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Two Algorithms of Image Segmentation and Measurement Method of Particle's Parameters

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Abstract: Some characteristics were used in image segmentation algorithms, however, these algorithms have some inevitable limitations, so appropriate methods were selected for a variety of practical applications against specific demands of various applications. The improved Otsu algorithm was studied in this article, and in the cluster-based image segmentation algorithm, fuzzy C-means algorithm and global optimization search (GOS) algorithm were also introduced to image segmentation. For the evaluation of the quality of image segmentation, a method of particle image measuring is proposed. The results of the simulation by different images were analyzed, studied, compared. The results through my proposed evaluation show that the improved Otsu algorithm can effectively improve the quality of image segmentation, the GOS is more effective through the simulation experiments and theoretical analysis of algorithm performance, and the method of particle image measuring could evaluate the advantages and disadvantages of image segmentation algorithms better.

Keywords: Particle's parameters; Image segmentation; Fuzzy C-means algorithm; Global optimization search

1 Introduction

Image segmentation refers to the technology and process in which images are segmented into regions each with a distinct identity, and are extracted into certain interested objects according to some features of the images [1, 2].

The Otsu algorithm [3] and my improved Otsu algorithm take advantage of classes' variance to automatically select the optimal threshold, while the latter overcame some inherent disadvantages of the traditional Otsu algorithm, such as Otsu couldn't converge to a global optimum while dealing with images discontinuous on grey level, etc. On the other hand, as the method of clustering analysis is similar to image segmentation, it can also be the theoretical basis of the research of image segmentation [1,2]. Among clustering algorithms, the fuzzy processing of Fuzzy C-Means (FCM) could reflect the actual distribution more accurately. Further, to avoid FCM converging to local minimum, a global optimization search (GOS) algorithm was introduced.

In the analysis and experiment methods, the quantitative experimental methods are most referred to and most adopted. Moreover, evaluation results with such methods are more convincing. In order to overcome problems of common segmentation evaluation methods, such as how to calculate these adhesive or overlapping regions, a method by means of measuring parameters for the particles in images is proposed.

2 The improved Otsu algorithm

In 1979, N. Otsu proposed the maximum classes variance method (known as the Otsu method) [3]. In this paper, we proposed the improved Otsu algorithm as following:

(1) Calculate the grey level L of the image, the mean grey level value μ_T of the image, and round off μ_T to $\lfloor \mu_T \rfloor$ as the grey level of the image, that is $L = \lfloor \mu_T \rfloor$;

(2) Assign initial value for segmentation frequency, $J = 1$;

(3) The implementation of Otsu algorithm. With Otsu algorithm calculate the pixel N, threshold K, threshold selection function η, in-class variance σ_w;

(4) Iterate. $N(J) = N$; $K(J) = K$; $L = K$; $\eta(J) = \eta$; $\sigma(J) = \sigma_w$; $J = J + 1$;

(5) if $J <= 1$ then goto (3);

(6) Calculate ε,

$$\varepsilon = \frac{[N(J-1) - N(J)]}{N(J-1)} - \frac{[\sigma(J-1) - \sigma(J)]}{\sigma(J-1)};$$

(7) if $\varepsilon >= 0$ then goto (3);

(8) Find the threshold corresponding to the largest $\eta(J)$, and take it as the best threshold value K.

In order to compare all kinds of algorithms, we adopt Lena.jpg and Cell.jpg shown in Figure 2.1 as the test images. With the use of the maximum entropy method, the minimum error method and the improved Otsu method, the obtained simulated images are shown in Figure 2.2-2.4.

Figure 2.1 Lena.jpg and Cell.jpg test images.

Figure 2.2 The obtained image by maximum entropy method

Figure 2.3 The obtained image by minimum error method

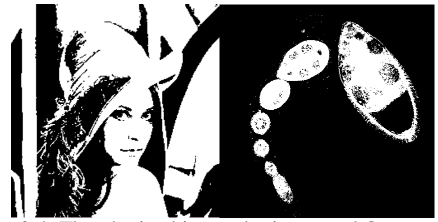


Figure 2.4 The obtained image by improved Otsu method

From Figure 2.2-2.4, we can see: In case of utilizing improved Otsu, maximum entropy, minimum error threshold segmentation methods and edge detection algorithm separately, different segmentation results are obtained. For Lena.JPG and Cell.jpg, the segmentation result of Otsu method is best, not only because the entire target is extracted completely, but the background divided into the target by mistake is also less.

3 The global searching algorithm

FCM clustering algorithm is an algorithm that iterates step-by-step. Since FCM algorithm needs initiating, and there exist many local minimum points in the target function, if initiating falls near a local minimum of the target function, it will result in the algorithm converging to local minimum. In order to solve the problem of local extremum, Selim adapted the annealing technique of global optimization to clustering, and Kamel proposed that analyzing data once leads to an adjustment of classification matrix U and the category centre V. The article carry out image segmentation with the GOS algorithm, and the steps of the algorithm are shown as below,

(1) Pop; $\min J_m(U,V)$;//Initial colony; Fitness function

(2) $P_C = 0.6$; $P_m = 0.02$;//Crossing probability; Mutation rate

(3) Code and randomly select the clustering centers of the Pop group;/*Each group of clustering centre composes of C S -dimensional vectors*/

(4) Calculate $J_m(U,V)$ and $\overline{J_m}(U,V)$;

(5) Calculate the optimum clustering centre of the current iteration $V^{(1)}$, given $k = 1$;

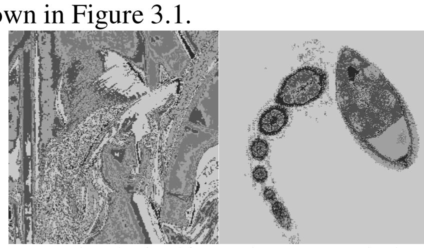
(6) The best individual instead of the worst one;// select and copy

(7) Crossing;/*Cross within every clustering centre corresponding to matching chromosomes, then regard every clustering centre as a whole, which cross between matching chromosomes, therefore, the present code length equals to C*/

(8) If some key element mutate then {regard the mean value of the former and latter ones of the key element as the mutation one of the key element, $k = k + 1$ }//mutate

(9) if $\left\| V^{(k)} - V^{(k+1)} \right\| < \varepsilon$ {Stop calculation, and output the result;}

Make use of Lena.jpg and Cell.jpg shown in Figure 1 as test images. In experiments, the initial colony is 10, the maximum of iteration number is 200, $\varepsilon = 0.001$, Crossing probability are 0.6 and 0.8, the rate before, during and after mutation are respectively 0.02, 0.03, 0.02. Simulate with FCM clustering and GOS algorithms, the obtained image is shown in Figure 3.1.



(a) The obtained image by FCM method.

(b) The obtained image by GOS method.

Figure 3.1 The obtained image by FCM and GOS method

4 The measurement method of particle's parameters

In order to better illustrate the image particles, a definition describing particles is given in this article: in a certain size range, the geometric solid with specific shapes in images are called particles. In order to accurately describe the image particle parameter measurement and evaluation methods, some general image particles are described in this article, as shown in Figure 4.1.

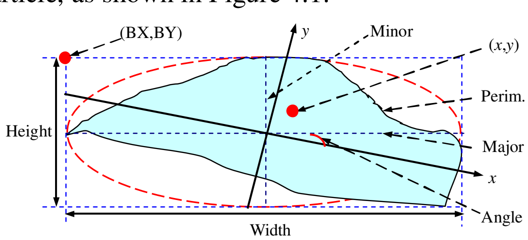


Figure 4.1 Particle image

In the smallest rectangle containing particles, with the following parameters describe its nature: Width is the width of the smallest rectangle that contains particles. Height is the height of the smallest rectangle that contains particles. BX is the upper left corner abscissa of the smallest rectangle that contains particles. BY is the upper left corner ordinate of the smallest rectangle that contains particles.

In the smallest oval that contains particles, with the following parameters describe its nature: Major is the major axis of the smallest oval that contains particles. (Also known as spindle or axis). Minor is the short axis of the smallest oval that contains particles. Angle is the angle between the major axis and the x-axis of the smallest oval that contains particles.

With the following parameters describe the shape measure: Perim is the perimeter of the edge particles. Circ's formula is $Circ. = 4\pi / \sqrt{Perim.}$.

(1) The selection of regular particles parameters: For the selection of regular particle parameters, we do not need so many parameters, for instance, the selection of parameters regarding particles as ellipse, the center is denoted with the (X, Y), the long axle with Major and the short-axle with Minor; while regarding particles as rectangular, Height express the length of rectangle, Width express the width, and so on.

(2) The selection of irregular particles parameters: For the selection of irregular particles parameters, they should be chosen according to the actual conditions. In dust images, sometimes only the amount of dust is concerned, then just calculate the number of particles (Count); for images with holes, we need to calculate the hole perimeter, area, etc.; for other image particles, we may need to calculate the particle centroid, coordinates, mean, standard deviation, etc.

(3) The calculation of parameter values of particle method: In order to calculate parameter values of particle method, we designed a particle parameter calculation method in this article, first scan the selected image region from left to right, top to bottom, determine the coordinates of the pixel value within each particle, and then store them in the corresponding array of each particle. Then obtain the rectangle and ellipse from coordinates of every particle array to determine each parameter. In the segmented image, I assumed the number of the particles in the image is *n*, and the number of pixels

in each particle is $1,2,3,\ldots,m_{\max}$, where $m_{\max}$ is the particle of the most pixels.

(4) Space complexity of my particle parameter calculation method: An n array is needed to store the coordinates of each particle (x, y), if each coordinate is expressed with two bytes, the maximum storage space is $n \times m_{\max} \times 2$, and the space complexity is $O(n^2)$.

(5) Time complexity of my particle parameter calculation method: Suppose the required processing image region is of $k \times l$ pixels, first scan the $k \times l$ pixels, at the same time determine the points of the 1 value to generate n arrays, and the time complexity is $O(k \times l)$. Calculate each particle for the resulting n arrays, and the time complexity is $O(n \times m_{\max})$.

From the performance analysis point of view, the space complexity and time complexity of particle evaluation methods are all polynomial-time and of high efficiency.

In order to illustrate the particle evaluation methods of image segmentation, here we adopt Cell.jpg as are shown in Figure 4.2 as the test images, in order to determine the shape and granularity distribution of cellular particles.

(1) Particle calculation

With the use of the image particle parameter measurement algorithms proposed by the article calculate the number of particles, particle aggregate areas, particle geometric mean scale and particle area fraction, while calculate the shape and size distribution of cells particle as is shown in Figure 4.3 and Table 1.

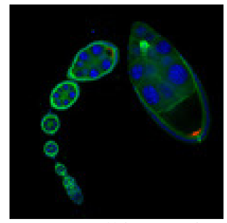


Figure 4.2 Cell.jpg test images

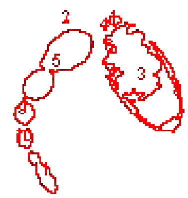


Figure 4.3 Cell.jpg test image' s particle

Table 1 The comparison of parameters for cell's particles in Figure 4.3.

Particle	1	2	3	4	5	6	7	8	9	10	11
Area	23	2	923	1	615	1	1	9	92	56	129
Mean	32	42.500	37.090	25	48.057	25	26	27.111	43.576	50.661	46.186
Min	25	31	14	25	12	25	26	25	18	25	21
Max	45	54	99	25	97	25	26	30	78	79	81
XStart	67	43	75	64	45	67	68	102	21	20	25
YStart	12	14	15	18	19	29	42	48	55	72	83

(2) Particle calculation results analysis

1) The contrast with commonly used inter-regional contrast method: With the use of particles means, we can calculate the gray scale contrast between the particles, for instance, the inter-regional contrast of 1, 2 particles is

$$GC_{1,2} = |32 - 42.5| / |32 + 42.5| = 0.1409.$$

2) The contrast with the uniformity within region method: We can contrast with the mean, the sum of all the pixel value in the particle, the mean value of particles, the third-order moment of the particle Mean, the fourth-order moment of the particle Mean and the standard deviation and so on, as is shown in Table 1.

3) The contrast with shape measurement method: We can contrast with the use of the perimeter of particles edges as well as area, as is shown in Table 1.

4) The contrast with target counting consistency method: The particle number (count) shown in Table 1, can be used to contrast.

5) The contrast with pixels number error method: Making use of the sum of all pixel values in the particles, we can contrast with pixels number error method.

From Table 1 and Figure 4.3, we can see that there is no cellular adhesion or overlap in the image of cells, and the cells are divided into 11 particles, the particle distributions are accurately calibrated in the segmentation image.

5 Summary

The thresholding technology and the feature space cluster both belong to the parallel region splitting technology, as ones of the most crucial and effective technology, and are widely used in actual image processing system. Especially developing image processing systems that need strong real-time, rapid and accurate image thresholding methods is becoming a significant research goal. On the other hand, in the clustering image segmentation algorithm, GOS algorithm is proposed in order to solve the problem that FCM algorithm tends to result in converging to local minimum. To select an applicable algorithm for a concrete image, we must implementing contrast experiment, for there is no existence of universal image segmentation algorithm. And the image particle parameter measurement method is also introduced to evaluate image segmentation methods more efficiently.

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References

[1] Huang Wei, Zhou Mingzheng, Li Xiaoni. A Color Image Edge Detection Modified Algorithm Based on Quaternion Representation. *Computer Technology and Development*, 2008, 45(3):121-124.

[2] Jia Lijuan, Zhang Guangnian, et a1. Improved method of color image segmentation [J]. *Computer Engneering and Applications*, 2008, 44(13):159-160.

[3] Otsu N. A threshold selection method from gray-level histogram [J]. *IEEE Trans. Systems Man Cybernet*, 1979, 9(1):62-66.

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