

An Improved Algorithm of Parameter Kernel Cutting Based on Complex Fusion Image

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Abstract—Aiming at the problem that the color image with more detailed textures is not highly segmented in the image segmentation process, a PKGC image segmentation method based on improved edge detection difference ratio is proposed. The method first constructs an energy function by using a parametric kernel graph cutting algorithm. Then, the value of the three-channel RGB edge detection ratio of the color image is used to change the constant balance factor in the energy function to change the ratio of the data item and the boundary smoothing term in the energy function, so that the image segmentation effect is optimal. The segmentation results of different experimental show that the improved paper method has better segmentation precision and better segmentation of texture details for complex images.

Keywords—image segmentation; energy function; parameter kernel segmentation; edge detection

I. INTRODUCTION

Complex color images have great research significance for image fusion algorithms. As in [1], the seam line detection method is used as a common method for complex image fusion. While the seam line passes through flat areas of some images where the color, brightness, and texture are simple or even uniform, image fusion works best. Therefore, the implementation of seam line detection algorithm requires high accuracy in extracting details of image texture in image segmentation. The first step in the seam line detection method is to determine the background area of the image and the salient target by image segmentation in [2]. In summary, improving the segmentation of image texture details has great research significance.

As in [3], image segmentation refers to the technique of extracting a target object according to the same features of each region in a complex background environment. In 2004, Boykov and Kolmogorov proposed the graph cut method in [4], which is usually applied to extract the foreground and background areas of an image. In the research process based on seam line detection, the accuracy of the background region segmentation effect directly affects the determination of the seam line position and the quality of the image fusion effect. In 2011, Salah et al. associate the graph cut algorithm with the nuclear clustering idea and propose a parametric kernel graph cut algorithm in [5]. The algorithm has significantly improved the flexibility and accuracy of image segmentation. In 2017, Dong Qiang proposed a new seam line detection method based on the

parametric kernel graph cutting algorithm, which can solve the problems of “geometric misalignment” and “distortion” in the image captured by the drone. Nonetheless, for the complex image, the color of the target object is close to the background area. The method has low segmentation precision and it could not meet the application of image processing in real life.

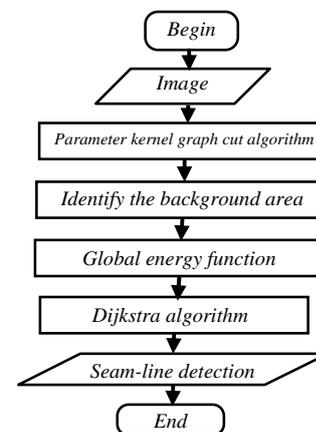


FIGURE 1. FLOW CHART OF THE SEAM LINE METHOD

In this paper, we present an improved algorithm based on parametric kernel graph cut to achieve image segmentation, which can improve the segmentation accuracy of complex images and make the method of determining the best seam line detection better in the field of image fusion.

II. IMPROVEMENT OF NUCLEAR MAP CUTTING ALGORITHM

A. Principle of the Seam Line Detection Method

The seam line detection method can effectively solve these problems, such as the "geometric dislocation" and the "ghosting" effect caused by image distortion during image mosaic fusion. It has great research value in the field of image processing. The flow chart implemented by this method is shown in Figure 1. It can be seen from the flow chart realizing the seam line detection method. Firstly, the fusion image needs to be segmented by the parameter kernel graph cut algorithm. The background region and prominent target region can be distinguished effectively.

B. Parameter Kernel Graph Cut Algorithm

The parameter kernel graph cutting algorithm is based on the graph cut method, and the complex image data is linearly separable by introducing the nuclear clustering idea. The method consists of three stages. Firstly, transform the original image data to be fused into high-dimensional feature space by kernel function mapping. Then calculate the piecewise constant model parameters of image data in nuclear space. Finally, a new graph cut energy function algorithm is established.

The segmentation energy function of parameter kernel graph cut algorithm is defined as follows:

$$F_K(\{\mu_l\}, \lambda) = \sum_{l \in L} \sum_{p \in R_l} (\varphi(\mu_l) - \varphi(I_p))^2 + \alpha \sum_{\{p, q \in N\}} r(\lambda(p), \lambda(q)) \quad (1)$$

where F_K is the value of non-Euclidean distance of regional parameters μ_l and observed data in the nuclear-induced space; $\varphi(\square)$ is a mapping method in which image data is nonlinearly transformed into a high-dimensional feature space by a kernel function; α is a non-weighting equilibrium factor.

The kernel function is implemented by the dot product of the vector in the feature space, defined as follows:

$$K(y, z) = \varphi(y)^T \square \varphi(z), \forall (y, z \in I^2) \quad (2)$$

Since the non-Euclidean distance in nuclear induced space can be defined as:

$$J_k(I_p, \mu) = \|\varphi(I_p) - \varphi(\mu)\|^2 = K(I_p, I_p) + K(\mu, \mu) - 2K(I_p, \mu), \mu \in \{\mu_l\}_{1 \leq l \leq N_{seg}} \quad (3)$$

Equation (3) is substituted into equation (1) to get:

$$F_K(\{\mu_l\}, \lambda) = \sum_{l \in L} \sum_{p \in R_l} J_k(I_p, \mu_l) + \alpha \sum_{\{p, q \in N\}} r(\lambda(p), \lambda(q)) \quad (4)$$

where the target energy function F_K is only related to the region parameters $\{\mu_l\}$ and labels $\lambda(\bullet)$.

In summary, the parameter kernel graph cutting algorithm. consist of realizing the spatial nucleation of image data via kernel function modeling, iterating the distance and smoothing terms by iterative model and achieving energy function minimization solution. Introducing a constant balance factor in the energy function, it is a coordination factor α between the distance term and the smoothed term of the image data.

C. Improved Parameter Kernel Map Cutting Algorithm

In the image fusion process, the optimal stitching line found needs to pass through the area where the background area of the image is flat and the texture is simple and consistent. It has the best fusion effect. Therefore, it has great requirements for the segmentation effect of the image, especially the segmentation accuracy of the image detail texture.

In order to improve the segmentation accuracy of complex background images, we present an improved algorithm based on parametric kernel graph cut with further studied in this paper. The implementation step is shown in Figure 2. Our method consists of three stages. The first step consists of constructing the energy function via the parameter kernel graph cutting algorithm. The second step consists of realizing dynamic adjustment of balance factor in energy function via calculating the difference ratio of edge detection of color image. The third step consists of constructing a new energy function and obtaining the minimum value to realize image segmentation via iterating the function.

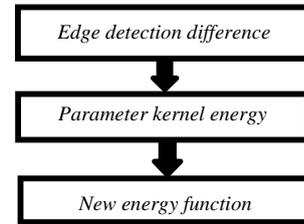


FIGURE II. STEP BLOCK DIAGRAM OF THE IMPROVED ALGORITHM.

Parametric kernel graph cutting algorithm and graph cutting algorithm realize image segmentation by constructing energy function. The energy functions have a constant balance factor α to adjust the relationship between the data term and the distance term, which is generally an arbitrary constant between 0 and 1. However, a large number of experimental results indicate that the equilibrium factor α makes the segmentation results very unstable. Because the balance factor α is a constant value, it cannot be dynamically adjusted when processing different types of images. Therefore, it is very important to dynamically determine the value of equilibrium factor α for kernel graph cutting algorithm.

In this paper, a large number of experiments are carried out on the above problems. By changing the value of the parameter α several times, there is a specific interval for the balance factor α of different types of images, within which there is little difference in the image segmentation effect. If the interval value is exceeded, the segmentation results will be significantly different. In this paper, the error percentage of single channel edge detection in color image is introduced into the balance factor α . It is ensure that the parameters α can be adjusted automatically according to the image type and the parameters can change in a stable range at the same time.

As in [6], color image edge detection method is an important tool for image segmentation that can achieve the extraction of contour edges in images. The edge detection is

realized by differentiating the gray value of the image with differential operator. Sobel operator in [7] and Canny operator in [8] are commonly used differential operators for image edge detection, which are widely used in image edge extraction. In most cases, image segmentation and image edge extraction are achieved via converting a color image into a grayscale image.

Color image is composed of R, G and B color component images. Edge detection can usually achieve image segmentation based on a single image or directly in the color vector space. But the realization of edge detection cannot be realized by edge detection of three components respectively. There are differences between the edge pixel features of a single channel image and the pixel features detected by the color image, which cannot represent the overall color change difference.

Location accuracy of edge detection is the main criterion of edge detection quality. The single-channel edge detection and comprehensive improvement of the three colors respectively can obtain the best edge detection quality. The lower the difference between the three-color channels, the better the image edge extraction effect. Therefore, this paper proposes to introduce the difference ratio of edge detection into the energy function to achieve dynamic adjustment of the balance factor. Due to the different ratio of edge detection in different images, the corresponding values obtained are not consistent. In addition, adding logarithms to the calculation also stabilizes the result between expected values.

The new calculation formula α is shown as follows:

$$\alpha = |1 + \lg(1 + |R/C|)| \quad (5)$$

where R/C is the error ratio of color component edge detection in single channel of color image, which is defined as follows:

$$R/C = \frac{\min(G_I - G_r, G_I - G_g, G_I - G_b)}{G_I} \quad (6)$$

where $G(x)$ represents the edge detection function of the color image and the three-channel component. Bringing the (5) into the (4) yields a new energy function for the purpose of image segmentation.

The above is the implementation of improved algorithm based on parameter kernel graph cut mentioned in this paper. Its advantage is to dynamically adjust the value of the balance factor in the energy function, and improve the accuracy of segmentation images. It is conducive to the realization of seam line detection. The experimental analysis of this method will be carried out below.

III. RESULTS AND EVALUATION

In this paper the algorithm is implemented on Matlab-R2017b experimental platform. The running environment of

the experiment was Inter(R) Core (TM) i7-479 CPU 3.60 GHz CPU and 8GB RAM. First select three images of different degrees of complexity in the Berkeley database [9]. The improved algorithm and the parameter kernel graph cutting algorithm are used to segment the image, and the segmentation accuracy of the two is compared. Precision, Recall and F-measure are three commonly used measures for verifying the accuracy of results in [10]. Comparative analysis of t Precision, Recall and F-measure parameters for segmentation results. In addition, the segmentation results between two images to be spliced and fused are compared. It further proves that the improved algorithm proposed in this paper can achieve better segmentation effect. The texture detail segmentation of the image background area is more accurate.

Figure 3 shows the segmentation results of images with simple background and complex background respectively by the parametric kernel graph cutting algorithm and the improved parametric kernel graph cutting algorithm. Among them, the value of dynamic equilibrium factor in the parameter kernel graph cutting method was selected within a specific range after repeated comparison experiments, i.e. $\alpha = 0.1$. It can be seen intuitively from the figure that the improved algorithm proposed in this paper has better segmentation effect for color images, and some minor details such as the background area of the image after segmentation are more obvious.

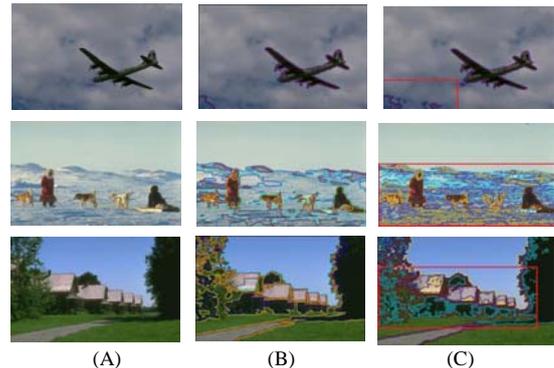


FIGURE III. SEGMENTATION OF THREE IMAGE WITH DIFFERENT METHOD (A) ORIGINAL IMAGES. (B) IMAGES OBTAINED BY PARAMETER KERNEL GRAPH CUT METHOD. (C) IMAGES OBTAINED BY IMPROVED METHOD.

Table 1 is the detection of image segmentation results of the parametric kernel graph cutting algorithm and the improved parametric kernel graph cutting algorithm. That is, three kinds of parameter values are evaluated and compared. As can be seen from the table, the improved method in this paper is more than the parameter of the parameter nuclear map cutting method. The Precision value has been significantly improved, and a comprehensive evaluation of the exact value and the recall value is performed. The value of the F-measure parameter has also been improved, that is, the accuracy rate has increased by about 4% on average. Therefore, from the perspective of data analysis, this paper further proves that the improved parametric kernel graph cutting algorithm is superior to parametric kernel graph cutting algorithm in terms of image segmentation accuracy through the numerical results of three

parameters are compared. It is also proved that this algorithm is more flexible than the parametric kernel graph cutting algorithm.

In this paper, a group of images taken by mobile phones that need to be fused are segmented to verify the superiority of

this improved method over the parametric kernel graph cutting segmentation results are shown in Figure 4. Figure 4-(a) and 4-(b) show two original images of the fused picture, figure 4-(c) shows the overlapping portions extracted during the image fusion process. The parametric image segmentation algorithm and the method are used to segment the overlapping parts of

TABLE I. COMPARISON OF PARAMETERS OF SEGMENTATION METHOD

Name	Fig.3(a1)		Fig.3(a2)		Fig.3 (a3)	
	PKGC	Improved-method	PKGC	Improved-method	PKGC	Improved-method
Precision	0.9918	0.9936	0.9232	0.9384	0.8210	0.9743
Recall	0.9619	0.9653	0.7491	0.8700	0.8438	0.7887
F-measure	0.9766	0.9793	0.8271	0.9030	0.8322	0.8717

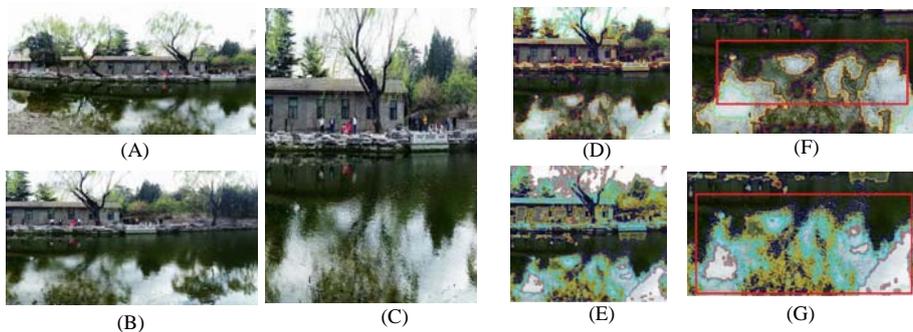


FIGURE IV. FUSION IMAGE SEGMENTATION RESULTS

the image respectively. The results are shown in Figure 4-(d) and Figure 4-(e). The results of Figure 4-(f) and Figure 4-(g) is more elaborate. In summary, the improved algorithm for parameter kernel map cut proposed in this paper has great practicability. It is more reasonable and accurate for the segmentation extraction of the detail texture of background regions, and improves the detection efficiency and accuracy of the optimal seam line.

IV. CONCLUSION

In this paper, an improved kernel graph cutting algorithm is proposed based on the complex images. This method, firstly, constructs the energy function by means of kernel function mapping. Then, it realized the dynamic adjustment of the balance factor in the energy function by introducing the difference ratio of the single-channel edge detection of the color image. Finally, the method constructs a new energy function to realize image segmentation. By comparing the segmentation results of different types of image segmentation, we can conclude that the improved parametric kernel graph segmentation algorithm has higher segmentation precision and more applicability.

The algorithm has achieved good results in the extraction of texture details of the background region of the image in the process of image segmentation, but the algorithm has not improved the timeliness of image segmentation. How to effectively improve the efficiency of the algorithm in future work requires further research.

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