An Image Segmentation Method Using the Histograms and the Human Characteristics of HSI Color Space for a Scene Image

Seiji Ito
Computer and Systems Science
Osaka Prefecture University
1-1 Gakuencho Sakai-City
Osaka 599-8531 Japan
seiji@sig.cs.osakafu-u.ac.jp

Michifumi Yoshioka
Computer and Systems Science
Osaka Prefecture University
1-1 Gakuencho Sakai-City
Osaka 599-8531 Japan
yoshioka@cs.osakafu-u.ac.jp

Sigeru Omatu
Computer and Systems Science
Osaka Prefecture University
1-1 Gakuencho Sakai-City
Osaka 599-8531 Japan
omatu@cs.osakafu-u.ac.jp

Kouji Kita
Noritsu Koki Co., LTD.
579-1 Umehara, Wakayama-City
Wakayama, 640-8550, Japan
k-kita@nkc.noritsu.co.jp

Kouichi Kugo
Noritsu Koki Co., LTD.
579-1 Umehara, Wakayama-City
Wakayama, 640-8550, Japan
k-kugo@nkc.noritsu.co.jp

Abstract

An image segmentation is an important subject for an image recognition. In this paper, we propose a new image segmentation method for scene images. The proposed segmentation method classifies images into several segments without using the Euclidian distance. We calculate the histograms of the image for each component of HSI color space, and obtain three results of the image segmentation from each histogram. We consider the achromatic colors to decrease the number of regions. We compare the results of the proposed and the k-means methods for the effectiveness of the proposed method.

Keywords: Scene image, Image segmentation, HSI color space, Achromatic color

1 Introduction

An image recognition is one of the most important techniques in robotics and image retrieval. However, the image recognition technique is not complete and is in study phase. An image segmentation is a very important subject for the image recognition.

The k-means method[1] is one of the most well-known clustering methods. However, the number of clusters and the initial values must be decided in the method. The k-means application[2],[3] and the ISODATA[4],[5] have been proposed in order to overcome the problems. The Euclidian distance have been applied by the traditional methods in order to represent a difference between colors. The Euclidean distance does not always correspond to the difference between colors in human eyes. In the [7], HSI color space is divided into 9 regions by thresholds previously. Images are segmented by the 9 regions. However the thresholds differ from image to image.

We propose a new image segmentation method for scene images. The proposed method segments images without using the Euclidian distance.

2 The problems of the conventional methods

The problems of the conventional methods[1]-[6] are shown in the follows.

1. The parameters optimization
2. The Euclidian distance

At first, we discuss the parameters. In the case of the k-means method, the most important parameter is the number of clusters. It is difficult to decide the number of clusters in our study. Setting of the initial value is also one of the papameter problems. Though, [5] has overcome the parameter problems, the number of parameters has increased.

Next, we discuss the Euclidian distance. The Euclidian distance is very useful, since we can translate multi-dimensional points into one-dimension. Therefore, it is also used as the indicator of a difference between colors in the image processing. The

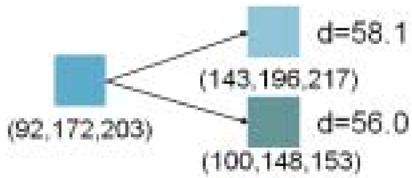


Fig. 1: An example of the Euclidian distance problem

Euclidean distance does not always correspond to a difference between colors by human eyes. For example, we give three colors whose RGB values are (92,172,203), (143,196,217) and (100,148,153) as Fig.1. The Euclidian distances between (92,172,203) and (143,196,217) and between (92,172,203) and (100,148,153) are 58.1 and 56.0, respectively. In the human visual sence, however, the distance between (92,172,203) and (143,196,217) is shoter than the distance between (92,172,203) and (100,148,153). Therefore, it is not effective that the Euclidian distance is applied to the difference of colors.

3 The proposed method

We propose the new image segmentation method to overcome the problem. The proposed method segments images without using the Euclidian distance. The process of the proposed method is as follows. At first, we transform image information from RGB to HSI (hue, saturation and intensity), since HSI color space is close to a human visual sense and the components of HSI are the high independent components. Human pays attention to not only a pixel but also pixels around it, when he sees an image. To reflect the human characteristics, the moving average method is used. We calculate the histograms of the image for each component, and obtain three results of the image segmentation from each histogram. The clustering is to decide the boundaries among the classes on the histograms. The boundary is decided by maximizing between-class variance. In the proposed method, the boundaries are decided at a valley between peaks in a waveform of a histogram. One or more boundaries are obtained by iterating the same process until a maximum value of between-class variance is less than a threshold. The final segmentation result is obtained by the AND operation from three clustering results. However, the simple AND operation may result in many regions, since the simple AND operation does not consider the achromatic colors. In our research, we obtain the final segmentation results by AND operation with the consideration of the achromatic colors, which have low intensity or low saturation values. In the former, only the result of the intensity is reflected to the final result. In the later, the results of the intensity and saturation are reflected to the final result. We describe the details of the processes in follows.

Fig. 2: An original image

3.1 The moving average method

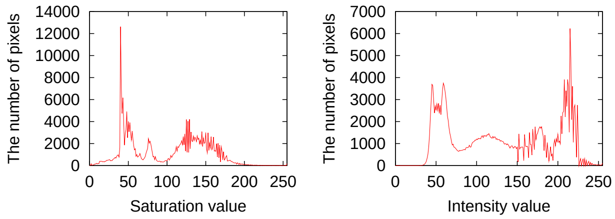
Human pays attention to not only a pixel but also pixels around it, when he sees an image. For example, when a target pixel color differs from colors of pixels around it, human understands it as a noise. To reflect the human characteristics, the moving average method is used. The moving average is the method that a value of a pixel (i,j) is converted into an average value of pixels around it. In this paper, the filter size of the method is defined as 5×5. The value of target pixel using the method is defined as $g(i,j)$, which is given by

$$g(i,j) = \sum_{k=-2}^{2} \sum_{l=-2}^{2} \frac{1}{5 \times 5} f(i+k, j+l) \quad (1)$$

where, f(i,j) is the value of target pixel in the original image. In this paper, although the method is used for the intensity and the saturation values, the method is not used for the hue. Figure 3 shows the histograms of Fig.2, and Fig.4 shows the histograms using the moving average method. From the figures, it is found that noises are removed by the moving average method.

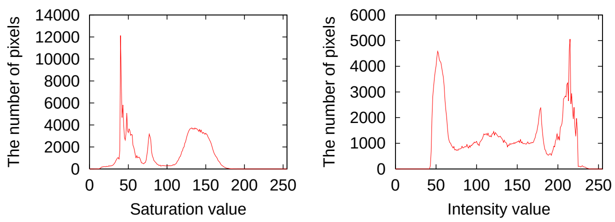
3.2 The clustering processing

The clustering method in this paper is to decide the boundaries among the classes on the histograms. A boundary is decided by maximizing between-class



(a) Saturation (b) Intensity

Fig. 3: Histograms of Fig.2



(a) Saturation (b) Intensity

Fig. 4: Histograms using the moving average method

variance. In the proposed method, the boundaries are decided at a valley between peaks in a waveform of a histogram. One or more boundaries are obtained by iterating the same process until a maximum value of between-class variance becomes less than a threshold. The between-class variance when a histogram is devided into two classes at a boundary i is given by

$$\sigma_B(i) = \omega_1(i)\omega_2(i)(M_1(i) - M_2(i))^2 \tag{2}$$

where, ω_1 and ω_2 mean the number of pixels in class 1 or 2 respectively, and M_1 and M_2 mean averages in class 1 or 2 respectively. Therefore, the boundary is given as

$$t = \arg\max_i \sigma_B(i) \tag{3}$$

The process is iterated until $\sigma_B(i)$ becomes a smaller value than a threshold.

3.3 The AND operetion

The final segmentation result is obtained by the AND operation from three clustering results. Figure 5 shows an example of the AND operation. However, the simple AND operation may result in many regions obtained, since the simple AND operation does not consider the achromatic colors. In this paper, we obtain the final segmentation results by AND operation with considering the achromatic colors. The regions of the achromatic colors are defined as the follows.

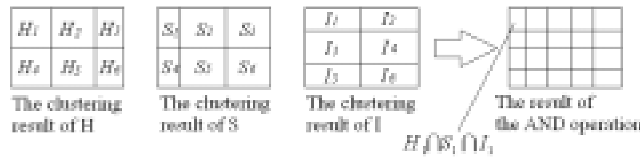


Fig. 5: An example of the AND operation

1. The region including low saturation pixels
2. The region including low intensity pixels

The reason of the (1) which is mentioned above is that the achromatic color is not vivid simply. However, the (1) does not cover all the achromatic colors. For example, the color whose RGB value is (0,0,1) does not satisfy the (1) despite being an achromatic color clearly. The calculating formula of the saturation in this paper is given by

$$S = \frac{\max(r,g,b) - \min(r,g,b)}{\max(r,g,b)} \tag{4}$$

Therefore, the saturation of the color is 1. The achromatic color condition is not only (1) but also (2).

The process of the AND operation with considering the achromatic colors is discribed in the follows. First, we check if a region satisfies (2). If so, the results of the saturation and the hue are not reflected to the final region. If not, we check if a region satisfies (1). If so, the results of the intensity and the saturation are reflected to the final region. If not, we use the all results to the final region. In this paper, the (1)'s condition is the region including even one pixel whose saturation is less than 25, and the (2)'s condition is the region including even one pixel whose intensity is less than 50.

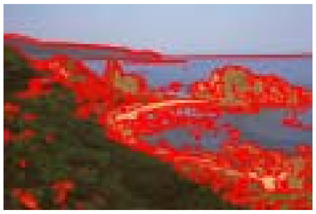
4 Computer simulation

In order to effectiveness of the proposed method, we simulate the proposed and the k-means (Method 1, Method 2) methods by several scene images. The parameters at end conditions and the number of clusters in the simulation of Fig.2 are shown in Table 1.

In the Method 1, the Euclidian distance between a center of a cluster $(\bar{H}, \bar{S}, \bar{I})$ and a point (H, S, I) is

Table 1: The end conditions of the clustering and the number of clusters

	H	S	I
Threshold	1000	490	450
The number of clusters	2	2	4



(a) The proposed method

(b) k-means (Method 1)

(c) k-means (Method 2)

Fig. 6: The image segmentation results of Fig.2

given as

$$D = \left\{ \left(\frac{1-\cos(\bar{H}-H)}{2} \right)^2 + (\bar{S}-S)^2 + (\bar{I}-I)^2 \right\}^{\frac{1}{2}} \tag{5}$$

In the Method 2, we compare the clustering method of this paper with the k-means method. The distances are given as

$$\begin{aligned} D_H &= |\bar{H}-H| \quad (\text{if} \quad D_H > \pi, \text{then} \quad D_H = 2\pi - D_H) \\ D_S &= |\bar{S}-S| \\ D_I &= |\bar{I}-I| \end{aligned} \tag{6}$$

The image segmentation results using each method are shown in Fig.6.

We compare the results of the proposed method and Method 1. The result of the proposed method is better than the result of Method 1 clearly. For example, in Method 1 the sea and the sky are the same region, and in the proposed method the sea and the sky are different regions. As the results of comparing the proposed method with Method 2, the proposed is similar to Method 2. However, the proposed method is more convenient than Method 2, since we must set the number of clusters in Method 2.

5 Conclusion

We have proposed the new image segmentation method. We have solve the problems of the parameters and the Euclidian distance using the proposed method, and have been reflected the characters of human visual sense. In order to show the effectiveness of the proposed method, we have segmented the several scene images. As the result of the simulation, We can show the proposed method.

In future work we will propose a image recognition method using the image segmentation method.

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