

# Color Image Segmentation Based on Automatic Seed Pixel Selection

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## Abstract

In this paper, we present color image segmentation based on automatic seed pixel selection. First, the input RGB color image is transformed into HSV color space. Second, the initial seeds are automatically selected based on non-edge and smoothness at pixel's neighbor as criterion. Third, the seed pixels are merged to form seed region if they are connected. Fourth, a seeded region growing method is used to segment the image based on seed regions. Finally, region-merging is used to merge similar or small regions. This method is applied to segment many natural color images, and experimental results show the effectiveness and efficiency of the method.

**Keywords-** *image segmentation; seed selection; region growing; region merging.*

## I. INTRODUCTION

Image segmentation often serves as a crucial initial step before performing high-level tasks such as object recognition and content-based image retrieval<sup>[1-2]</sup>. Image segmentation is a process of pixel classification. An image is segmented into subsets by assigning individual pixels to classes. It should be noted that there is no single standard approach to segmentation. Selection of an appropriate segmentation technique depends on the type of images and applications. The existing image segmentation techniques can be classified into the following approaches, thresholding techniques, boundary-based techniques, region-based techniques and hybrid techniques.

Thresholding is based on adjacent pixels which have some similar properties. The boundary-based method is based on the properties that pixels change abruptly in the boundary. Region-based technique makes use of the similar properties of the neighboring pixels in the same region, such as specific ranges of gray level or color. Hybrid methods tend to combine boundary detection and region growing together to achieve

better segmentation.

Seeded region growing (SRG) is one of the hybrid methods<sup>[3]</sup>. The selection of the initial seeds much influences the segmentation results. How to assign the initial seeds is the major topic in SRG. Fan et al.<sup>[4]</sup> propose a seeds selection method to assign the pixels that are centroids between adjacent edge regions to be the initial seeds. Deng et al.<sup>[5]</sup> (JSEG) and Jing et al.<sup>[6]</sup> use a smoothness measurement, J-value, H-value to determine the initial seeds, respectively. Shih et al.<sup>[7]</sup> (ASRG) use the similarity in the local region to automatically select the initial seeds.

In this paper, a method of color image segmentation by automatic seed selection and region growing is proposed in HSV color model. The non-edge and smoothness at pixel's neighbor are used as criterion to determine the initial seeds. The initial seed points are merged to form seed region if they are connected. Seeded region growing and region merging are used to segment color image.

## II. AUTOMATIC SEED SELECTION

In this paper, HSV (Hue, Saturation, and Value) color model is used, which is correspond to human color perception. After conversion from RGB to HSV, the obtained values  $h$ ,  $s$ , and  $v$  are the hue, saturation, and bright component values, and  $h \in [0, 2\pi]$ ,  $s \in [0, 1]$ ,  $v \in [0, 1]$ .

### A. Initial seeds selection

The following two criteria must be satisfied for automatic seed selection. One is no-edge, the other is smoothness. No-edge means that the pixels are not on the edge or detailed region, smoothness means that the pixels have high similarity to its neighbors.

Given a color image  $I$ , of size  $m$  by  $n$  pixels the color value at location  $(i, j)$  is  $(h(i, j), s(i, j), v(i, j))$ .

j)). Let  $N(i, j)$  denote  $3 \times 3$  neighborhood of a pixel at  $(i, j)$ . No-edge and smoothness can be defined as following statement.

1) *No-edge*

For every pixel  $(i, j)$ , let  $g(i, j)$  denote the average of hue values over  $N(i, j)$ , i.e.:

$$g(i, j) = \frac{1}{9} \sum_{N(i, j)} h(i, j) \quad (1)$$

The value of  $g(i, j)$  over  $N(i, j)$  can be viewed as a measure of edge. Calculate the average and the standard deviation of the  $g$ -values in the  $G$ -image; denote them by  $t_g$  and  $\sigma_g$  respectively.

The threshold is defined as following statement:

$$T_g = \begin{cases} t_g - 0.5\sigma_g, & (t_g - 0.5\sigma_g) > 0 \\ t_g, & \text{otherwise} \end{cases} \quad (2)$$

An initial seed pixel must have the  $g$ -value which is less than threshold  $T_g$ .

2) *Smoothness*

For a pixel at location  $(i, j)$ , the color value at location  $(i, j)$  is  $(h(i, j), s(i, j), v(i, j))$ . Let denote  $(\bar{h}(i, j), \bar{s}(i, j), \bar{v}(i, j))$  as the average value of color value over  $N(i, j)$ . We compute the distance between  $(h(i, j), s(i, j), v(i, j))$  and  $(\bar{h}(i, j), \bar{s}(i, j), \bar{v}(i, j))$  as following equation.

$$d(i, j) = \sqrt{(v - \bar{v})^2 + (s \cosh - \bar{s} \cosh)^2 + (s \sinh - \bar{s} \sinh)^2} \quad (3)$$

The value of  $d(i, j)$  over  $N(i, j)$  can be viewed as a measure of smoothness. Calculate the average and the standard deviation of the  $d$ -values in the  $D$ -image; denote them by  $t_d$  and  $\sigma_d$  respectively.

The threshold is defined as following statement:

$$T_d = \begin{cases} t_d - 0.1\sigma_d, & (t_d - 0.1\sigma_d) > 0 \\ t_d, & \text{otherwise} \end{cases} \quad (4)$$

An initial seed pixel must have the  $d$ -value which is less than threshold  $T_d$ .

A pixel is classified as a seed pixel if it satisfies the above two conditions. Fig.1 gives an image and the detected seeds which are shown in red color.

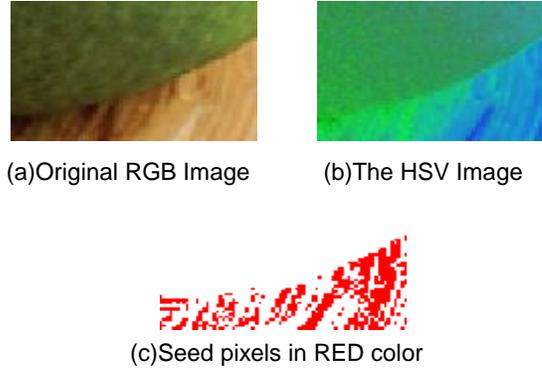


Figure 1: Original color image, HSV image and detected seeds.

B. *Seed Region*

There are many initial seed pixels. If two initial seed pixels are 4-adjacency, they can be merged to a seed region. Classify seed pixels to seed regions according to 4-adjacency.

III. SEEDED REGION GROWING AND REGION MERGING

A. *Seeded region growing*

After getting seed regions, every seed region have been labeled with different labels. The mean color value of the seed region can be computed, and it is denoted as color value of the seed region. Seeded region growing can be performed according to 4-adjacency and the color value of seed region. The seeded region growing algorithm is described as following steps:

- (1) For neighbors of all seed regions, if they aren't labeled, record them in a list  $L$  in increasing order of distance.
- (2) While  $L$  is not empty, remove a pixel  $p$  and check its 4-neighbors, if all labeled neighbors of  $p$  have a same label, set  $p$  to this label. If the labeled neighbors of  $p$  have different labels, calculate the distances between  $p$  and all neighboring regions and classify  $p$  to the nearest region. If the distances between  $p$  and two neighboring regions are equal, then classify  $p$  to the larger region. Then update the mean of this region, and add 4-neighbors of  $p$ , which are neither classified yet nor in  $L$ , to  $L$ .
- (3) Repeat (2) until  $L$  is empty.

Note that in step (2), the distance between

the pixel  $p$  and its adjacent region is calculated by equation (3), where  $(h, s, v)$  is the color value of  $p$ ,  $(\bar{h}, \bar{s}, \bar{v})$  is mean of the color values in that region.

It is possible that several seeds are generated to split a region into several small ones. To overcome the over-segmentation problem, we apply region merging. Two criteria are used: one is the similarity of color and the other is the size of region.

### B. Region merging based on color similarity

The distance between two regions  $k, l$  is calculated by

$$D(k,l) = \frac{1}{\sqrt{(\bar{v}_k - \bar{v}_l)^2 + (\bar{s}_k \cosh \bar{h}_k - \bar{s}_l \cosh \bar{h}_l)^2 + (\bar{h}_k \sinh \bar{h}_k - \bar{h}_l \sinh \bar{h}_l)^2}} \quad (5)$$

Where  $(\bar{h}_k, \bar{s}_k, \bar{v}_k)$ ,  $(\bar{h}_l, \bar{s}_l, \bar{v}_l)$  are mean values of region  $k, l$  respectively.

The less the distance between two regions are, the more similar between two regions are. If the distance between two neighboring regions is less than a threshold value, we merge the two regions, and recompute the mean of the new region and the distance between the new region and its neighboring regions. Repeat the process until no region has the distance less than the threshold. Based on our experiments, 0.146 is set as the threshold.

### C. Region merging based on size

The size of region means the number of pixels in the region. If the size of a region is smaller than a threshold, the region is merged into its neighboring region with the smallest color difference. This procedure is repeated until no region has size less than the threshold. Based on our experiments, 1/100 of the total number of pixels in an image is set as the threshold.

Fig.2 gives the process of seeded region growing and region merging. (a) Original color image, (b) seeded region growing result, (c) the result of merging adjacent regions based on color similarity, (d) the result of merging small regions based on size.



(a) Original RGB Image



(b) Seeded region growing result



(c) Merged image based on color similarity



(d) Merged image based on size

Figure 2: The process of seeded region growing and region merging

## IV. EXPERIMENTAL RESULTS

The algorithm has been implemented in Matlab 7.0.1 in Windows XP. We have tested many natural color images which are 24-bit JPEG and Bitmap color images. We can obtain reasonably good results. Figure 2 shows our segmented results.

## V. CONCLUSION

A method of color image segmentation based on automatic seed pixel selection is proposed. The non-edge and smoothness at pixel's neighbor are used as criterion to determine automatically which ones are seed points. A seeded region growing method is used to segment the image based on seed regions. Finally, region merging method based on color similarity and size is used to obtain satisfactory segmentation results. Experimental results show that our algorithm can get good segmentation results.

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