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Comment on image segmentation algorithm under the background of information age

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ABSTRACT

At present, various kinds of electronic imaging equipment have emerged endlessly, and the means of image processing are also continuously updated. As a basic technological means of image processing, image segmentation impacts on the quality of image processing. Image segmentation algorithm has many types, people measure between the qualities of image segmentation and the time required to process, and then pick out the best. This paper has discussed three image segmentation algorithms in detail, those are image segmentation algorithm based on calculus of variations, image segmentation algorithm based on clustering methodology, and image segmentation algorithm based on genetic algorithm. Image segmentation steps of these three types are respectively represented and the effects of those are shown. Meanwhile, the goal programming theory knowledge can be used to compare among the OTSU image segmentation method, the basic genetic algorithm and IGA algorithm. The result of comparison shows that IGA algorithm is the most effective one, which is consistent with the experimental results.

KEYWORDS

Image segmentation; Calculus of variations; Clustering methodology; Genetic algorithm; Goal Programming.

INTRODUCTION

With the rapid development of information science and technology, various image processing appear in people's daily lives, such as medical image processing, beauty camera application and etc. Image segmentation has laid a certain theoretical basis for image processing. In recent years, image segmentation technology is steadily progressing and various algorithms are constantly changing and improving.

In 2013, Ma Yanli pointed out that image segmentation laid a foundation for the target recognition and image understanding in the paper of the Image Segmentation and the Study of Image Restoration Based on Calculus of Variations. The author made the inconsistent grayscale images as research objects to do depth study of the law of the algorithm. It is not difficult to find that most existing algorithms are convex model, but its global solutions are hard to get. The author put forward that the pixel grayscale within the local area can be seem to accord with the Gaussian distribution, establishing convex models by second-order statistics and then to solve the model through optimized algorithm. With this, the global solution of the model can be drawn. According to this method, texture images can be segmented. Since the second-order statistics can extract the texture information intelligently and locally, the author suggested the use of characteristic features of a histogram to describe the outline of the border.

In 2012, Xu Xiaoli pointed out morphology watershed and *Ncut* image segmentation algorithm in the paper of Study on Image Segmentation Algorithms Based on Cluster Analysis. The fusion of advantages of the two is suitable for color image segmentation. Regarding the region that is segmented by the watershed method as a node for mapping, a new weight matrix is constructed by the color information and spatial location information. The author improved the algorithm of neighbor clustering color image segmentation. After pre-segmenting the color image by *MS* algorithm, the average pixel in every region can be seen as regional color value. The difference values in each region constitute the similarity matrix of the *AP* algorithm. In view of the medical image segmentation, the author put forward the hierarchical clustering algorithm, which can consider the information in whole regions and get efficient clustering results.

In 2009, Liu Junwei pointed out that medical image segmentation mainly consists of two parts in the paper of Research on Image Segmentation Method Based on Level Set and Its Application to Medical Image, one is identification of the specific organs and tissues in the images and the other is description and extraction of the complete target areas. Compared to other images, medical image is much more complicated and difficult to segment. Therefore, medical image segmentation has become a bottleneck in the medical auxiliary diagnostic techniques. Taking the Active Contour Model as an example, this paper emphasized it has some limitations. Then make the *Balloon* Model and *GVF* Model as the basis of theoretical research to improve the Active Contour Model, which can quickly segment edge fracture images and deep hollow images. For the disadvantages of this model for complex image segmentation, the author put forward a global optimal geometric model based on marginal information. The experiments proved that the model is practical.

This paper will discusses several different image segmentation algorithms and compare them to find out the most effective image segmentation algorithm.

PART OF THE IMAGE SEGMENTATION ALGORITHM

The current image segmentation algorithms are various, most of which regard mathematical method as the fundamental theoretical basis, such as calculus of variations, genetic algorithm and clustering methodology. The basic principle of calculus of variations is Lagrange equation, which can solve the problem of maximum value and minimum values, has important application in the in the theoretical research of physics. Clustering analysis method belongs to the disciplines of mathematics and

statistics, which can achieve the purpose of "like attracts like" by classification according to object's certain features. Genetic algorithm is a kind of search algorithm to compute the optimal problems in mathematics, which dose the iterative calculation based on the genetic traits in the biology. This algorithm is also in constant improvement

Image segmentation algorithm of calculus of variations

The characteristics of the variation method:

Image segmentation model based on the theory of calculus of variations is called the active contour model. This model is suitable for successive images within space and makes the partial differential equation of it as a basis of transformation of contour curve. The segmentation algorithm is relatively consistent with the aesthetic requirements of humanity and psychological change process when observing things.

(1) Uninterrupted differential operators are used to describe discrete filter in calculus of variations that is much easier to achieve local nonlinear analysis.

(2) Calculus of variations can make the theory of partial differential equations as the basis of numerical calculation so that the algorithm can have good stability.

(3) Based on the theory of calculus of variations, the processing of a variety of images can be normalized to a model, image smoothing and edge operator maintaining can be blended.

Development of active contour models:

First proposed active contour model is the *Snake* model. In the process for image segmentation, people gradually found the algorithm is inadequate, and made improvement gradually to improve the process as shown in Figure1.

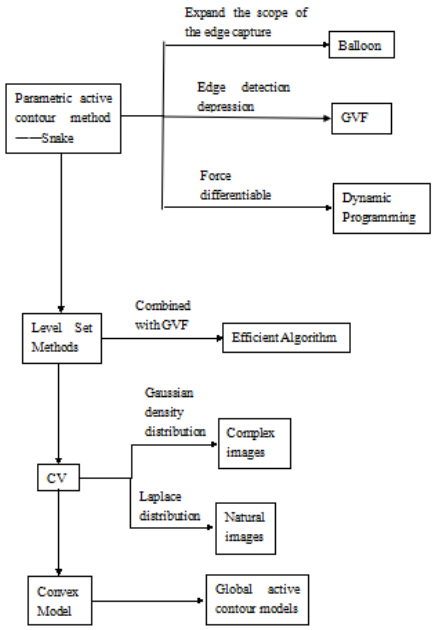

Figure 1 : Active Contour Model Improvement Process

Although *Snake* model has many advantages, but its ability to capture the image edge is weak, and it can't detect the edge of depression. In order to detect the edge of the image capturing regions, someone proposed *Balloon* model; in order to detect the edge of the recess, someone proposed *GVF* model. Of course, these types of models are parametric active contour method, and can't deal with structural change curve topology. To solve this problem, Osher put forward the zero level set method, the combination of methods and *GVF* models later developed a more effective method.

The image segmentation within the outline of the area outside the two is a prerequisite for the proposition of *CV* model, and two region homogeneity. It takes the information on both sides of the contour lines as a basis the evolution of the curve. Because of its hypothesis is straightforward. Therefore, later raised when a Gaussian density distribution of pixel values, the model for complex image segmentation, when the pixel values in line with the Laplace distribution, the model is applicable to natural image segmentation.

All the models mentioned above belong to the non-convex model, it although able to correct the problem described, but is not very accurate when solving. Later someone improved the *CV* model into the convex model, thus obtained global active contour models. Currently, global active contour model is still in the research stage, and not widely used in the actual image segmentation, some problems still need to be solved.

Cluster analysis algorithm for image segmentation

Cluster analysis is an important statistical mathematical calculation method; it is necessary tool for processing large amounts of data. With the rapid development of digital cameras and other electronic imaging devices, image segmentation difficulty is constantly increasing; the quality of segmentation, segmentation has become a bottleneck in the development of speed.

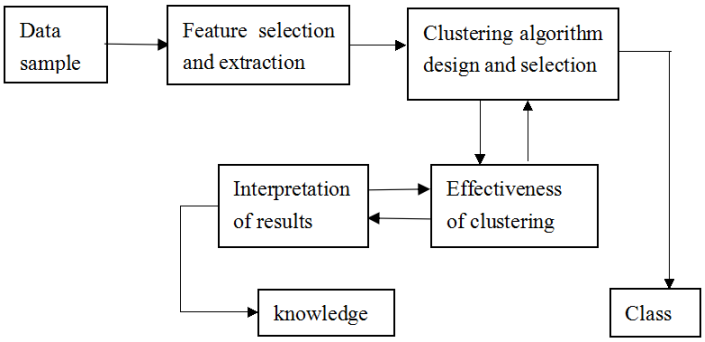

Figure 2 : Cluster analysis process diagram

There is three kinds of image segmentation algorithm based on the theory of cluster analysis of roughly. First one is the traditional spectral clustering method with a combination of morphological watershed. Second one is affinity propagation clustering algorithm. Third one is hierarchical clustering algorithm. The effect of image segmentation clustering algorithm is shown in Figure 3.

Figure 3 : Cluster analysis segmented image rendering algorithm

In Figure 3, the image above is source image and the image below shows the image after segmentation. As you can see from Figure 3, the boundaries of image segmentation are not very clear.

TRADITIONAL *Ncut* SPECTRAL CLUSTERING ALGORITHM

(1) Traditional *Ncut* spectral clustering algorithm is not suitable for processing very complicated image segmentation. But if it is combined with morphology watershed and the color image segmentation can be properly solved by taking advantage of those two. When the combination of these two ways is compared with simple *Ncut* spectral clustering algorithm, the segmented image is better; the segmented efficiency has been further improved.

(2) Affinity propagation clustering algorithm

From the current point of view, affinity propagation clustering algorithm is not suitable for complicated large-scale image segmentation. When it is combined with *MS* algorithm, the speed of image segmentation has been greatly accelerated. After the initial segmentation by using *MS* algorithm, pixel can be replaced by the amount of regions, which can greatly reduce the scale of matrix.

(3) Hierarchical clustering algorithm

Hierarchical clustering algorithm is a segmentation algorithm that can take the whole image's information into consideration. Due to the large amount of data, the algorithm running time is relatively longer. When this algorithm is combined with *MS* algorithm, the processing time can be reduced, and important roles will be played in medical image segmentation.

Image segmentation algorithm of genetic algorithms

Genetic algorithm means to find the optimal solution in the data group. Different from other methods, it is able to avoid the phenomenon of false results got from single data point. Since it can simultaneously perform a large amount of processing of multiple data, the speed of image segmentation is significantly faster.

The procedure of image segmentation by genetic algorithm is relatively simple but the total number of steps is numerous.

(1) Write basic programs. When writing programs, pixel gray field need to be set that is generally at about 0.255.

(2) Set the parameters of genetic monomers. The parameters of genetic monomers in this algorithm will directly affect the quality of image segmentation. If the parameter is too small, it can lead to inaccuracy of optimal solution; otherwise, it will result in long computation time.

(3) Set fitness function. Each monomer of heredity requires limitations that can also be called suitable amendment degree. Generally, this value may be ascertained by the pending value.

(4) Compute evolving mathematics factors. Evolving mathematics factor in models often contains gene identification, gene calling, and gene mutation. The determination of this factor is aimed to keep the individual that is suitable for evolution.

(5) The principle of algorithm termination. To define the maximum number of evolution as 50, domain values range is $[1.000,1.005]$ before proceeding to the maximum evolution generation.

(6) Do final processing of the obtained data. The solution got from this algorithm may have certain deviation from the given results. For example, on the image of 235 level grayscale, the results obtained may be different about 24 from the given one, which need to search again for solving the exact optimal solution.

The effect of genetic algorithms image segmentation

The image segmented with genetic algorithm has a more clear edge and a better visual effect. As shown in Figure 4. In Figure 4, the left-hand image is the source image; the right-hand image is the segmented image of genetic algorithm. The image below is the image of other segmentation.

Figure 4 : Segmentation comparison chart

As shown in Figure 4, the boundaries of image segmentation are much clearer, especially the hair and the hat.

COMPARISON OF IMAGE SEGMENTATION ALGORITHM

This model search for the OTSU algorithm, basic genetic algorithm and the IGA algorithm to find the most suitable for image segmentation algorithm based on goal programming theory. OTSU algorithm is the images regional information which could be used for segmentation of images. IGA algorithm is the best threshold image segmentation method based on genetic algorithm. The results table of three kinds of segmentation is shown in TABLE 1.

TABLE 1 : The results table of three kinds of segmentation

Number of experiments	OTSU Image segmentation method		The basic genetic algorithm		IGA algorithms	
	Image thresholding	Time (ms)	Image thresholding	Time (ms)	Image thresholding	Time (ms)
1	67	12.359	87	10.859	87	9.335
2	67	12.583	88	10.583	88	9.193
3	67	12.041	90	10.6674	88	9.355
4	66	12.349	86	10.643	87	9.193
5	67	12.28	85	10.661	88	9.344

Goal Programming

Goal programming is to program the problem given by the system through the method of mathematics planning, thus a set of actual desire optimal solutions are obtained. Goal programming overcame the limitations of linear programming, which can only solve a set of linear constraints. In addition, in real life, for a certain goal, both the main secondary, complement each other, in opposition to each other. At the same time there are minimum, maximum, and quantitative and qualitative. LP is unable to solve these problems, and goal programming is to overcome the shortcomings.

Generally, there are three kinds of goal programming method, the weighted coefficient of priorities and effective solutions. Among them, the weighted coefficient method is to determine a weighting each prayer targets, thereby the complex multi-objective problem is transformed into single objective problem, but the rationality of its weight is bad; Priority ranking method that is, the target will be divided into different grades, the division is based on the target to the importance of the effective method to consider the various goals, and the most satisfactory solution is obtained

The objective function of goal programming of is to press the positive and negative deviation value of each target constraint and gives the corresponding priority factor and structure. Its basic form is:

(1)The positive and negative deviation variables is as small as possible, thus to achieve the target.

$$\min z = f(d^+ + d^-)$$

(2)The positive and negative deviation variables as small as possible, even not achieve the target.

$$\min z = f(d^+)$$

(3)Negative deviation is as small as possible and surpasses the target, and the amount is beyond limitation.

$$\min z = f(d^-)$$

Among them, the meaning of positive and negative deviation variables is as follows:

If d is the function of the decision variables, the positive deviation variables $d^+ = \max\{d - d_0, 0\}$ represents the part of decision-making value over the target value, the negative deviation variables $d^- = -\min\{d - d_0, 0\}$ represents the part which didn't reach the target. And d_0 is the target value of d, then $d^+ \times d^- = 0$ is constantly existed.

Priority factors: $P_1, P_2, \cdots, ,$ and $P_k >> P_{k+1}, k = 1,1, \cdots, q$. Which represents P_k has a greater priority than P_{k+1}.

A general mathematical model of goal programming

If $x_j (j = 1,2, \cdots, n)$ is the decision variables of goal programming, there is m constraints which are rigid constraints, equality constraint, or inequality constraints. There is l flexible goal constraint, and its planning constraints of goal deviation is d^+, $d_i^- (i = 1,2, \cdots, l)$. There is a priority level, respectively $P_1, P_2, P_3, \cdots, P_q$. There is different weight in the same priority P_k, that is ω_{kj}^+, $\omega_{kj}^- (j = 1,2, \cdots, l)$. So the general mathematical expression for the goal programming is:

$$\min z = \sum_{k=1}^{q} P_k \left(\sum_{j=1}^{l} \omega^-{}_{kj} d_j^- + \omega^+{}_{kj} d_j^+ \right)$$

$$\begin{cases} \sum_{j=1}^{n} a_{ij} x_j \le (=, \ge) b_i, i = 1, \cdots, m \\ \sum_{j=1}^{n} c_{ij} x_j + d_i^- - d_i^+ = g_i, i = 1, \cdots, l \\ x_j \ge 0, \ j = 1,2, \cdots, n \\ d_i^-, d_i^+ \ge 0, i = 1,2, \cdots, l \end{cases}$$

Comparison process

On the basis of the above goal programming of guiding ideology, make data tables for data processing of image segmentation effect. As shown in TABLE 2, by using the algorithm of sequential type here. Sequential algorithm is based on the order of the priority, the complex goal programming problem into multiple single objective programming problem, the main process is as follows:

Firstly, the image segmentation quality is affected by the image threshold, that is the first class P_1 , secondly, Its quality will be affected by the running time of the image segmentation, that is the second class P_2 .

TABLE 2 : Effect value of each algorithm

Algorithm	Threshold	Time (ms)
OTSU segmentation algorithm	66.8	12.3
Genetic algorithm	87.2	10.7
IGA algorithm	87.6	9.3

The corresponding goal programming model is obtained by TABLE 2:

$$\min z = P_1 d_1^- + P_2 (d_2^+ + d_2^-)$$
$$66.8x_1 + 87.2x_2 + 87.6x_3 \geq 100$$

$$12.3x_1 + 10.7x_2 + 9.3x_3 \leq 15$$

$$x_1, x_2, \cdots, x_i, d_i^+, d_i^- \geq 0, i = 1,2,3$$

Calculated the target function by MATLAB software, thus the optimal solution of goal programming is obtained. $z^* = (3)$. The results is obtained from theoretical analysis above illustrates the IGA algorithm is scientific.

From the perspective of experiment, the experiment result is as shown in Figure 5.

Figure 5 : The experimental results figure

In Figure 4, the left-hand image is the source image; the right-hand image is the segmented image of genetic algorithm. The image below is the image of GA segmentation. We can see that the

image of GA is clearer in outline than the image of genetic algorithm, and The observer's visual feeling is better

CONCLUSION

Image segmentation is the basis of image processing; there are many types in image segmentation, and including division according to gray scale, edge information and segmentation in a variety of ways. According to present application, it is difficult to meet the use requirement for only a segmentation algorithm. The two kinds of algorithms are usually combined. In this paper, the theoretical knowledge of goal programming problem is applied to explore the best image segmentation algorithm, the results show that IGA algorithm is the most effective algorithm.

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