Extraction of Figures and Characters with the Aid of Color Discrimination

Y. Sakai*, M. Kitazawa*, and Y. Kuo**

*Dept. of Mechanical Engineering Yamaguchi University, Ube, Yamaguchi 755, JAPAN
FAX:+81-836-35-9411
**Graduate School, Yamaguchi University, Ube, Yamaguchi 755, JAPAN
E-mail;kaku@ccti.cct.yamaguchi-u.ac.jp

1. INTRODUCTION

The present paper deals with extraction of figures and characters from their background using the knowledge of color. At each pixel of the image on the CRT sent from a video camera, RGB values are transformed into the values in another color system, HSI, where "H" denotes hue;"S" denotes saturation;"I" denotes intensity. Representing color in HSI color space is advantageous, since a human feels color mainly in hue with the aid of brightness and purity. Comparing HSI data thus obtained with the masked original image detects noise-free edges included in the orginal image. Then setting a set of HSI thresholds and changing it identifies the portion of image of the same color. This color information is used in recongnizing characters and figures as an auxiliary system of a hierachical figure categorization method for characters and figures recognition.

2. PROCESSING COLOR INFORMATION

2.1 Color Space of Computer Screen

C.I.E. (Commission Internationale de L´Eclairage) defined [1] CRT colors are rather restricted compared with those of human visual system as in Fig.1 which shows the color triangle, the range of colors representable on CRT, as part of all the visual colors.

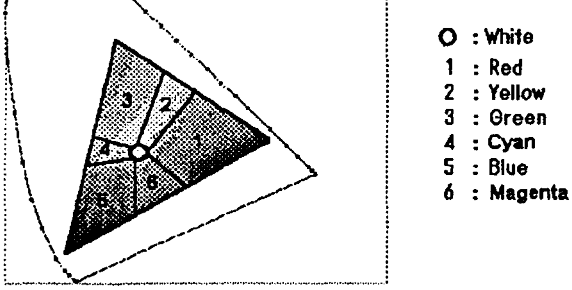

Fig. 1 Color domain of computer display in CIE chromatic diagram

2.2 Preprocessing

Preprocessing can be largely broken down into image pressing, noise elimination, and contour extraction. Number of pixels on CRT is 640x320, but by image compressing, the inputted image is compressed to 1/4 of the number of pixels of the original image. Gaussian masking,

$$G(r,\sigma) = \frac{1}{2\pi\sigma^2 e^{\frac{r^2}{2\sigma^2}}} \quad (1)$$

is applied to smooth the image data to obtain a better situation in discriminating image contaminated by noise. In Equation(1), r, and σ denote distance and variance, respectively. In dealing with "contour" extraction, Prewitt mask is employed, and a first order differential is employed for "boundary" extraction. Here in this paper, "contour," and "boundary" are defined as follows:

(1)Contour consists of edges included in the original image.

(2)Boundary means part of contour which is formed by the pixels satisfying a given color threshold level in HSI system.

2.3 Conversion of RGB system to HSI System

As already mentioned, RGB values are transformed into HSI values. Equations for the transformation are:

$$H = \begin{cases} \dfrac{(G-B)}{R-\mathrm{Min}(R,G,B)} \cdot 60^\circ & \text{if } R \text{ is max} \\ \left[\dfrac{(B-R)}{G-\mathrm{Min}(R,G,B)}+\dfrac{1}{3}\right]\cdot 60^\circ & \text{if } G \text{ is max} \\ \left[\dfrac{(R-G)}{B-\mathrm{Min}(R,G,B)}+\dfrac{2}{3}\right]\cdot 60^\circ & \text{if } B \text{ is max} \end{cases} \quad (2) \quad -60^\circ \le H \le 300^\circ$$

$$S = \frac{\mathrm{Max}(R,G,B)-\mathrm{Min}(R,G,B)}{\mathrm{Max}(R,G,B)} \quad (3) \quad 0 \le S \le 1$$

$$I = \mathrm{Max}(R,G,B) \quad (4) \quad 0 \le I \le 255$$

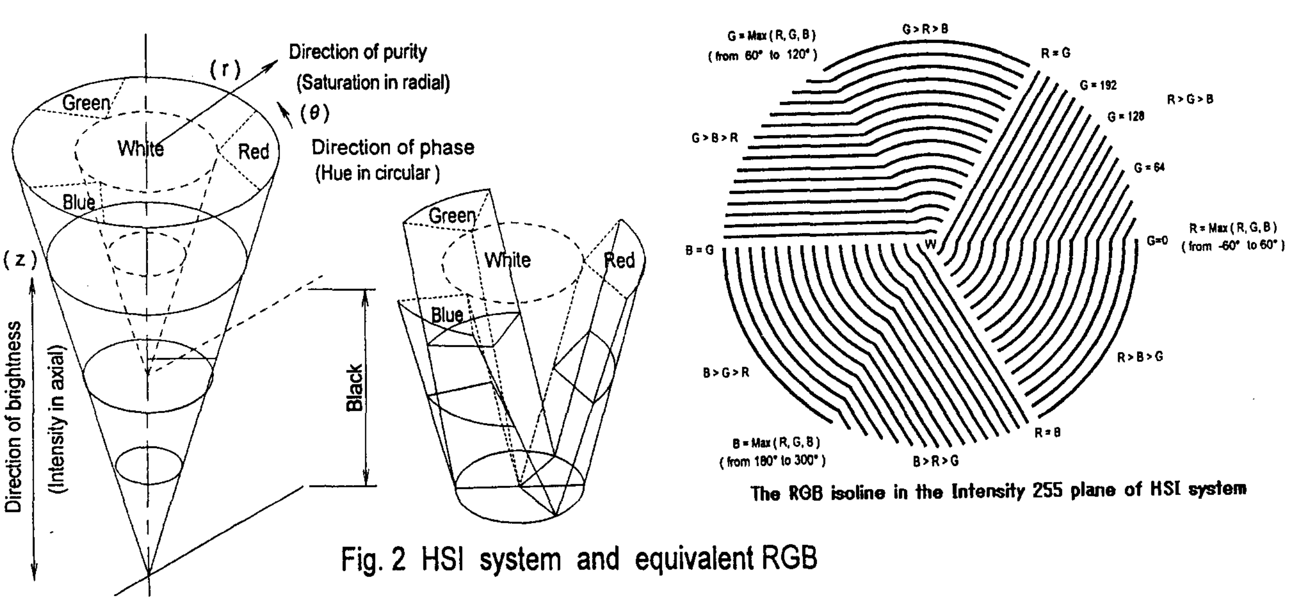

Fig. 2 HSI system and equivalent RGB

Fig. 2 shows the HSI cone together with RGB isolines. As indicated in Fig. 2, hue H corresponds to an angle measured in counterclockwise, saturation S is measured in radius, and intensity I, along the vertical axis z as the gray scale. The center in the top surface of the HSI cone denotes the color white, and with increasing the radius, color increases purity.

2. 4 Postprocessing

A certain set of threshold values determined for H, S, and I discriminates color. Application of smoothing reduces noise successfully. A detailed discussion will be made with respect to the experimental results.

2. 5 Categorization

Figures thus obtained are linearized by a hierarchical categorization method[3], and classified. The method utilizes instances experienced in separating general figures and characters. [4] Fig. 3 shows the flowchart of the whole system.

3. ALGORITHM OF PROCESSING AND EXPERIMENT

3. 1 Material for Image Processing

In the present experiment, characters are painted red on the white wall of a can which has black lid with a white, round label on it. The background is blue colored.

3. 2 Hardware Description

The experimental apparatus mainly consists of a video camera and a personal computer with an image processing board installed. Video camera here is a commercial camcorder. By the image processing board with a frame buffer, over 10 million colors are

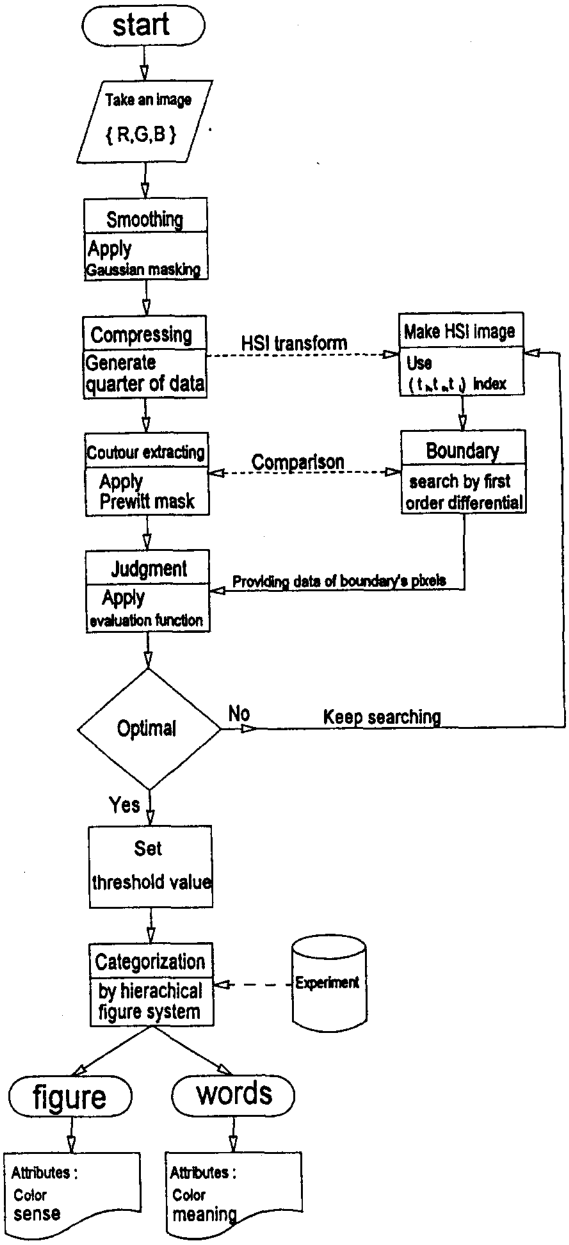

FIG 3. Flow chart of the present system

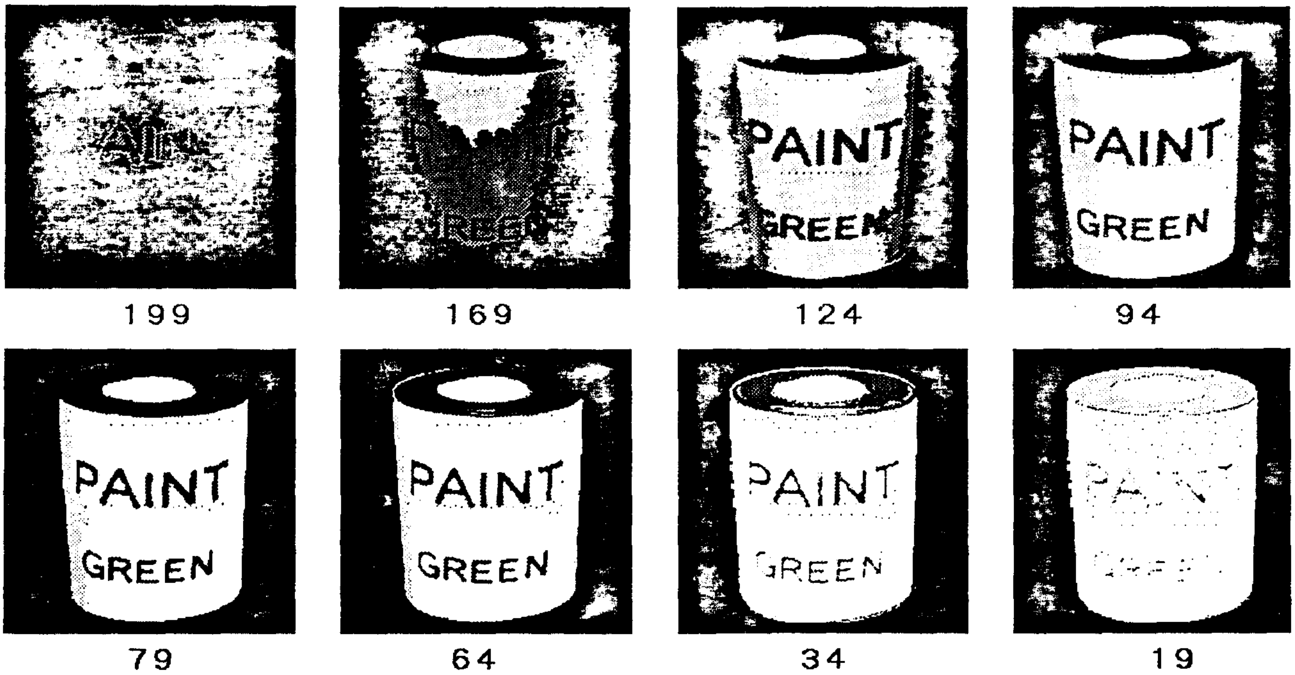

Fig 4. The images under given theshold values

available, RGB values being taking on value 0 to 255.

3. 3 Contour and Boundary Matching

As in Fig. 3, an original image is processed in two ways; contour and boundary processings, in order to identify characters and figures included in the original image, as meaningful shapes. The original figure includes noise pixels, and the boundary processing is for eliminating noise and for extracting figures and characters of a particular single hue by matching with the original image. For doing this, the following evaluation function is used:

$$E = \sum_{i=1}^{320} \sum_{j=1}^{200} \{I(i,j) \cap I'(i,j)\} \qquad (5)$$

where I(i, j) takes on values 1 and 0 corresponding to the condition of the pixel (i, j); i.e., 1 if (i, j) is an element of contour, and 0 if otherwise; I'(i, j) is given 1 or 0 in a similar manner; i.e., 1 if the pixel (i, j) is an element of the boundary, and 0 if otherwise. Determining a threshold value for intensity t_i to obtain a boundary also determines thecorresponding threshold values for hue t_h and saturation t_s:

$$t_h = (1-t_s) * 60^\circ \qquad (6)$$

$$t_s = t_i/I \qquad (7)$$

The boundary thus obtained is compared with the contour by applying the evaluation function(5). The set of threshold values (t_h, t_s, t_i) which maximizes evaluation function of E is the optimal threshold level.

3. 4 Experimental Result

Fig. 4 shows the change in boundary with threshold level. Numerical figure under each image shows the t_h value applied. The optimal value of t_h was 94. Thus the edges included in the original image are detected, eliminating almost noise. Then further processing is necessary in order to identify a portion, a character or a figure, of a particular color as in Fig. 5. In doing this, color must be identified and differentiated from other portions of the image. To pick up only the pixels of the same color, cutting off pixels of other colors must be made. As in Fig. 5, each of H, S, and I distributes over the whole range, but it concentrates in a particular restricted range in this case. Experiment showed that it is optimal for filtering unnecessary colors to take the range of ± 40% of the whole range around the average. In the case of the present image, hue has two isolated peaks. But in general, hue may also be rather continuously distributed. The present idea can also be applicable by scanning a cutting off filter over the whole range of hue. Fig. 5b shows some outcomes of applying the above filtering which shows its effectiveness.

4. CONCLUSION

The following conclusions are obtained:

(1) HSI system is preferable than RGB system in the sense that it is easy to apply.
(2) Color is informative in discriminating characters and figures, and the present idea is effective as an auxiliary means for hierarchical categorization system already developed by the authors.

5. REFERENCES

[1] R.H.Wardman, "An Update on Numerical Problems in Colour Physics," Rev.Prog. Coloration, Vol.24, pp.55-63, 1995.
[2] David F.Rogers, " Procedural Elements for Computer Graphics," McGraw-Hill, pp.480-500, 1985.
[3] Y.Sakai, M.Kitazawa, and T.Murahashi, "A Figure Categorization Structure for Image and Conceptualization," Proc. of '93KACC, Seoul, Korea, pp.265-270, 1993.
[4] Y.Sakai, and M.Kitazawa, "PC Networked Parallel Processing System for Figures and Letters," ibid., pp.277-282, 1993.

Fig 5b. The postprocessing effect

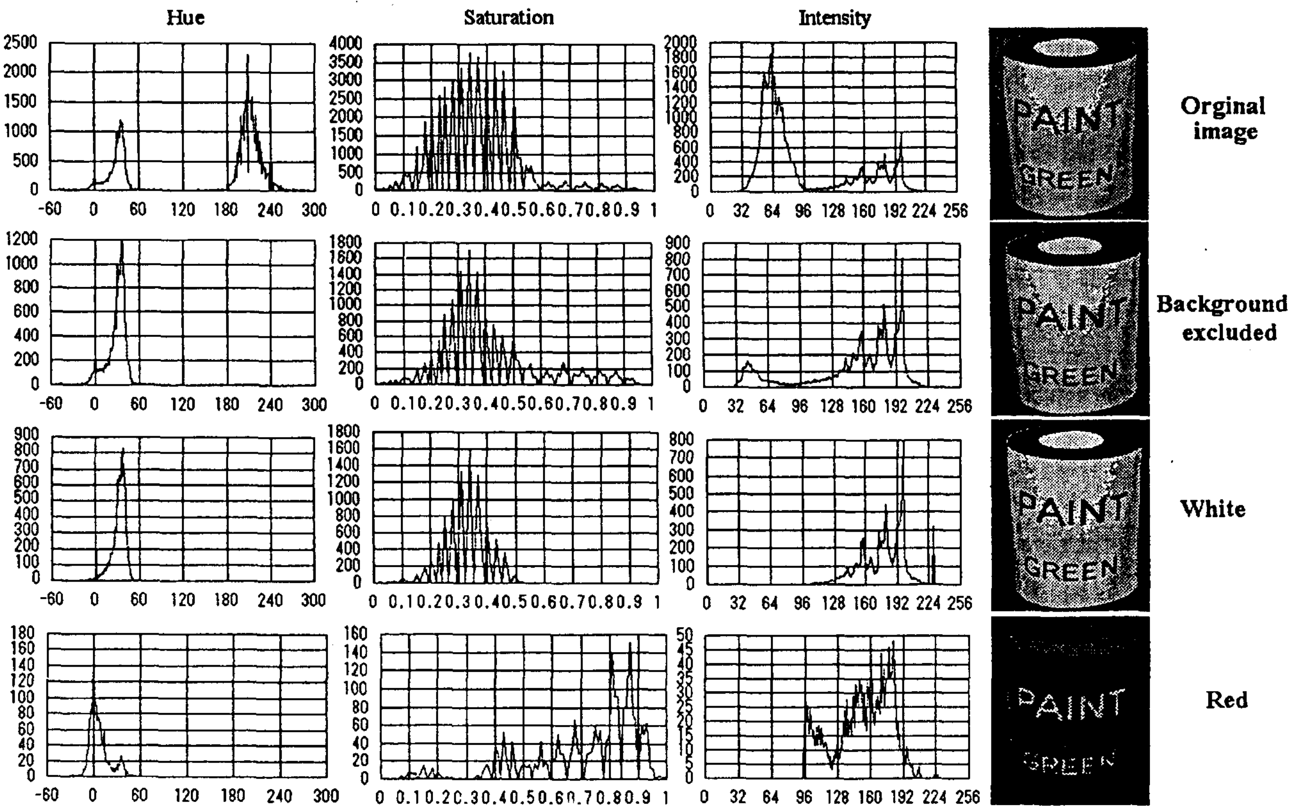

Fig 5. The distribution of HSI value in each images