Region Segmentation of the Color Images for Recognition Based on the Spatial Characteristic and Histogram

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ABSTRACT

In this paper, to segment the regions of the color image for recognition and to solve the problem of noise, spatial characteristics of image are proposed. Also to reduce the number of colors, histogram techniques are used. The results of the proposed region segmentation algorithm are compared with the results of the clustering technique and shows that the proposed algorithm makes much better region segmentation of the color image.

1. INTRODUCTION

To recognize color printings, accurate region segmentation should be done first. No good region segmentation deteriorate cognition rating in the image recognition. So region segmentation takes very important part in the object recognition of image.

Because of color printing techniques, colors of the inside regions of displayed color printings are different from those of their boundaries. Because of such properties of the color printings, unreasonable region segmentation might be done and they make color image recognition difficult. Generally, people utilize histogram scheme or clustering scheme[Pal93] for the purpose of color printing recognition. But because of using the characteristic of probability or statistic of image, these techniques are sensitive to noise and don't solve noise problem in essential. Therefore region segmentation using those techniques are not proper for the purpose of color printing recognition.

To solve a noise problem of region boundary and to make reasonable region segmentation, we propose a technique using spatial characteristic and histogram of color image. We first do the processes, such as edge detection, binary process, and thinning, to adopt these spatial characteristic of color image in resolving the noise. Also we propose a technique to reduce the number of colors as we want to separate by applying histogram scheme on the hue component of color images.

2. REGION SEGMENTATION USING SPATIAL CHARACTERISTIC

2.1 boundary detection

Color map has spatial characteristics and the color difference between pixels is very small in the internal part of the region but in the boundary part of the region the difference is relatively large. We utilize these spatial characteristics of color image to solve the noise problem.

To separate regions of image, we first apply Sobel's edge detection[Pit93] to original image $C(x,y)$ then binary process to result image $G(x,y)$ and get $B(x,y)$. The result of binary process shows that the pixels in the internal part of region is 0(white) and the pixels of region boundary is 1(black). Performing binary process, thresholding value must be selected for region not to connect each other. We determine it in proportion to average value of $G(x,y)$.

When the size of scanned color image is PxQ, let average of $G(x,y)$ is μ, threshold is T, linear function of μ is $f(\mu)$, and binary image is $B(x,y)$. The expression to get binary image equal to :

$$\mu = \frac{1}{P*Q}\sum_{y=1}^{Q}\sum_{x=1}^{P} G(x,y)$$

$$T = f(\mu) = a*\mu \qquad \text{......(2-1)}$$

$$B(x,y) = \begin{cases} 1, & G(x,y) \geq T \\ 0, & elsewhere \end{cases}.$$

where $1 \leq x \leq P,\ 1 \leq y \leq Q$

In the result of binary process, region boundary may have one or more pixel width. So to make its width one pixel, thinning process is performed [Che88].

2.2 region determination

To determine the color of the region, we investigate the color of white pixels(internal pixels) of the region which is surrounded by black pixels(boundary pixels). Then the color of the region is unified into one color having the most frequency. To determine the color of boundary pixels of the region, the color of each pixel is compared with the color of its adjacent regions(each region already unified and has only one color) and is replaced with the most similar color among the colors of adjacent regions.

3. COLOR GROUPING USING HISTOGRAM

3.1 peak detection

Even if above processes are done, the color image consists of several regions and each region may have similar colors. Therefore it is necessary to specify a color to recognize the color correctly. To reduce the number of colors, we apply Sezan's one-dimensional peak detection algorithm, which uses the image cumulative distribution function and the average operator of one dimensional histogram in the gray level image, to color image which is represented in the three-dimensional space. Peak detection signal r_N is defined as[Sez90] :

$$r_N(n) = C(n) - \overline{C_N(n)},\quad n = 0,1,\ldots,M-1$$

$$C(n) = \sum_{l=0}^{n} h(l) \qquad \text{.......(3-1)}$$

$$\overline{C_N(n-1)} = \sum_{k=-(N-1)/2}^{(N-1)/2} C(n-k)W_N(k)$$

$$W_N(n) = 1/N,\quad -(N-1)/2 \leq n \leq (N-1)/2$$

where $h(\cdot)$ represents the histogram function, $C(\cdot)$ represents the cumulative distribution function, $\overline{C_N}(\cdot)$ is the average of $C(\cdot)$, $W_N(\cdot)$ is the mask used in the $\overline{C_N}(\cdot)$.

To apply one-dimensional peak detection algorithm to the color image, first we convert the RGB color model to the HLS color model[Pra91] that match well to the human visual perception. Then peak detection algorithm is used to find the peaks of the histogram of the hue component of the color image.

Let N_W be the number of colors that we want to figure out. And the number can be set by the user. For a given value of N, if the number of resulting peaks N_C is less than N_W, decrease the value of N (e.g., N is replaced by $(N-1)/2-1$) until the number of resulting peaks is larger than N_W. If the number of resulting peaks is larger than N_W, decrease the number of resulting peaks by combining the successive peaks based on a closeness criterion.

3.2 peak merge

In the HLS color model, gray colors

(defined as the color of the same values of red, green, and blue components) have zero saturation and undefined hue value. Also we can find the fact that color is looked like black only if its lightness value is low whatever the hue value is. Therefore we can group colors into two sets, that is, the gray set and the color set. The gray set contains the gray colors and the colors looked like black whose hue value are less than the threshold and the color set contains the other colors. The gray set is segmented into one of four types; no color, black, white, or black and white according to the lightness. And the color set is segmented according to the number of colors $(N_C - N_g)$ by peak detection algorithm, where N_g is the number of segmented the gray.

Because the color of regions of image can be the color of maximum point of peaks, it is reasonable to combine the peaks by the distance between maximum point of successive peaks. And the combination can be done if the successive peaks satisfy the relation :

$$\min\{\text{distance}(m_k, m_{k+1}), k=1, ..., N_C\}$$

where m_k is a maximum-point of k's peak.

4. SIMULATION

We compared the results of the proposed region segmentation algorithm with the results of Uchiyama's clustering technique[Uch94]. Figures show the results of segmentation of the color image. Figure (a) is the original image and Figure (b) is the result of thinning process for the binary image after the edge detection algorithm is applied. Figure (c) is the segmented image only using the spatial characteristics. Figure (d) is the final result of the image whose colors are reduced by the histogram method for Figure (c). Figure (e) is the result of the image segmented by the clustering technique on the RGB space. Figure (e) has regions which are segmented incorrectly but Figure (d) shows a well segmented result

5. CONCLUSION

This paper proposed a region segmentation technique which is the preprocessing step required to recognize color images. Also we apply the edge detection technique to color image and solved the noise problems occurred on the boundary of regions because of color printing techniques.

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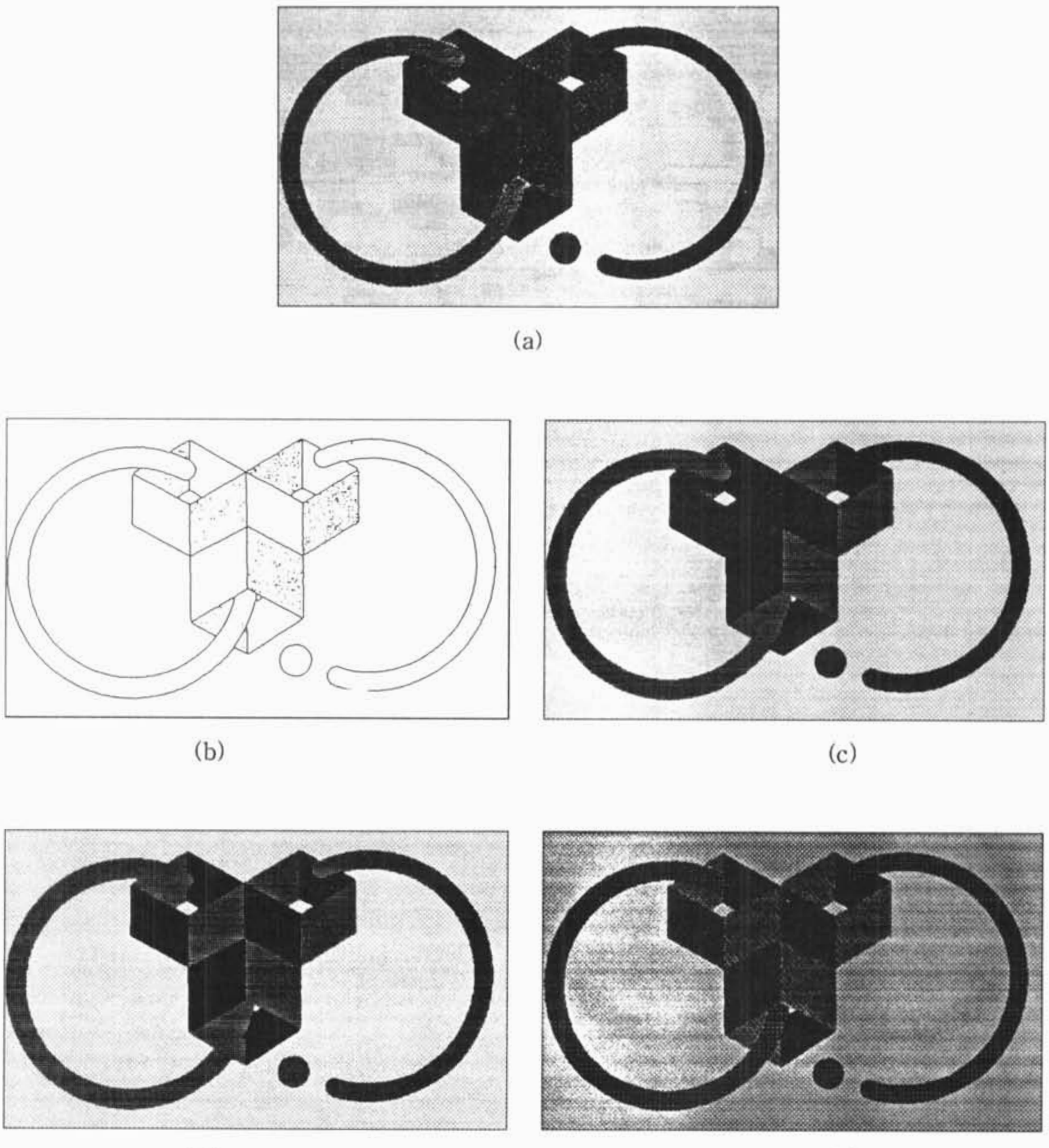

Figure: The results of segmentation of color image :
(a) original image (b) thinned image (c) region segmentation using spatial characteristic (d) region segmentation using histogram (e) region segmentation by clustering method