# A Texture and Color Based Method for Color Image Segmentation

*Yin Haiming[1,2], Lou Xiaoyan[1], Qiu Mangxian[1], Yue Guangxue[1,2]*
*1.Computer Application Research Lab of Jiaxing Univ, Zhejiang Jiaxing, 314001*
*2. State Key Lab for Novel Software Technology, Nanjing Univ, Jiangsu Nanjing, 310092*
*haimingyin_hawk@hotmail.com*

## Abstract

*A new method of fully automatic color image segmentation is proposed in this paper. First, colors in the image are quantized to several representing classes in the HSI color space. And then the uniform surface uncertainty of every pixel is computed which will be used to generate the fuzzy image. Then seeds are detected and region growing is implemented to form the initial regions. A region merging algorithm base on the color information is used to merge the over-segmented regions. Utilized in natural image and texture image processing, the new method has got a good performance.*

## 1. Introduction

Image segmentation is the prime work for any image analysis. A proper and effective segmentation can provide much useful information for image searching, object analysis and so make the comprehensive processing possible[1,2]. Image segmentation has been studied for decades, but there is no one method which can deal with all kinds of images. All these methods can cursorily be divided into three kinds: color quantization based, edge based and region growing based.

The color quantization based method always use K-means[3] or C-means[4] quantization algorithms to divide the image pixels, and then get the regions according to the connectivity feature in the same kind of pixels. These algorithms sometimes generate unreasonable segmentation results.

Edge based segmentation methods use the image edges of regions to segment the image. There are some edge detect operators such as Sobel, Laplacian and Canny[5] which will be used to extract edges. Since noises wildly exist, the edges detected are always not consecutive, we can use some edge closing technique to deal with this circumstance, but rarely get the exact edges of regions.

Region growing based segmentation methods merge the connective regions according to the similarity after finding the seeds. The linchpin of this method is to establish the rules of stopping merging. One representative algorithm is JSEG[6]. The disadvantage of region growing based methods is restrict of the sequence, the segmentation quality is limited by the seeds' selection and the order in which the regions grow also affects the result in a big way. Comparing to the other algorithms region growing based algorithms can simultaneously take consider into the color distribution and the space zone feature, to some complex images, specially texture image's processing, usually can obtain better effects than the formers.

The researches[7,8] indicate that hybrid algorithms are easier to get high quality of segmentation, it means considering the edge and the color information simultaneously or add the color information into the region growing algorithms usually can get better results.

This paper presents a new color image segmentation method which blends the region and color information. The algorithm quantizes the colors and uses the uniform surface uncertainty to generate seeds, then employs color similarity to grow the seeds and merge the regions.

## 2. Color quantization

There are many methods for color quantization in many kinds of color spaces[2,9,10]. Because on HSI color spaces, human vision is symmetrical, and it's wildly used in color image segmentation. In this paper we choose the HSI space as our work space for color quantization. In HSI space, *H* represents hue; *S*

978-0-7695-3381-0/08 $25.00 © 2008 IEEE
DOI 10.1109/CW.2008.111

represents saturation; $I$ represents intensity. In the three parts, $H$ is the most important one, we use it to quantize the image colors. As the RGB image is in common use, we shall transform them into HSI image. The transform formula is as following.

$$\begin{cases} H = \frac{1}{360}[90 - \arctan(\frac{2R-G-B}{\sqrt{3}(G-B)}) + \{0, G > B; 180, G < B\}] \\ S = 1 - \frac{\min(R,G,B)}{I} \\ I = \frac{R+G+B}{3} \end{cases} \tag{1}$$

But the perceptual color spaces' irregularity is the question which cannot neglect, specifically when the $R$, $G$, $B$ component values are close, this pixel's hue is indefinite, nearby singular point, even if the $R$, $G$, $B$ values will have the very small change also to cause the $H$ value to have the very big fluctuation, moreover after transforming the distribution will take on the false form type. Thus when the pixels are nearby singular point, we use the $I$ component to cluster the colors. Experimental results show this method work well.

## 3. Texture and color based segmentation

### 3.1 Fuzzy texture feature extraction

Texture is an important feature of the image. There are many kinds of methods for texture extraction[11, 12, 13]. Lee et al. proposed the grayscale image's uniform surface uncertainty[14], indicated the degree that one point $P$ in the texture belongs to the homogeneous surface, its value scope is [0,1], through it, we may transform the grayscale image to the fuzzy image. We extend it to the color image.

First we compute the color image's uniform surface uncertainty.

$$m = \frac{1}{N}\sum_{z \in Z} Z \tag{2}$$

Here $m$ is the mean of all N data points in the set $Z$, $z$(x,y) is one point which belongs to $Z$.

$$m_i = \frac{1}{N_i}\sum_{z \in Z_i} z \tag{3}$$

Here $m_i$ is the mean of pixel set $Z_i$ with $N_i$ data points.

$$r^2 = \sum_{1}^{k} \frac{N_i}{N} \| m_i - m \|^2 \tag{4}$$

Here $k$ is the color number after quantization and || || is the Euclidean distance.

We define the uniform surface uncertainty of point $P_{xy}$ in the image as:

$$U_{xy} = 1 - \frac{r^2}{R^2} \tag{5}$$

### 3.2 Initialize the crude regions

Compute the $U_{xy}$ value of each point in the image, and divide the pixels with value more than the threshold *Thre1* into certain class and others uncertain class. Then we define the pixels satisfying the following conditions to form the seeds:

(1) all belongs to certain class;
(2) connected at four adjoining points;
(3) the number of connected pixels is bigger than threshold *Thre2*

The pixels that have been divided into certain class but the connected pixels number is less than *Thre2* we get them into uncertain class again. And as for the certain class pixels connected to the seeds they will be merged into the seed regions directly.

The pixels left will be merged into one seed region by the following algorithm.

(1) To deal with the every uncertain pixel $P$, search the four adjoining points, if there's point in the seed region $K$, take this point as the center of a circle and increase the radius gradually and let the circle contain enough pixels which are in the $K$th region, the pixel number threshold is *Thre3*.
(2) Compute the $U_{xy}$ value of $P$ using the formulas (2)-(5), this time only the pixels belonging to region $K$ will be considered.
(3) Compute the $U_{xy}$ value with every connected seed region and get the min $U_{xy}$, assuming the corresponding seed region is $R$, if the min $U_{xy}$ is more than threshold *Thre4*, merge point $P$ into region $R$.
(4) Increase the value *Thre4* gradually until all the uncertain pixels are merged into one seed region.

### 3.3 Region merging based on color information

In order to avoid the different object being divided into the same region, during the initial segmentation, generally the threshold value is quite low. As the image itself has certain noise, in addition the color cluster's influence, the identical object is usually divided into several regions. Region merging is to merge these regions into one again, thus eliminate the over-segmented phenomena.

$$P_{xi} = m_{xi} / N_x \qquad (6)$$

Here $m_{xi}$ means the number of the $i$th kind of pixels in the region $X$, $N_x$ is the total pixel number in this region.

We define the similarity between two regions $Q_x$ and $Q_y$ as follows.

$$S_{xy} = L_{xy} \cdot N_{xy} \cdot \sum_{i=1}^{k} (P_{xi} - P_{yi})^2 \qquad (7)$$

In this expression, $L_{xy}$ is set to 1.0 when $Q_x$ and $Q_y$ is adjacent, otherwise $L_{xy}$ is set to a infinite value. If the order of the first $k$ kind of pixel according to the number in $Q_x$ is same as those in $Q_y$, $N_{xy}$ is set to 1.0. Otherwise, $N_{xy}$ is set to infinity. Generally the $k$ is 1/3 of the color number after color quantization. If the color number in two regions are both lesser than 1/3 of the total color numbers, $k$ is set to the small one. If one color number is larger than 2/3 of the total number and the other is smaller than 1/3, $S_{xy}$ is set to an infinite value directly. In our experiments, the threshold value $S_{xy}$ is 0.15.

### 3.4 Segmentation algorithm description

The entire segmentation algorithm can be depicted as Fig 1.

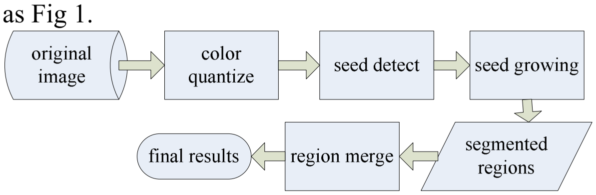


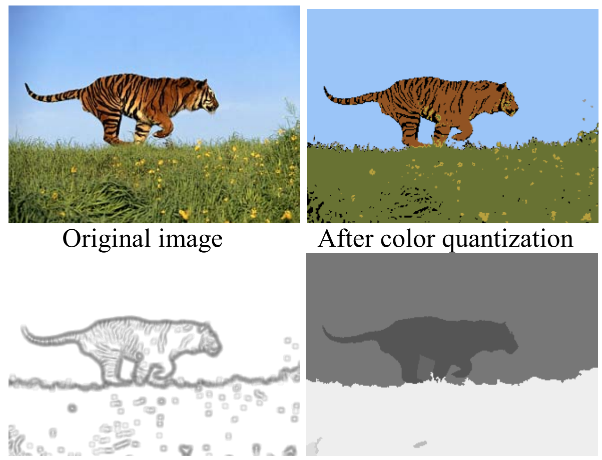

Fig 1. Flow-chart of the steps in segmentation

## 4. Experimental results and analysis

This algorithm is tested on a variety of images. Fig 2 shows the process of the algorithm. While Fig 3 shows some experimental results. In our experiments, the natural images and the texture images are all tested. The experimental results indicate the algorithm can deal with the two kinds of images in a good way.

Compared to the JSEG, this algorithm uses the uniform surface uncertainty value instead of the $J$ value and greatly reduces the computation complexity. Since there's no multi-level scale for computation, it's easily to be implemented. The use of color information makes the merging process more accurate.

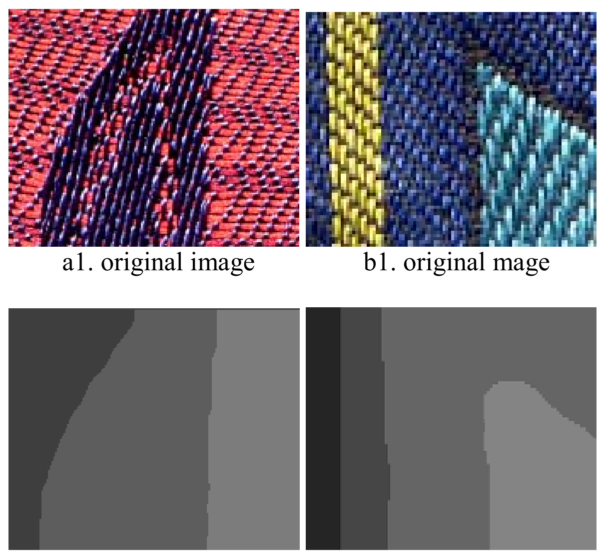
In our experiments, the radius of widow for computing the uniform surface uncertainty is 7; the value of *Thre1* is 195; the value of *Thre2* is 0.5% of all the pixel number of the image; the value of *Thre3* is 112; and the initial value of *Thre4* is 0.25, the step of increment is 0.05.



Original image　After color quantization

Fuzzy image　Final result

Fig 2 the process of the algorithm on image "tiger"



a1. original image　b1. original mage

a2. result image　b2. result image

Fig 3. color image segmentation examples

## 5. Conclusions

In this work, a new approach for fully automatic color image segmentation is represented. The segmentation consists of color quantization and uniform surface uncertainty based segmentation. Our experiments show the algorithm can provide good segmentation results on a variety of color images. Several limitations are found for the algorithm in the experiments. For example when two neighbor regions do not have a clear boundary, or there are many small regions in the image, the results can not be satisfying. Future research work is on how to solve these problems and improve the results.

## 6. References


[1]. YE QX, GAO W, WANG WQ, HUANG TJ. A Color Image Segmentation Algorithm by Using Color and Spatial Information. Journal of Software, 2004, 15(4), 522-530.

[2]. WEI BG, LU DM, PAN YH, YANG Y. Interactive Image Segmentation Using Multiple Color Spaces. CHINESE J. COMPUTERS. 2001, 24(7), 770-775.

[3]. Lucchese L, Mitra SK. Unsupervised segmentation of color mages based on K-means clustering in the chromaticity plane. In: Collins F, ed. Proc. of the Content-Based Access of Image and Video Libraries. Los Alamitos, CA: IEEE Computer Society Press, 1999. 74~78. http://csdl.computer.org/comp/roceedings/cbaivl/1999/0034/00/00340074abs.htm

[4]. Tuan DP. Image segmentation using probabilistic fuzzy C-means clustering. In: Mercer B, ed. Proc. of the Int'l Conf. on Image Processing. IEEE Signal Processing Society Press, 2001. 722~725. http://ieeexplore.ieee.org/xpl/conferences.jsp

[5]. Malik J, Belongie F, Leugn T, Shi JB. Contour and texture analysis for image segmentation. Int'l Journal of Computer Vision, 2001,43(1):7~27.

[6]. Deng YN, Manjunath BS. Unsupervised segmentation of color-texture regions in images and video. IEEE Trans. on Pattern Analysis and Machine Intelligence, 2001,23(8):800~810.

[7]. Zhu SC, Yuille A. Region competition: Unifying snakes, region growing, and Bayes/MDL for multiband image segmentation. IEEE Trans. on Pattern Analysis and Machine Intelligence, 1996,18(9):884~900.

[8]. Fan JP, Yau DKY, Elmagarmid AK, Aref WG. Automatic image segmentation by integrating color-edge extraction and seeded region growing. IEEE Trans. on Image Processing, 2001,10(10): 1454~1466.

[9]. PAN C, GU F. Color Image Segmentation Based on 3D Histogram. Journal of Image and Graphics. 2002, 7(8),800-805.

[10].LIN KY, WU JH, XU LH. A Survey on Color Image Segmentation Techniques. Journal of Image and Graphics. 2005,10(1),1-10.

[11]. S. Belongie, C. Carson, and H. G. nad Jitendra Malik. Color- and texture-based image segmentation using the expectation-maximization algorithm and its application to content-based image retrieval. In Sixth International Conference on Computer Vision, 1998,675–682.

[12]. C. Sagiv, N. A. Sochen, and Y. Y. Zeevi. Texture segmentation via a diffusion-segmentation scheme in the gabor feature space. In Proc. Texture 2002, 2nd International Workshop on Texture Analysis and Synthesis, Copenhagen, 2002.

[13]. N. Paragios and R. Deriche. Geodesic active regions and level set methods for supervised texture segmentation. International Journal of Computer Vision, 2002, 46(3): 223.

[14]. Lee YG, Lee JH, Hsueh YC. Texture classification using uncertainty texture spectrum. Neurocomputing. 1998, 20(1-3):115~122.