Image Segmentation Based on Improved Regional Growth Method

Zhanshen Feng, Peiyan Sun

***Abstract*—**Image segmentation is to divide an image into multiple regions according to the consistency requirement of certain image features. In image segmentation, firstly, we should mark and locate the target and background in the image according to the prior knowledge of the target and background. Secondly, the target to be identified is separated from the background. The segmentation of images, the separation of targets, the extraction of features and the measurement of parameters will transform the original image into more abstract and compact form, making the analysis and understanding of the higher level possible. It is not only a key step to conduct image analysis, but also the foundation to further understand the image. Regional growth method is a method to gather the pixel points according to the similarity of the regional pixels of the same object and starting from the surrounding small neighborhood of every pixel, it incorporates the pixels with the same feature or other regions into the current region so as to gradually expand the region until there is not point or another small region to be incorporated. This paper, in order to solve the deficiency of slow transition in gray value and inconspicuous boundaries of conventional regional growth method, improves the growing criterion of regional growth method, gathers pixels based on the similarity of the regional pixels of the same object and includes the neighboring pixels with the same features or other regions into the exiting region in order to gradually increasing the region until there are no more pixels or other tiny regions to be included. The similarity measurements of the regional pixels include average gray value, textures, colors and other information. The experiment result proves that the algorithm of this paper results in better segmentation, improves the segmentation accuracy and reduces the over-segmentation and insufficient segmentation.

***Keywords*—**image segmentation, regional growth method, pixel neighborhood.

I. INTRODUCTION

Image segmentation is the foundation of target representation and it significantly affects feature measurement. In the process of image research and application, people are often only interested in some parts of each image. These parts are often called targets or prospects. They generally correspond to specific regions of the image. In order to distinguish and analyze the targets, they need to be separated and extracted. On this basis, it is possible to make further use of the target. Image segmentation is the technology and process of separating images into regions of interest and extracting interesting targets. As image segmentation as well as the target representation, feature extraction and parameter measurement based on segmentation can transform the original image into a more abstract and compact form, it makes it possible to conduct higher level image analysis and understanding. Regional growth method is an iterative method. Its basic idea is to gather the pixels with similar features to construct a region and in essence, it connects the pixels with similar features into a region, which is used to segment complex image, such as the natural scenery. Without any prior knowledge to be used, it can also have ideal performance, but given the impact of noises and the update of regional statistical features, the introduction of certain prior knowledge can lead to a better result, but this method takes more space and time. The key of regional growth method is to select proper growing or similar criterion. The common growing criteria and methods include two kinds: based on regional gray difference and based on regional gray distribution statistics [1, 2]. In order to design the segmentation algorithm applicable for images under complex background, this paper analyzes and summarizes the general image segmentation theories, methods and research status, focuses on research of and improves the image segmentation based on regional growth method.

The study of image segmentation technology can be dated back to the 1960s and with a research history of about 50 years, plenty of research has been conducted with numerous algorithms being proposed. The development of image segmentation methods can be divided into two stages: gray image segmentation method and color image segmentation. For the former, people have proposed histogram method, regional growth method, edge detection method, method based on watershed and neural network method from different perspective and as for the latter, they can be divided into the following three types: the segmentations method based on color feature space, the segmentations method based on texture feature space and the segmentations method based on mixed features [3]. Regional growth method is old image segmentation method and the earliest version was brought forth by Levine. This method usually has two forms. One gives a small area or a seed region of the target object in the image to be segmented and adds its surrounding pixels into the seed region on this basis according to a certain rule so as to combine all pixels which represent the object into a region. The other segments the image into multiple small consistent regions and

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then fuses these small regions into big regions according to certain rules to achieve the purpose of image segmentation. The classical regional growth method includes the regional growth method based on facet model proposed by Pong. So far, there is not an algorithm which can be used for the segmentation of all images and the algorithm needs to solve more and more problems with more and more complexity [4][5].

This paper first introduces the main image segmentation methods. Then it analyzes the principles of traditional regional growth method and finds an improved algorithm through the research of related images with reduced computation. Regional growth method starts from the surrounding small neighborhood of the initial region or every pixel, merges the pixels with the same feature or other regions into the current region so as to gradually expand the region until there is not point or another small region to be merged. The similarity measurements of regional pixels include average gray value, textures, colors and other information. The algorithm of this paper can improve the operation efficiency, make the computer automatically select the growing starting point, avoid any error brought by manual selection and make regional growth automatically segment the image. Finally, the experiment proves that the algorithm of this paper is effective.

II. IMAGE SEGMENTATION METHODS

Image feature extraction and target recognition all depend on the quality of image segmentation, so image segmentation determines the final success or failure of image analysis. Each region of the image is consistent or similar in some image features such as edge, texture, color and brightness. One of the basic purposes of image segmentation is to extract meaningful features or features that need to be applied in images. These features can be the original features of the image, such as the pixel gray value of the object in the area, the contour of the object and the texture features, and it can also be the spatial spectrum or histogram features.

In some part of the image or object, its characteristics (gray, color, texture, etc.) are similar, but the characteristics of different objects will be changed accordingly. The image space is divided into some meaningful regions according to certain requirements. Meaningful-it is hoped that these regions correspond to objects (or backgrounds) in the image scene separately. The set R represents the entire image area. The segmentation of R can be regarded as dividing the R into several non-empty subsets (sub-regions) that meet the following five conditions.

(1) $\bigcup_{i=1}^{n} R_i = R$, the sum of all sub-regions of the segmentation should include all pixels in the image or divide each pixel in the image into a sub-region.

(2) For all i and j, there are $R_i \cap R_j = \Phi(i \neq j)$, and each sub-region does not overlap each other.

(3) For $i = 1,2,3,......,N$, there are $P(R_i) = True$, the pixels of the same sub-region should have some common characteristics.

(4) For $i \neq j$, there are $P(R_i \cup R_j) = False$, the pixels of the different sub-region should have different characteristics.

(5) For $i = 1,2,3,......,N$, R_i is a connected region, the pixels of the same sub-region should be connected.

Among these, condition 1 points out that the sum of all sub-regions of the segmentation result of an image is the original image, or the segmentation should be divided into a sub-region of every pixel in the image. Condition 2 points out that each sub-region is not overlapping in the segmentation result, or that one pixel can not belong to two regions simultaneously. Condition 3 points out that each sub-region has unique characteristics in the segmentation result, or the pixels of the same area should have some identical characteristics. Condition 4 points out that in the segmentation result, different sub-regions have different characteristics, there are no common elements, or the pixels of different regions should have some different characteristics. Condition 5 requires that the pixels within the same sub-region of the segmentation result be interlinked, that is, any two pixels in the same sub-region are interconnected in the sub-region, or the region obtained by the segmentation is a connected component.

A. *Otsu threshold Segmentation Method*

Based on a certain image model, the threshold segmentation algorithm obtains the image by the threshold value and thus each area can be separated. By assuming that the image is composed of the target and background with the single peak grayscale distribution, the most commonly used image model is determined according to the gray value of the image pixel. For a single target image, by only selecting one threshold value, the image can be divided into two categories: target image and background image. This method is named the single threshold segmentation; if the target image is complicated and the image has a number of areas with different grey values, multiple threshold values can be selected (a series of threshold value) to divide each pixel into the right category, thus the target area and background of the image can be segmented into multiple ones, and such method of segmentation with multiple threshold values is called the multiple threshold segmentation method. At this point, we need to distinguish the image target in the detection result, and distinguish the unique identification of each image target area. In case that the pixel gray value or other characteristics of the target and background area are obviously different, such algorithm can realize the segmentation of image very effectively. The key of the threshold segmentation method is how to obtain an appropriate threshold. The threshold is selected only based on the image gray value, and only the threshold value related to the nature of each image pixel is selected. In addition, the threshold selection also depends on the gray value of the image and some local characteristics of the neighborhood, namely, the threshold value associated with local regional characteristics, which is the local threshold. In addition to the depending on the image grayscale value and some local characteristics of the neighborhood, it also depends on the spatial coordinate is also depended on, namely, the threshold value obtained is related to the coordinate, which is called dynamic threshold or self-adaptive threshold. Assume that the object and background are respectively in different grayscale, the image is polluted by the Gaussian noise with zero mean, two normal distribution probability density functions of the image gray distribution curve approximation respectively represent the histogram of target and the background. The histogram of the overall image is fitted by using the synthetic curve of both functions, then two separate peaks will appear in the histogram of the image, and the segmented threshold is determined by the corresponding grey value of the trough between two peaks of the histogram according to the minimum error theory. Such method is suitable for images with good bimodal properties, but it is very complicated to use such algorithm as the numerical approximation, and the histogram of most images is discrete and irregular.

Threshold segmentation algorithm, according to the gray scales, divides the pixel set. Such division can be achieved by selecting one or multiple thresholds starting from the gray scales. Assume that the original image is $f\left(x,y\right)$, find the feature value T in $f\left(x,y\right)$ according to certain criteria and segment the image into two parts. The segmented image is as follows.

$$g(x,y)=\begin{cases}0 & f(x,y)<T\\ 1 & f(x,y)\ge T\end{cases} \tag{1}$$

In this formula, $g(x)$ represents the segmentation result. 0 means that the pixel is black and 1 indicates that it is white. In general, threshold operation can be seen as a function of the gray scale, certain local characteristics and the position of some pixel in the image. If the gray value of the pixel is smaller than the threshold T, this pixel is displayed with blacked, if it is bigger than or equal to T, it is displayed in white. In this way, a binary image can be obtained with the target region and background region displayed in white and black respectively. Threshold segmentation methods include the global threshold method based on pixels, the global threshold method based on regions, the local threshold method and multi-threshold method. Threshold segmentation method works very well in the images with big gray difference between the target and the background, but not so well in the images without distinct gray differences [6].

Otsu performs segmentation by setting a threshold and maximizes the segmented two between-class variances. It first determines the gray threshold of the image and then compares the gray value of all pixels with that threshold. Make the gray value 0 if it is smaller than the threshold and make it 255 if bigger than that threshold. In this way, the image is divided into two classes so as to divide the region.

Assume that there are m different classes in image X, then there are $(m-1)$ thresholds $k_1,\ldots,\ k_{n,}\ldots\ ,k_{m-1}$ used to divide the image into m classes. These classes are represented as $C_0=\left\{0,1,\ldots k_1\right\},\ldots,$ $C_n=\left\{k_n+1,k_n+2,\ldots,k_{n+1}\right\},\ldots,$ $C_n=\left\{k_m+1,k_m+2,\ldots,L-1\right\}$. Then the between-class variance is defined as follows.

$$\sigma_{BC}=\omega_0(\mu_0-\mu_T)^2+\ldots+\omega_n(\mu_n-\mu_T)^2+\ldots \\ +\omega_{m-1}(\mu_{m-1}-\mu_T)^2 \tag{2}$$

Here,

$$\omega_0=\sum_{i=0}^{k}P_i,\ldots,\omega_n=\sum_{i=k_{n+1}}^{k_{n-1}}P_i,\ldots,\omega_{m-1}=\sum_{i=k_{m+1}+1}^{L-1}P_i \tag{3}$$

$$\mu_0=\frac{\sum_{i=0}^{k}P_i}{\omega_0},\ldots,\mu_n=\frac{\sum_{i=k_{n+1}}^{k_{n-1}}iP_i}{\omega_n},\ldots,\mu_{m-1}=\frac{\sum_{i=k_{m+1}+1}^{L-1}iP_i}{\omega_{m-1}} \tag{4}$$

$$N=\sum_{i=0}^{L-1}N_i \qquad \mu_T=\sum_{i=0}^{L-1}iP_i \tag{5}$$

The group of thresholds which maximizes σ_{BC} is the optimal thresholds to be sought [7].

B. Edge-based segmentation

An important approach of the image segmentation is to pass the edge detection, namely, the detection of the grey value or the point where the structure changes, and such point indicates the end of one area and the beginning of another. This discontinuity is called the edge. Different images have different gray-scale, and the boundary usually has obvious edge, and this feature can be used to divide the image. The gray value of the pixel at the edge of the image is discontinuous, and this discontinuity can be detected by determining the derivative. For the step edge, its position corresponds to the extreme point of the first derivative and corresponds to the zero point of the second derivative (zero crossing point), and the differential operator is usually used to realize the edge detection. Because the edge and noise both belong to the gray discontinuities, and also belong to the high frequency component in the frequency domain, it is difficult to overcome the influence of the noise by directly adopting the differential operation. In practice, various differential operators are commonly represented by small region templates. The differential operation is realized by using the template and image convolution. These operators are sensitive to the noise and are only suitable for the less complex images with small noise. The following Fig.1 is Examples of image edge types and derivative curve rules.

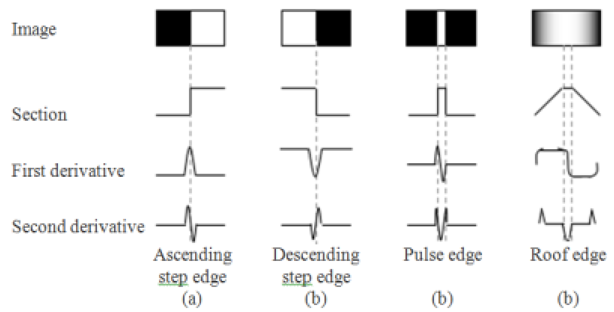


Fig. 1. Examples of image edge types and derivative curve rules

First derivative usually produces a rough edge in the image, and the second derivative has a strong response towards fine details such as fine lines, isolated point and noise. The second derivative will produce the double edge response in the gray level slope and gray level step transition. The second derivative symbols can be used to determine whether the edge transits from light to dark or from dark to bright. The commonly used first differential operators are Roberts operator, Prewitt operator and Sobel operator, and the second differential operators are Laplace operator and Kirsh operator. Therefore, it is necessary to carry out the smoothing filtering towards the image before detecting the edge by using the differential operator. The LOG operator and Canny operator belong to the second and first differential operators with smooth function.

1) Roberts edge detection operator

Roberts crossover operator provides a simple approximation method for the gradient amplitude calculation. The determination of such method operator is based on the rule that the gradient can be calculated by any pair of difference in the mutually vertical direction, and the operator can be determined by the difference between two adjacent pixels, thus the gradient amplitude of such method can be obtained. We can select the appropriate threshold method according to the actual situation. For pixels that are greater than the threshold, they can be used as the step-shape edge points. The set of all edge points is called the edge image, the determination effect of such method is far better than the method of oblique direction due to the adoption of the horizontal and vertical method. Such method also has a stronger noise sensitivity and higher, positioning accuracy.

2) Prewitt gradient operator

Prewitt gradient operator is also called the weighted average difference method, and also belongs to the edge detection of the first differential operator. The extremum detection edge can be realized at the edge point, and some false edges are taken out by using the gray level difference between up and down, left and right neighboring points of pixels point. In addition, such method has smoothing effect towards the noise, namely, the average is first determined and then the gradient is determined after the determination of the difference, thus reducing or eliminating the noise. Such method is realized by completing the neighborhood convolution between templates and images in two directions in the image space. For such two direction templates, one detects the horizontal edge and one detects the vertical edge. By using the detection template, the gradient of horizontal and vertical direction can be obtained, and the detection results of the average difference method can be obtained through gradient synthesis and edge point determination. The results of Prewitt operator and the Sobel operator in extracting the edges are almost the same. Prewitt operator has the smoothing effect towards the noise when extracting the edge, and can suppress certain noise. At the same time, it has a smoothing effect on noise and can suppress certain noises. Because the Prewitt edge detection operator realizes the convolution operation of the image through eight direction templates, its calculation is relatively large.

3) Sobel edge operator

Sobel operator is the typical edge detection operator based on first derivative, focuses on pixel points close to the center of the template, which is used to calculate the gradient approximation of the image brightness function. Because such operator introduces the operation similar to the local average, so such operator has smoothing effect towards the noise and can better eliminate the influence of noise. The effect of Sobel operator on pixel position is weighted. The Sobel operator consists of two sets of 3x3 matrices, which are respectively horizontal and vertical templates which convolve with the image to obtain the horizontal and longitudinal brightness difference approximation. Sobel operator fault lies in that it does not strictly distinct the theme and the background of the image, in other words, Sobel operator does not process based on the image gray. Due to Sobel operator does not strictly simulates human visual physiological characteristics, so the extracted image contour is sometimes not satisfactory.

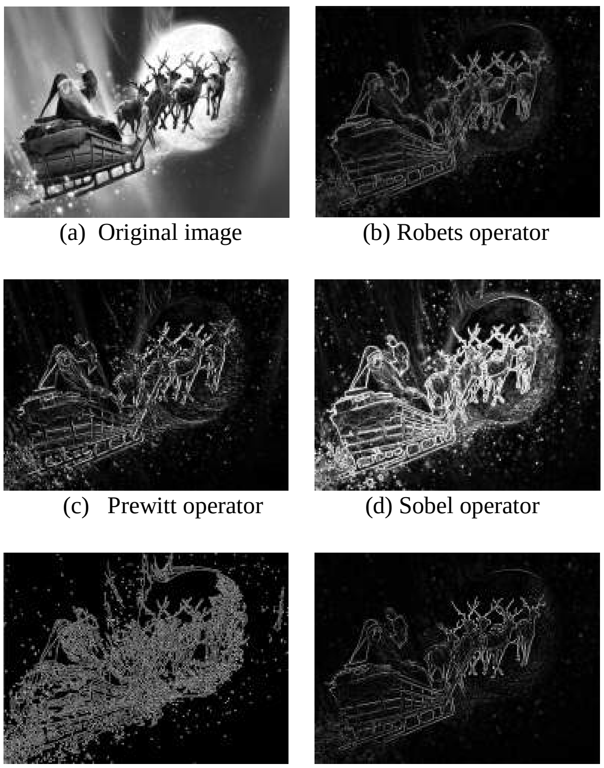
4) Canny edge detection operator

Although the basic idea of edge detection is relatively simple, it is very difficult to implement in practice. The basic reason is that the actual signal is noisy, and the general performance is high frequency signal. In this case, if the above edge operator is used directly, what is detected is the false edge point caused by the noise. The solution to this problem is to carry out the smoothing filtering towards the signals to filter the noise. Such method is to compare the gradient amplitude of the adjacent pixels in the direction perpendicular to the edge, and eliminate the gradient amplitude smaller than the domain. According to this operation, if the non-maximal point of the gradient amplitude is omitted, and the edges become thinner.

5) LOG operator

The LOG operator is implemented on the basis of the Laplace operator. Because the Laplace operator is sensitive to noise, in order to reduce the influence of noise, the processing image is smoothed first, then the edge is detected by Laplace operator. In the process from the scene to the image, for each pixel gray level, the effect of the surrounding points of real scene corresponding to such pixel on such pixel gray is in the normal distribution along the radial distance, namely, closer to the real scene corresponding to the pixel and thus having greater contribution to the pixel gray. Therefore, the smoothing function should reflect the different effects of different distant points on a given pixel. In fact, the Gaussian function satisfies the above smoothing requirements. Therefore, Gaussian is used in the LOG operator.

By comparing several commonly used edge detection operators, the partial derivative form of Sobel edge operator and Prewitt edge operator is exactly the same. Sobel operator focuses on pixels close to the center of the template. The characteristics of Laplace operator are: isotropic, linear and displacement invariant; good detection effect of fine line and isolated point. The Canny operator determines the edge points based on the first derivative. It is one of the operators with best effect to detect step edge in first traditional differential. For different systems, considering different environmental conditions and requirements, the appropriate operators are selected to perform edge detection of images. Figure 2 is the comparison of Robets operator, Prewitt operator, Sobel operator, Canny operator and LOG operator.



(a) Original image (b) Robets operator

(c) Prewitt operator (d) Sobel operator

(e) Canny operator (f) LOG operator

Fig. 2. Several classical edge operator test results

C. Watershed segmentation

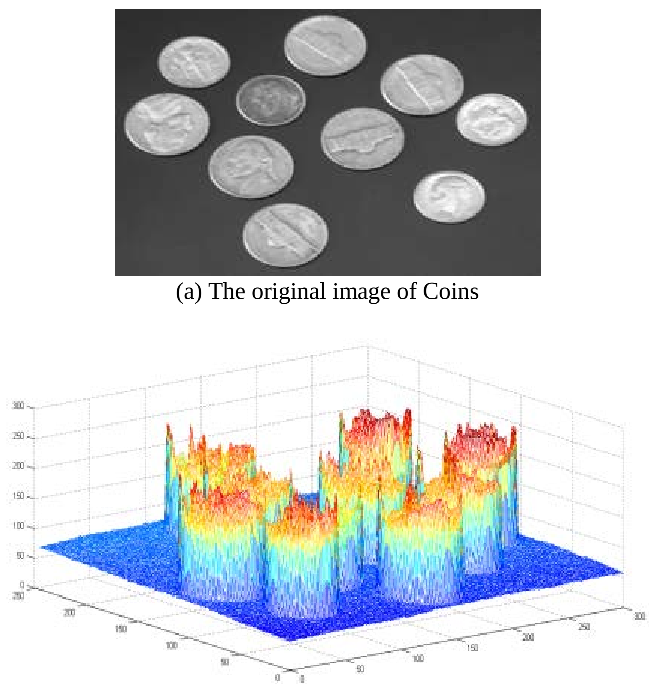
Mathematical morphology takes the morphological characteristics of images as the research goal, it describes the relationship between elements and elements, parts and parts in images with a certain form of structural elements, so as to achieve the purpose of image analysis and recognition. The most typical example of mathematical morphology using region based image segmentation is the Watershed algorithm.

Watershed algorithm is a relatively new image segmentation method based on region. The idea of this algorithm comes from the process of water accumulation in low-lying land. First, the gradient image is obtained. Then, the gradient image is regarded as a high and low topographic map. The gradient value of the flat region is smaller, and the basin is formed. The gradient value of the boundary area on the original map is large, and the ridge of the divided basin is formed. Then, water permeates the most low-lying areas in the basin, and as the water level grows, some low-lying land will be connected. In order to prevent the two blocks from being connected, the dams are built on the ridge of the two blocks. The higher the water level, the higher the dam. Finally, when the dam reaches the height of the highest ridge, the algorithm ends, and each isolated basin corresponds to a segmentation area.

Watershed transform is the catchment basins image of input image, and the boundary point between basins is watershed. The boundary between the basins is a watershed. Obviously, the watershed represents the maximum value of the input image. Therefore, in order to get the edge information, gradient images are usually used as input images, that is,

$$g(x,y) = grad(f(x,y)) = \{[f(x,y) - f(x-1,y)]* \\ 2*[f(x,y) - f(x,y-1)]\}*0.5 \quad (6)$$

In the formula, $f(x,y)$ represents the original image, and $grad\{.\}$ represents gradient operation. The following Fig.3 is the catchment basins of Coins image.



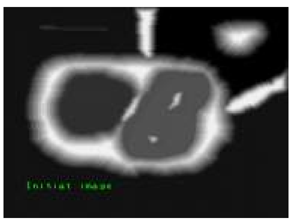
(a) The original image of Coins

(b) Catchment basins

Fig. 3. Catchment basins of Coins image

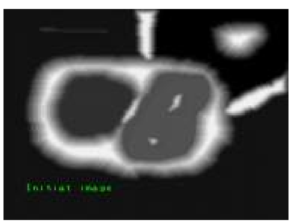
Gradient function is needed to improve to reduce the over segmentation of watershed algorithm by using gradient function. A simple improvement method is to thresh the gradient image, so as to eliminate the slight change of pixel gray value that cause over segmentation. It can be seen that watershed algorithm has a good response to weak edges, and can obtain closed continuous edges. The closed catchment basin built by watershed algorithm provides a possibility for analyzing the regional characteristics of images. The main goal of Watershed segmentation is to find the connected area of the image. It uses gradient information as input image, and there is a contradiction. It is easy to separate objects into multiple objects if they are not filtered and smoothed by gradient computation, that's because of the effect of noise. If filtering is processed, it is easy to synthesize some original objects into one object, of course, the object here mainly refers to the target area with little change or gray value.

The watershed algorithm has good robustness, and it has a good response to weak edges. The noise in the image, the slight grayscale change on the surface of the object, or the noise or local irregularities will result in over segmentation. In order to avoid such excessive segmentation, two methods can usually be used: the first one is to delete the unrelated edge information by using prior knowledge, the second one is to modify the gradient function so that the catchment basin only responds to the detected targets. The following Fig.4 is the operation principle of Watershed segmentation algorithm. Fig.5 is the over segmentation of the watershed algorithm.

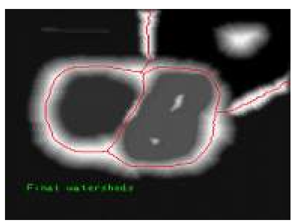


(a) Initial image

(b) Topographic surface

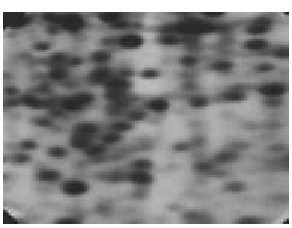


(e) Initial image

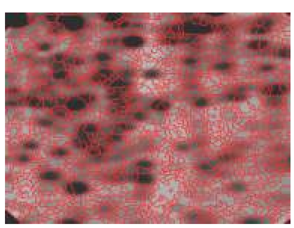


(d) Final watershed

Fig. 4. The operation principle of Watershed segmentation algorithm



(a) Electrophoretic gel image



(b) Segmentation by Watershed algorithm

Fig. 5. The over segmentation of the Watershed algorithm

D. Growing Criterion Based on Regional Gray Difference

In regional growth method, the basic operating unit is pixel and the method based on regional gray different mainly includes the following steps:

1) Assume that the threshold of gray difference is 0. Use the above method to expand the region and merge the pixels with the same gray value.

2) Seek the average gray difference between all neighboring regions and combine the neighboring regions with the minimum gray difference.

3) Set the termination criterion. Repeat the operations in Step 2 to incorporate the regions one by one until the said criterion is met and then the growing process ends.

For a region R with N pixels, its mean value is

$$m = \frac{1}{N}\sum_{R} f(x, y) \tag{7}$$

The comparison test whether the pixel is to be merged is represented as

$$\max_{R} \left| f(x, y) - m \right| < T \tag{8}$$

Here, T is the given threshold.

In the regional growing process, the gray change of the same region of the image needs to be as small as possible and that between different regions shall be as big as possible [8].

1) If the region is even, the gray value of every pixel is the sum of the mean value m and a zero-mean Gaussian noise. When using Formula (8) to test a certain pixel, the probability of invalid condition is as follows.

$$P(T) = \frac{2}{\sqrt{2\pi\sigma}}\int_T^{\infty} \exp\left(-\frac{z^2}{2\sigma^2}\right) dz \tag{9}$$

This is error probability function. When T is 3 folds of variance, the error probability is $1 \sim 99.7\%$, indicating that in consideration of mean gray value, the regional gray change shall be as small as possible [9].

2) If the region is uneven, which is constituted by the pixels of two different targets and the two parts of pixels take up q_1 and q_2 in R with gray value of m_1 and m_2 respectively, then the regional mean value is $q_1 m_1 + q_2 m_2$. For the pixels with gray value of m, its difference from the regional mean value is

$$S_m = m_1 - (q_1 m_1 + q_2 m_2) \tag{10}$$

It can be seen according to Formula (8) that the correct probability is

$$P(T) = \frac{1}{2}[P(|T - S_m|) + P(|T + S_m|)] \tag{11}$$

It means that given mean gray value, the gray difference between different parts of pixels shall be as big as possible.

The growing criterion based on the regional gray distribution statistics considers the gray distribution similarity as the growing criterion to determine the merge of the regions and divides the image into small non-overlapped regions. Then, it compares the cumulative gray histogram of neighboring regions and performs regional merge according to the gray distribution similarity. Finally, it sets the termination criterion. Assume that the cumulative gray histograms of two neighboring regions are $h_1(z)$ and $h_2(z)$, the two commonly-used detection methods are

① Kolmogorov- Smirnov Detection

$$\max_z | h_1(z) - h_2(z) | \tag{12}$$

② Smoothed- Difference Detection

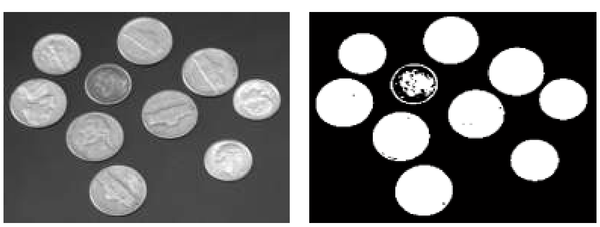
$$\sum_z | h_1(n) - h_2(2) | \tag{13}$$

If the detection result is smaller than the given threshold T , then merge these two regions. With this method, the size of the small region may greatly affect the result. The detection may not be very reliable if the size is too small and the region shape may not be ideal and small targets may be lost if it is too big. To detect the histogram similarity with Smoothed-Difference method is better than Kolmogorov-Smirnov because it has taken all gray value into consideration [10].

The following Fig.6 is global threshold segmentation, Fig.7 is Otsu threshold segmentation, Fig.8 is watershed segmentation.

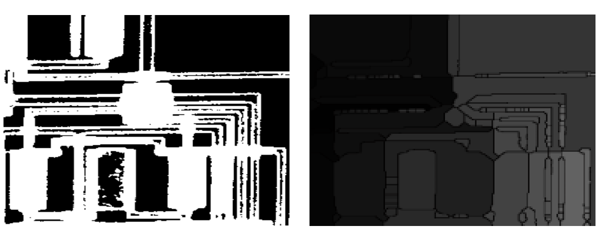
(a) Original image of trees (b) Segmentation result

Fig. 6. Global threshold segmentation



(a) Original image of coins (b) Segmentation result

Fig. 7. Otsu threshold segmentation



(a) Original image of circbw (b) Segmentation result

Fig. 8. Watershed segmentation

III. Growing Criterion of Algorithm of This Paper

Regional growth method needs to determine the seed pixel as well as growing and stopping criteria according to specific features of specific image in different practical applications and the use of different growing criteria will affect the regional growth. Generally speaking, the segmentation method based on regional growth mainly depends on the similarity measurements between pixels. Select or determine a group of seed pixels that can correctly represent the necessary region, namely the selection of seed pixels. Identify the criteria which can incorporate the neighboring pixels in the growing process. Formulate the conditions that can stop the growing process. To be specific, this method is achieved with the following steps.

1) Identify and select a group of seed pixels which can correctly represent the necessary regions and select one pixel of the region to be segmented as the seed pixel (x_0, y_0) .

2) Confirm the criterion which can include the neighborhood pixels in the growing process. This similarity measurement can be the structure, gradient gray scale, color value or other features. The similarity measurements can be determined by the identified threshold. With (x_0, y_0) as the center, consider the four neighborhood pixels (x, y) around (x_0, y_0) . If (x, y) can meet the growing rule, merge (x, y) with (x_0, y_0) and substitute (x, y) into the array.

3) Similarity can be judged by selecting the gray difference between the selected pixels and the neighborhood pixels or the gray difference between the seed region and the neighborhood regions.

Assume (m, n) is the coordinate of the basic unit (i.e. the pixel or seed region), $f(m, n)$ is the gray value of basic unit or the mean gray value of seed region, T is the threshold of gray difference and $f(i, j)$ is the gray value of the basic unit neighboring (m, n) which doesn't belong to any region yet and it hasn't been marked yet. The gray difference formula is

$$\{C = | f(i,j) - f(m,n) |\} \begin{cases} < T & merged, \text{ } belong\ to\ the\ same\ region \\ \geq T & unchanged \end{cases} \tag{14}$$

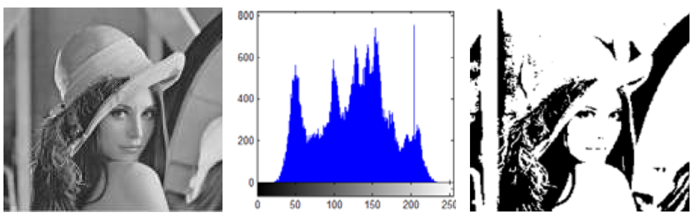
When $C < T$, it means that the basic unit (i, j) is similar to (m, n) and (i, j) should be merged with (m, n) , in other words, the same mark as (m, n) shall be added to it. Calculate the mean gray value of the seed region after the merge. When $C \geq T$, it indicates that they are different. In this way, keep $f(i, j)$ the same and it is still a basic unit that doesn't belong to any region.

4) Take out a pixel from the array and see it as (x_0, y_0) . Return to Step 2), when the region is empty, the growth ends.

Anyway, the key of this algorithm is that, starting from the seed point, find in the 4 areas meet the growth criterion, and merged into the seed region, through the push to the stack to achieve in this algorithm, each traversal of the elements will be marked. All marked elements will not be considered at the next time of detection, because it has "belonged", and the purpose of regional growth is to separate the "attribution" part from the seed point area. As iteration increase, after top and pop a element each time, the elements added to the stack are slowly decreasing, until the growth is stopped.

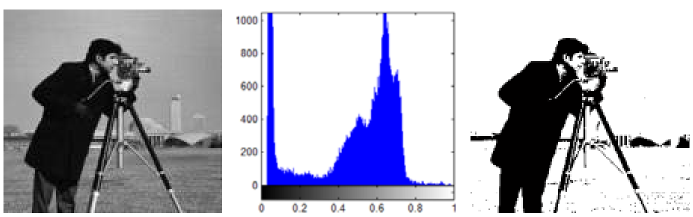
IV. Experimental Test and Analysis

The basic idea of this algorithm is to combine the pixels with similar features to construct a region. To be specific, it gives a small area or a seed region of the target object to be segmented in the image. On this basis, it adds the surrounding pixels to the region according to a certain rule so as to make all pixels which represent the object into a region. This method has adopted the foregoing growing criterion. The software tool used in this experiment is Matlab 2012 and it uses the standard test images Lena and Cameraman as the images to be segmented. The processing results are shown in Fig.9, Fig.10 and Tab.1.



(a) Original image (b) Histogram (c) Segmentation result

Fig. 9. Image segmentation of Lena



(a) Original image (b) Histogram (c) Segmentation result

Fig. 10. Image segmentation of Cameraman

Tab.1 Objective indexes of segmentation results

	Time (s)	SNR	PSNR	Threshold
Lena	0.726133	40.15	6.56	100
Onion	0.940828	43.67	7.28	100

It can be seen from Fig.9, Fig.10 and Tab.1 that the method of this paper leads to better segmentation result and the target segmented has clear and refine details. Besides, it also saves the operation time and it is highly efficient especially when it is used in large search space. In the segmentation of gray image with specific targets, it has an excellent segmentation result and high segmentation efficiency. The key to the proposed image segmentation method is the selection of the number of seeds and the determination of the threshold. When the details of the image are not too many, we can determine the approximate range of the seed number and the size of the threshold through the image histogram, and can achieve the best segmentation result by adjusting the size of the seeds and the threshold. In addition, we can do expansion operation processing of the region growing image, make the dense point area with higher gray value in the object image become larger, and prevent the disconnection, and the object image has fewer defects and better visual effect. Besides, it can also process median image of the expanded image, making the defect points in the object image further reduced, so that the object image is more continuous.

V. Conclusion

Image segmentation is an important and fundamental link in the entire field of image processing and it is the premise of target extraction and feature analysis. The image segmentation quality will directly affect the subsequent image processing, so it is of great significance. As regional growth method is the image segmentation technique which takes the direct search of regions as the foundation, its purpose is to divide the image into different regions. This study has improved the growing rule of regional growth. The experiment result has shown that the improved algorithm has improved the accuracy of image segmentation, reduced over-segmentation and insufficient segmentation, enhanced the segmentation effect and improved the operation efficiency.

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