (all the caution sign's boundary is red cirque and usually use blue shading or character to describe the direction), then do further processes.

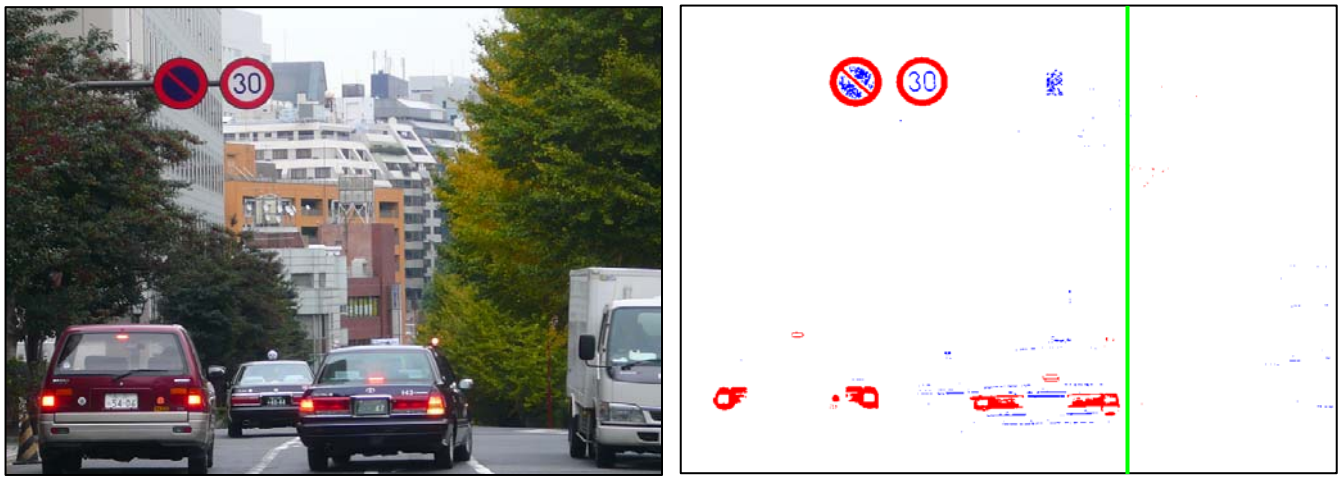
Passing largely experiments and analysis, let:

$\varphi_B = 360^\circ$, $\varphi_M = 70^\circ$, $\varphi_R = 110^\circ$, $\varphi_C = 300^\circ$ and $T$=10.

If the barycenter of color triangle in the red region as Fig. 2 show, let the RGB values as (255, 0, 0), in the blue region set to (0, 0, 255) and other regions set to (255, 255, 255,). After this, the primary goal image can be got as Fig. 4(b).

### C. Filtering

Observing the Fig. 4(b) it can be found that have many noise, so use open/close operation to denoise the red and blue region respectively at first. Then by means of CCL of red color region to filtering other noise, pixels connecting with one another are encoded to components along with labeling. Instead of interpreting pixel by pixel, only several remaining components on the image are to be observed. Furthermore, regarding the characteristics of road sign of roundness boundary with red color, it is much easier to determine if a component is valuable to be analyzed. The boundary of road sign have distinct characteristic of roundness and width ratio,



(a) Original Image (b) CBH Model Thresholding Result

Fig. 4 Thresholding of Sample Image

using this as constraint for filtering, final result can be got.

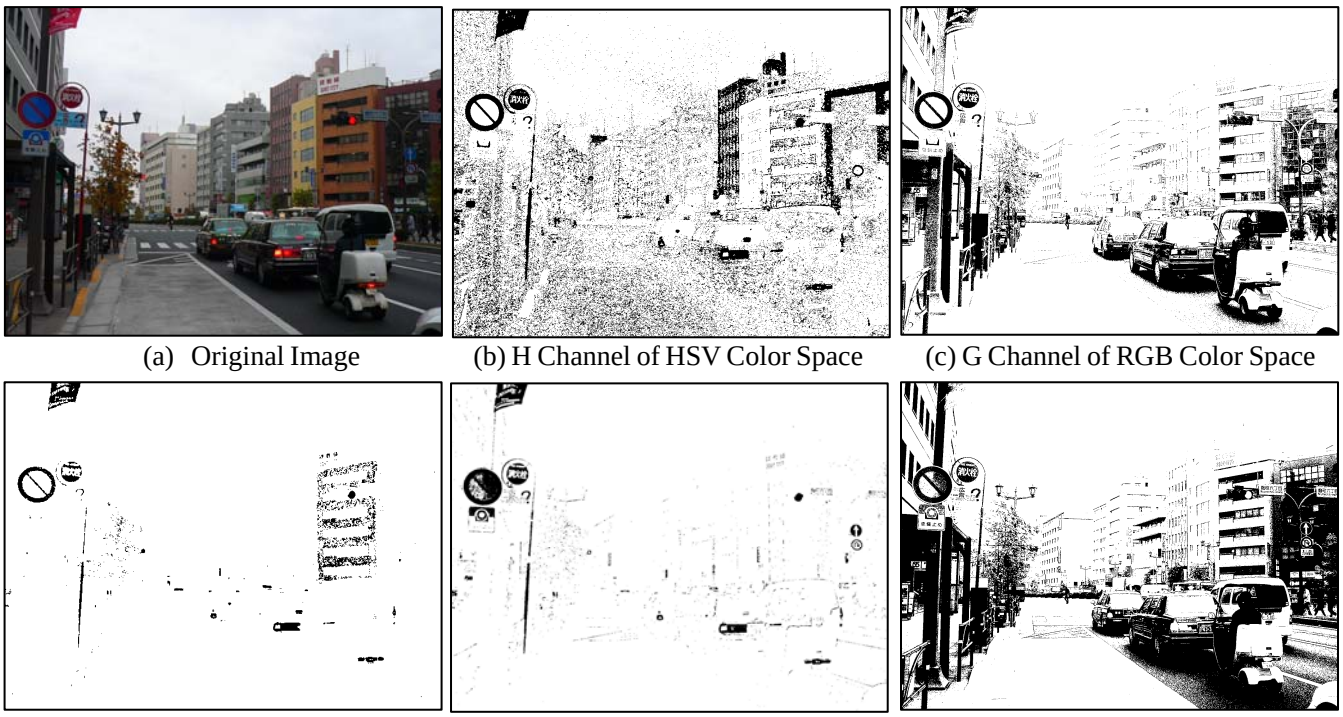
### *D. ROI Segmentation*

Passing the stage above, the idea goal region can be got. After this, let the detected region smoothing and as mask, then use the mask replace the corresponding region of original image with red, blue and white. So that the road sign can be show as brightly color and show warning by system.

## IV. Result and Analyze

The proposed CBH model can be used to thresholding and can get good effect for detection road sign. To use the CBH model it need calculate the color barycenters in the coordinate and get the right thresholds to calculate the threshold curves. Passing those processes, the thresholding segmentation result can be got.

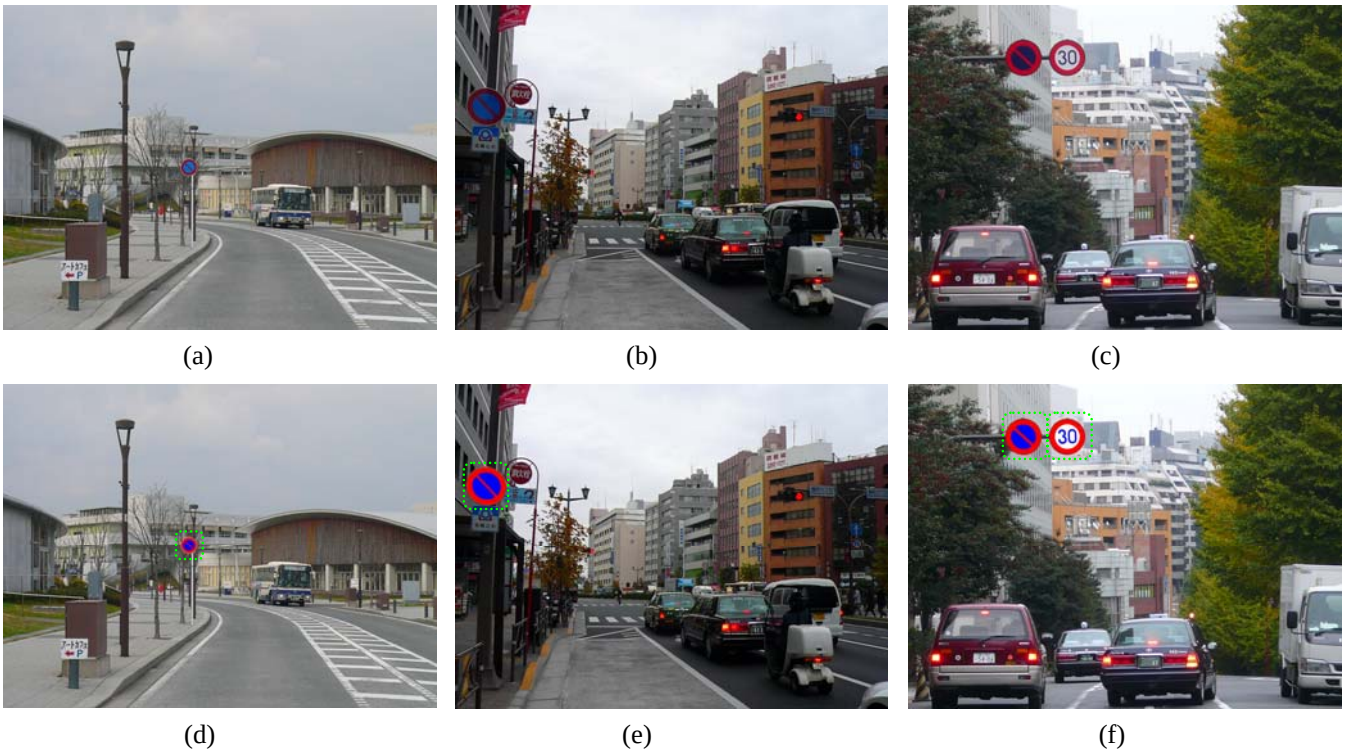
Fig. 5 shows the segmentation result with the proposed method and other four color space. If the background is simple, other color space may be able to get good effect; but at the complex situation, there can not get good effect. Because existing color space transforms method is passing calculate the values of RGB and get a new color channel, so it can not reflect the original color characteristic some times. For example, we want distill red region, but Fig. 5(b)(c)(f) not only detect the red region's sign and some part of building, but also detect the black region's car and much other regions. So aiming those characteristic of image, those three color space is not good choice. Fig. 5(e) use CMKY color space, to reflect the goal region magenta channel is the best choice, but this channel can not distinguish red and blue region, so it is not good choice for detection the goal region. The proposed CBH model use red information to detect the goal region and use blue information to judgment the caution content of road sign. Because of the proposed method is multi-thresholding method, so it can be distinguish the image into red and blue region clearly as Fig. 5(d) for further recognize. Fig. 6 shows the result with different conditions.



(a) Original Image (b) H Channel of HSV Color Space (c) G Channel of RGB Color Space

(d) Proposed CBH Model (e) M Channel of CMKY Color Space (f) L Channel of Lab Color Space

Fig. 5 Compare with the Thresholding Result in Different Color Space




(a) (b) (c)

(d) (e) (f)

(a)(b)(c) are the Original Images and (d)(e)(f) are Result Images

Fig. 6 Experiment Result Images

## V. Conclusion and Future Work

In this study, a new model for road sign detection scheme is proposed. The advantages of CBH model is: it can distinguish the color of image into seven parts, and aim different requirement of images, choice different value and number of thresholds to describe image and can get ideal result. The scheme indeed has better effect compared with CMYK, RGB, HSV and Lab color space. In CBH model, simple thresholding with threshold curves can avoid the influences of brightness and darkness region of image effectively, which usually influence the result of threshold segmentation. The proposed method achieves the goal of road sign detection for either surroundings with satisfactory results. The proposed method can get good result passing analysis the color's excursion direction, and ignore the influence of the size, distance or surroundings.

The future work is finding a way to calculate the thresholds automatically, so can detection the goals region automatic.

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