Design of Simulated Pattern Painting Based on Image Segmentation and Recognition Method

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***Abstract*—The paper introduces the segmentation method of binary image and grey level image into the design of simulated pattern painting. They are region segmentation method based on seeds and region segmenting and merging method. Firstly according to the design characteristic of simulated pattern painting, it carries on the chromatic image segmentation regarding chromatic aberration as distance. Secondly carry on mathematical morphology treatment to layers of different colors. Thirdly it forms multiple spots of simulated pattern painting based on Matlab programming. We get the spots of simulated pattern painting using computer to carry on the color segmenting and clustering. We can find that the color, dimension and shape are unanimous or very similar to the spots on the background. It accords with the design principle of simulated pattern painting.**

***Index Terms*—pattern painting, image segmentation, grey level image, mathematical morphology**

I. INTRODUCTION

With the development of image processing technology, the image segmentation and clustering are gradually applied to the design of pattern painting. Utilize digital image processing technology to carry on the treatment of chromatic image segmentation and clustering to the background image. It does not only have the characteristic of high precision and quick speed but can also abstract its main color and concrete parameter value. It can offer "the standard" while matching colors for the pattern painting.

From the view of image color, it can be divided into chromatic image and grey level image segmentation. Choose two indexes of luminance comparison and chromatic aberration as the gist of confirmed spots of pattern painting. Among them the spot got by color image segmentation method predominates.

II. GREY LEVEL IMAGE SEGMENTATION

The larger the luminance difference between target and background in the image is, the greater the identification probability of the target is. In the condition of farther reconnoiter, the factor of luminance (grey level) must be considered, so we adopt the luminance index as the accordance of image segmentation.

The contribution of each base color to luminance is different. The luminance equation is often used in the grey level characteristic extraction of color image. Consider that the relative luminance equation recommended by CIE accords with the vision of human eye well, we choose formula (1).

$$L = r + 4.5907g + 0.0601b \quad (1)$$

After the normalization, change the chromatic image into grey level image.

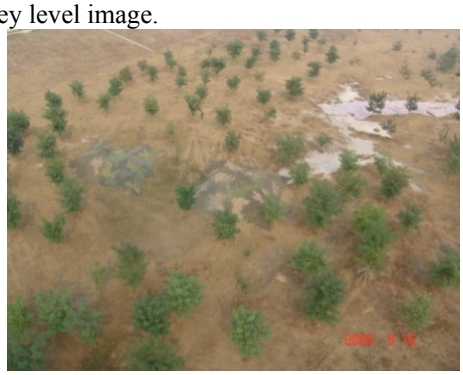

Figure 1. Primitive chromatic image

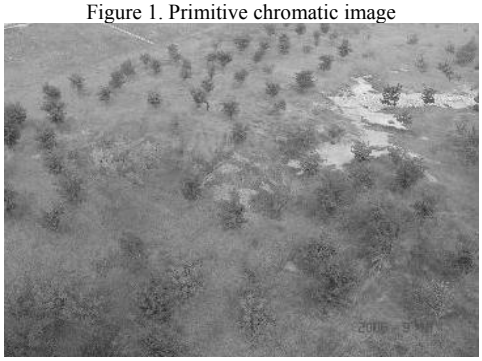

Figure 2 .Transformed grey level image

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III. CHROMATIC IMAGE SEGMENTATION

Compare with the segmentation algorithm of color image and grey level image, mostly the segmentation thought is unanimous. But the chromatic image includes more abundant information, and there are multiple expression ways of color space, so the segmentation algorithm is different, the method used in the grey level image is not suited to segmenting chromatic image directly. The paper adopts the two image-segmentation methods which are region growing method based on seeds and region segmenting and merging method. It segments the chromatic image through using the method of different layers of different main color.

A. Region Growing Method Based on Seeds

Region growing method based on seeds is described as follows. Firstly find a seed pixel as the starting point of growth to each region that needs to be spitted. Then the pixel which has the same or similar color characteristic of seed pixel is merged to the region of seed pixel according to certain rule, until covering the whole image.

1) Choice of seed point

Because the design of simulated pattern painting mainly cares about color spot of large area in the image, while selecting the spot color, we usually do not consider the background spots whose area does not exceed 5% of the total background area. Through quantization of chromatic image, we can have the statistic color histogram of Fig.1. It is as Fig.3 shows. Several main color cover most pixels of the image, the statistics value of other color is very small, nearly tend towards zero. Select several main colors and get the main color reference histogram. It is as Fig.4 shows. It is reference for artificially choosing the seed points.

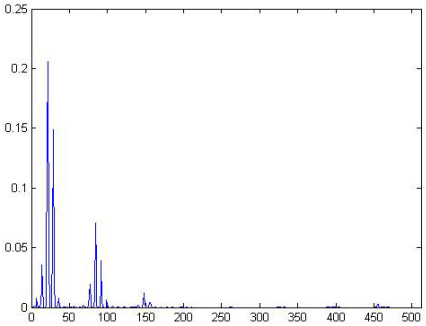

Figure 3. Statistical histogram of chromatic color

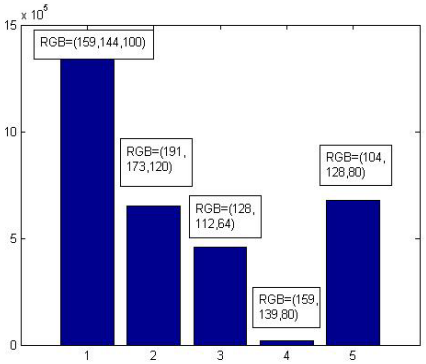

Figure 4. Histogram of color reference

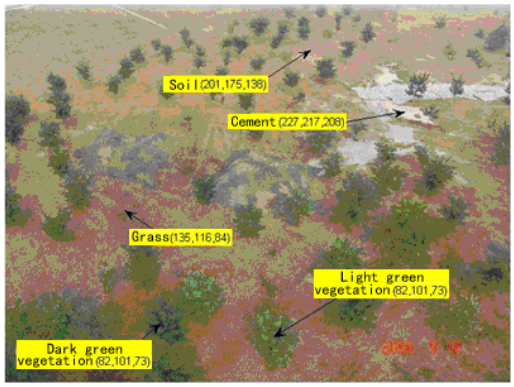

Figure 5. Seed point

We can find from Fig.5 that though ashen (cement) color is small in area, only accounts for about 2% of the whole area of the background, but it is being obvious in color contrast. If amalgamate this cluster color to other kinds, it will influence pattern painting effect. When select artificially, we have fully utilized the sagacious resolving power of human eye to the color and overall situation hold ability of human. While choosing the seed point using human-computer interaction, it can not only reduce the quantity of samples greatly, but also reduce the calculation amount, and it has benefited the control of segmenting at the same time.

2) Region image segmentation

According to the color and image luminance characteristic of image P (M, N), we select k ($3 \le k \le 8$) initial clustering center $\{W_j\}$ $j = 1,2,\cdots,k$. When it belongs to the $No.i$ kind of pixels, it will satisfy formula (2).

$$d(w_i, p(m,n)) = \min\{d(w_j, p(m,n))\} \quad (2)$$

Where $w_i \in \{w_j\}$ $j = 1,2,\cdots,k$; $p(m,n)$ is the pixel value of coordinate position (m, n), $m = 1,2,\cdots,M$, $n = 1,2,\cdots,N$; $d(w_j, p(m,n))$ is the chromatic aberration between $p(m,n)$ and clustering center w_j .

Namely the pixel $p(m,n)$ is clustered to which clustering center when the chromatic aberration distance between them is the smallest. Considering the error that people's subjectivity brings, we should ask for the average of all kinds of pixel value.

$$\overline{w_j} = \frac{1}{n_j}\sum_{x \in w_j} x \quad j = 1,2,\cdots,k \quad (3)$$

$$\left| w_j - \overline{w_j} \right| \le \varepsilon \quad (4)$$

Where the pixel number is n_j included in the number w_j kind and $\{\overline{w_j}\}$ is the new clustering center. Carry on the dynamic clustering until it satisfies formula (4), ε is the threshold value.

We can get the final clustering center according to above calculation, and replace the color of corresponding kind with pixel color of center point. We can calculate

the percentage of the cluster area in the image at the same time while carrying on the cluster calculation.

According to above procedures, we can carry on the region segmentation to different color spaces; the segmentation result is as Fig.6 to Fig.10 show.

W1 expresses the grass, W2 expresses the soil, and W3 expresses the jade-green vegetation, W4 expresses the bottle-green vegetation, W5 expresses cement.

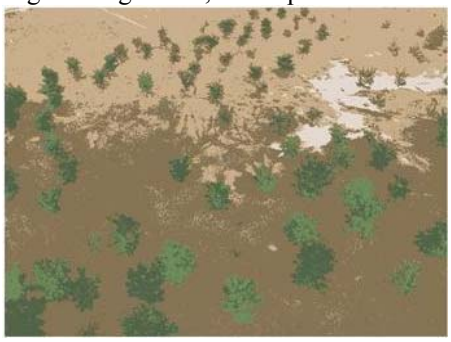

Figure 6.Region segmentation of $L^*a^*b^*$ color space

W1 color percentage is 52.8126%
W2 color percentage is 27.5667%
W3 color percentage is 6.068%
W4 color percentage is 10.804%
W5 color percentage is 2.7487%
Elapsed time is 587.441473 seconds.

Figure 7.Region segmentation of RGB color space

W1 color percentage is 48.3886%
W2 color percentage is 26.5066%
W3 color percentage is 5.9098%
W4 color percentage is 17.2443%
W5 color percentage is 1.9507%
Elapsed time is 17.735067 seconds.

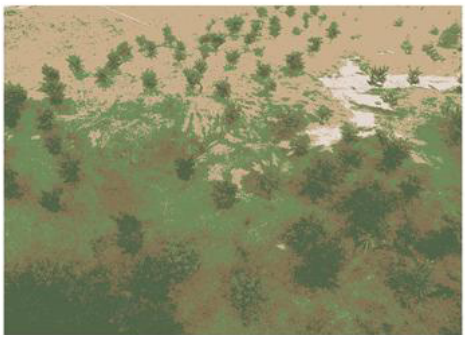

Figure 8.Region segmentation of XYZ color space

W1 color percentage is 24.9856%
W2 color percentage is 24.7495%
W3 color percentage is 28.5165%
W4 color percentage is 19.7941%
W5 color percentage is 1.9543%
Elapsed time is 110.829602 seconds.

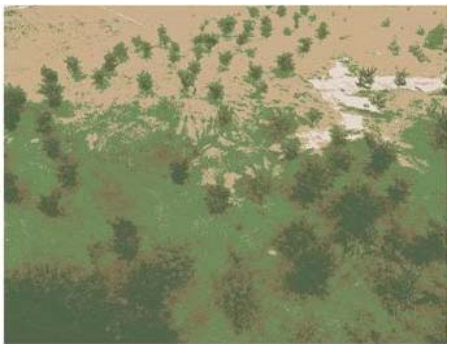

Figure 9.Region segmentation of HIS color space

W1 color percentage is 17.1853%
W2 color percentage is 25.8045%
W3 color percentage is 35.4062%
W4 color percentage is 19.7981%
W5 color percentage is 1.8059%
Elapsed time is 0.000007 seconds.

Figure 10.Region segmentation of $L^*u^*v^*$ color space

W1 color percentage is52.4734%
W2 color percentage is 26.864%
W3 color percentage is7.341%
W4 color percentage is 9.6013%
W5 color percentage is 3.7203%
Elapsed time is 442.395894 seconds.

Because the region segmentation is based on pixel, the pixels of the image color spots are in the condition of scattered distribution, they can not form meaningful spot image, and we need to connect through amalgamation of them, form the spot of pattern painting needed by pattern painting design.

B .Region Segmenting and Merging Method

The kernel thought of region segmenting and merging method is described as follows. Firstly choose reasonable region uniformity rule, the design of simulated pattern painting spot can choose chromatic aberration and luminance variance etc. As formula (5) shows, divide the image into several sub-blocks, generally there are four, it is as Fig. 11 shows. It can also be shown by quad tree as Fig. 12shows.

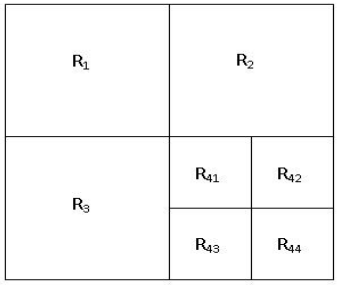

Figure 11.Sub-blocks after division

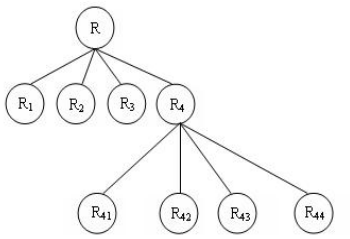

Figure12. Quad tree expression

Then to each sub-block calculate according to rule, if the sub-block calculation does not satisfies the rule, the sub-block will be divided into several sub-blocks again, until all the region reaches the uniformity and finish the image segmentation. The merging method is to merge the neighbored sub-blocks which satisfy the rule. For example, the points in region R_3 and R_{41} satisfy formula (6), so they are merged to one sub-block.

$$\left|\max(\Delta E(R_4))\right| > 3 \qquad (5)$$

Where $\Delta E(R_4)$ is the chromatic aberration between each pixel in region R_4.

$$\left|\max(\Delta E(R_3, R_{41}))\right| < 3 \qquad (6)$$

Where $\Delta E(R_3, R_{41})$ is the chromatic aberration of each pixel in region R_3 and R_{41}.

According to above description, we can find out that if we carry on treatment to the primitive image, it will reduce the times of segmentation and amalgamating greatly. Carry on the $L^*a^*b^*$ color space segmentation and amalgamating to Fig. 5, ΔE fetches 1.5、2、3 and 5, we can obtain Fig.13, Fig.14, and Fig.15and Fig.16.

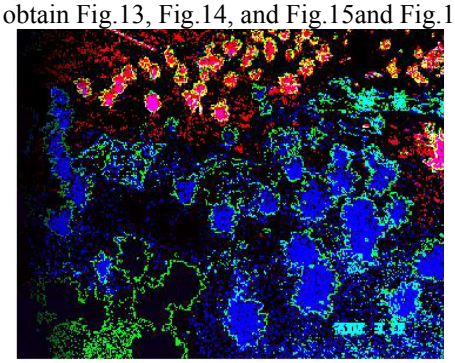

Figure13. $\Delta E = 1.5$

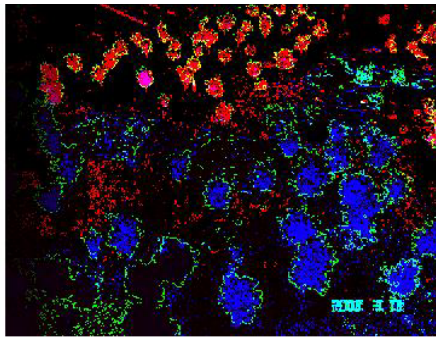

Figure14. $\Delta E = 2$

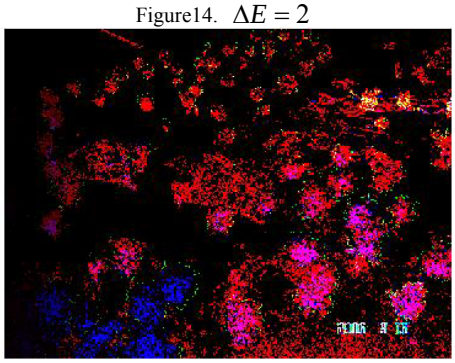

Figure15. $\Delta E = 3$

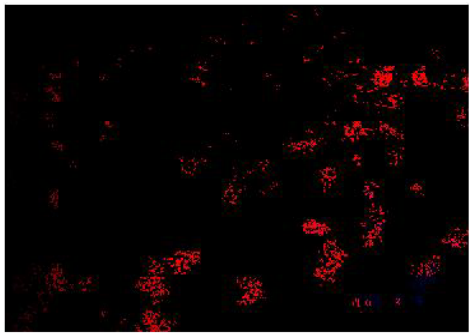

Figure16. $\Delta E = 5$

Owing to $L^*a^*b^*$ color space, color in the image changes. The size of ΔE influences the color kind in the image and the image needs further treatment to form the simulated pattern painting spots.

IV. MATHEMATICAL MORPHOLOGY AND REGION CONNECTION

A. Grey Level Morphology Algorithm

The region segmentation method based on pixel is apt to introduce the noises in the image, and the segmentation result may easily generate isolated small region that does not exist in the primitive image. Because the design of stimulated pattern painting especially considers the actual performance of disguise, not need to describe the detail of the image. Before forming the spots, we adopt the morphology algorithm to clear away detail of the image or noises expressed by small area and form the disguised pattern painting spots.

According to the above analyses, we can use Fig. 17 which is the segmentation result of adopting region segmenting and merging method. Firstly cluster according to luminance comparison, for example four kinds of main color, it shows as Fig.18.

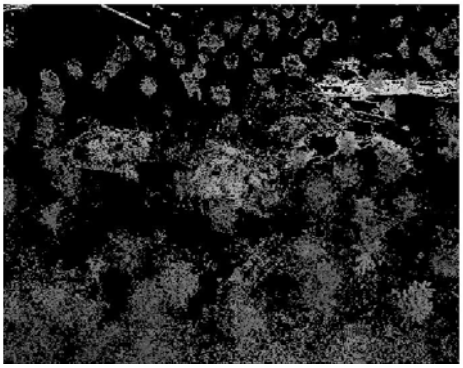

Figure 17.Segmentation result

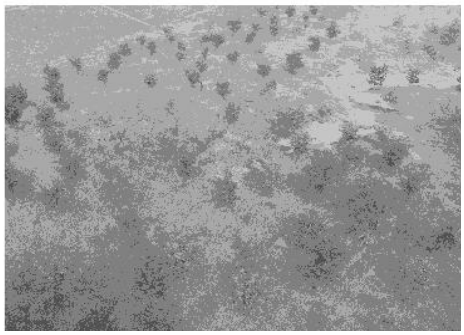

Figure 18.Grey level segmenting and merging clustering image

Utilize Matlab to carry on the follow-up treatment of mathematical morphology, its structure element as formula (7) shows. The image is as Fig. 19 shows.

$$b = strel(shape, parameters) \quad (7)$$

Where *shape* can fetch *arbitrary ball*, *diamond*, *and octagon* and *disk* etc, *parameters* fetch one or two, for example $b = strel('disk', R, N)$.

The actual main color spots can be generated after the morphology treatment to the segmentation image. It can control the shape and size of the main color spot through the control of selecting $shape$ and $parameters$. It gets better result of extracting round $b = strel('disk', n)$. Fetch *n*=5, carry on the treatment of first open and last close, it can obtain the actual main color spots, it is shown in Fig.20.

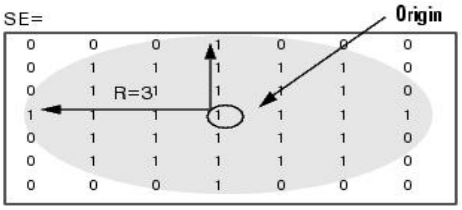

Figure19. Image of structure element

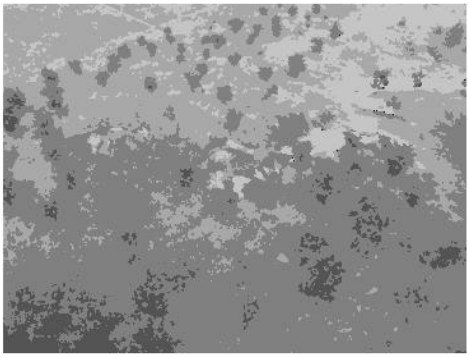

Figure20. Grey level clustering image

B. Color morphology algorithm

The application of morphology in chromatic image is still at the experience stage. The main problem lies in the setting-up of sequence structure. The "including" relation of binary image and "intensity" relation of grey level image have established the sequence structure of their pixels. But the color of chromatic image pixel is a multidimensional vector quantity, and it does not have obvious sequence structure.

1) Region growing method based on seeds

According to the characteristic of main color spot and design demand of stimulated pattern painting, the paper propose utilizing layer image to carry on the treatment of mathematical morphology. Namely after the image segmentation, the color of the image is clustered to several kinds, regard each kind of color as a layer of the image, then carry on the morphology treatment.

Take Fig.21 as an example, carry on the treatment of first close and last open, the structure element $b = strel('disk', n)$, fetch *n*=3 and *n*=5, we can get Fig.22and Fig.23.

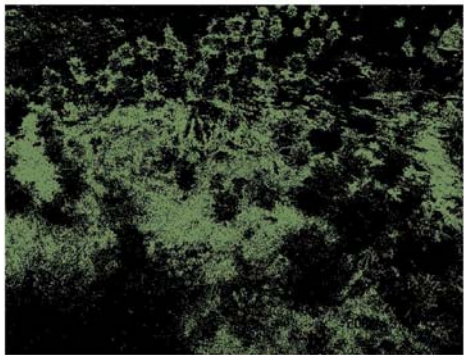

Figure21. Layer image segmentation

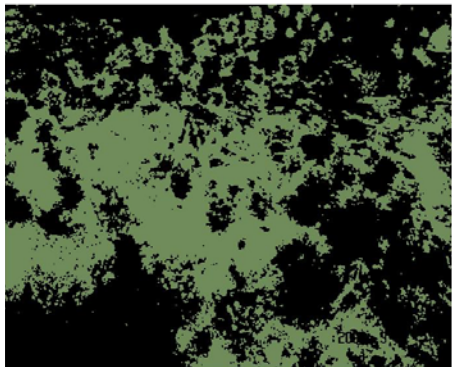

Figure22. n =3

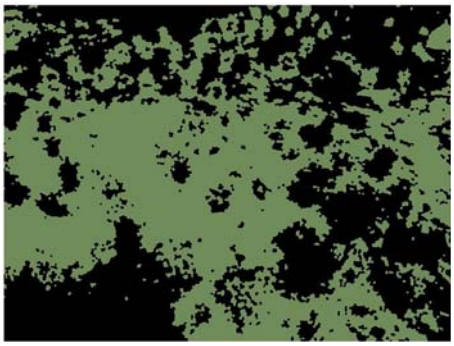

Figure23. n=5

According to above analyze, we can carry on the treatment of first close and last open to Fig.6, Fig.7, Fig.8, Fig.9 and Fig.10, the structure element is $b = strel('disk', n)$, n fetches 3 and 5; For RGB we can get Fig.24 and Fig.25; For XYZ we can get Fig.26 and Fig.27; For HIS we can get Fig.28 and Fig.29; For $L^*a^*b^*$ we can get Fig.30and Fig.31; For $L^*u^*v^*$ we can get Fig.32and Fig.33.

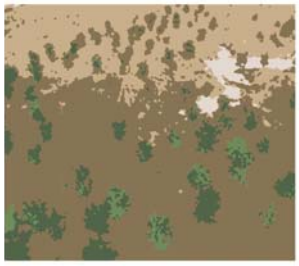

Figure 24.RGB (n=3)

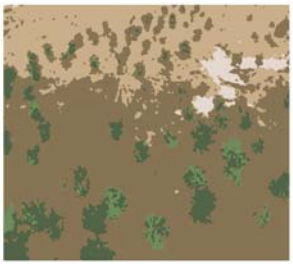

Figure25.RGB (n=5)

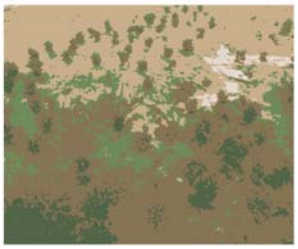

Figure 26.XYZ (n=3)

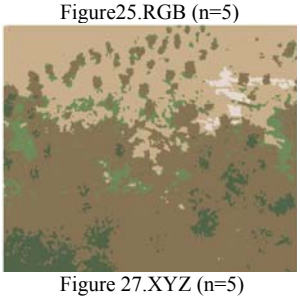

Figure 27.XYZ (n=5)

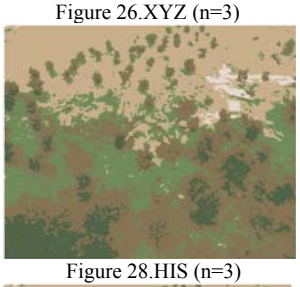

Figure 28.HIS (n=3)

Figure 29.HIS (n=5)

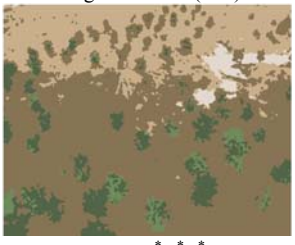

Figure30. $L^*a^*b^*$ (n=3)

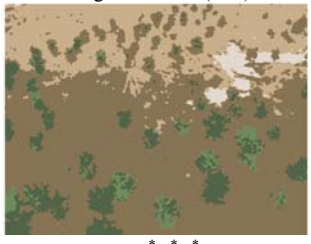

Figure31. $L^*a^*b^*$ (n=5)

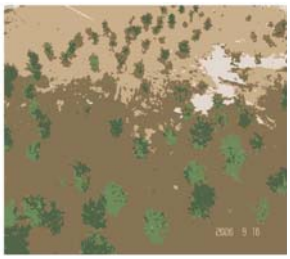

Figure32. $L^*u^*v^*$ (n=3)

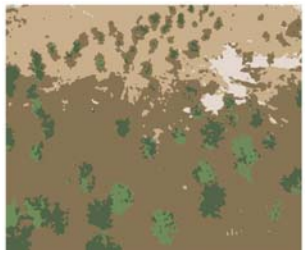

Figure33. $L^*u^*v^*$ (n=5)

2) Region segmenting and merging method

After the image segmentation based on region segmenting and merging method, there are many minute spots exist in the image, we can reduce the resolution ratio of the image first and reduce the calculation amount. Actually the pattern gotten by segmentation accords with the complexity of natural pattern painting, but consider the pattern painting construction. It is necessary to carry on the treatment of mathematical morphology to form spot of pattern painting. According to the design demand of simulated pattern painting, we can automatically extract color spots with more pixels before treatment and find out the similar color between them, 3-8 kinds of clustering color. The follow-up work duplicates the image segmentation treatment with region growing method based on seeds.

Fetch the spot image with 8 kinds of main color in Fig.15, and get Fig.34, we can see that there are detailed lumps or pixels between large spots. Carry on the mathematical morphology treatment, $b = strel('disk', n)$, n=3, and we can get Fig.35.

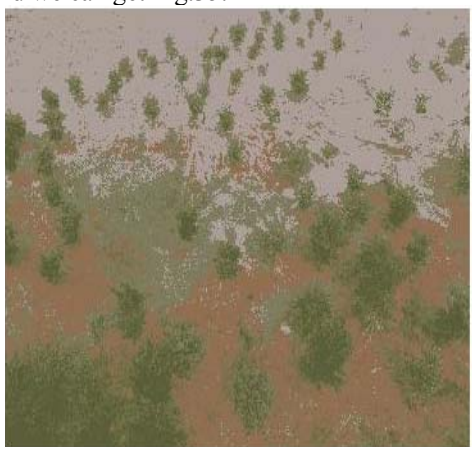

Figure34. Spot image with main color

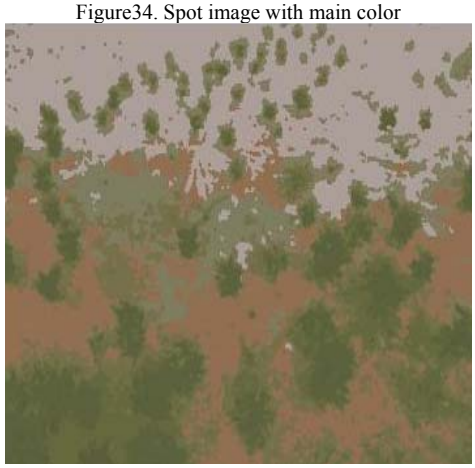

Figure35.Image with treatment

We can find out that the region segmenting and merging method gets better effect in the image spot segmentation. But in the automatic choose of color, it is a bit distorted, especially the soil color above the image.

V. CONCLUSIONS

Image segmentation is an important previous course in the design of simulated pattern painting. The image segmentation method based on region is not merely easy to control, and the extracted background characteristic can well match the design requirement of simulated pattern painting. So the paper choose the popular image segmentation method which are region growing method based on seeds and region segmenting and merging method at present. Especially region segmenting and merging method can deal with the segmentation of complicate scene and natural scene etc, the result is comparatively ideal.

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