Partition Method of Infrared Image Using Otsu Algorithm and Morphology

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***Abstract*—Infrared image segmentation is the basis of the infrared target detection identification. The key point of image threshold segmentation algorithm to realize the effective segmentation of the target and background is choosing appropriate and accurate threshold. This paper studies the current commonly used infrared image threshold segmentation method, proposes the image segmentation method combined with morphology based on the analysis of the segmentation results of maximum between-cluster variance algorithm (Otsu method). The algorithm simulation experiment is also carried out in this paper according to different situations of different target. The shape of the image segmentation result is basically intact, which has made up for the details of target and segmented the target.**

Keywords—Infrared image; Image segmentation; Maximum between-cluster variance; Morphology

I. INTRODUCTION

The purpose of image segmentation is to divide the area that people interested in, and using some characteristic information contained in the image at the same time. Besides, image segmentation is the foundation of infrared image target detection and recognition, and will influence the subsequent image processing work. So the role of image segmentation cannot be ignored.

Due to its intuitive and implement conveniently, the threshold segmentation method, which is simple and effective, is one of most representative way in infrared image segmentation methods. It has an obvious difference between infrared target and background, which is considered in the image threshold segmentation algorithm to classify the pixels according to the different grayscale and form the infrared target and back ground region. This kind of method is particularly applicable to the image which has a great range of grayscale of target and background. The commonly use methods are the histogram method, the iterative threshold method, the maximum between-cluster variance threshold method (Otsu method), the adaptive threshold method, and so on.

II. THE MAXIMUM BETWEEN-CLUSTER VARIANCE THRESHOLD METHOD

The maximum between-cluster variance threshold method (Otsu method) uses the maximum variance between target and background as the principle to select threshold. It has some advantages as simple calculation and nice stability, so it has been widely used in many fields. The least square method is the core concept of algorithm, and is a classical automatic threshold segmentation method without supervision and parameters. Its basic idea is to divide the image into two parts by initial threshold which is the grayscale level of a pixel of the image, and then calculate the variance of both parts, and finally use the maximum variance as a threshold for image segmentation.

Assume that the number of gray values in a image is m, and the number of pixels with i gray values is n_i . So the total number of pixels is:

$$N = \sum_{i1}^{m} n_i \tag{1}$$

The probability of each gray value is:

$$P_i = \frac{n_i}{N} \tag{2}$$

Then use the value of k to divide the gray values into two groups: $C_0 = [1 \mathrm{L}\, k]$ and $C_0 = [1 \mathrm{L}\, k]$. The probability of group is:

$$w_0 = \frac{\sum_{i=1}^{k} n_i}{N} = \sum_{i=1}^{k} p_i \tag{3}$$

The probability of group C_1 is:

$$w_1 = \frac{\sum_{i=k+1}^{m} n_i}{N} = \sum_{i=k+1}^{m} p_i = 1 - w_0 \tag{4}$$

The average gray value of group C_0 is:

$$u_0 = \frac{\sum_{i=1}^{k} n_i * i}{\sum_{i=1}^{m} n_i} = \frac{\sum_{i=1}^{m} p_i * i}{w_0} \tag{5}$$

The average gray value of group C_1 is:

$$u_1 = \frac{\sum_{i=k+1}^{m} n_i * i}{\sum_{i=k+1}^{m} n_i} = \frac{\sum_{i=k+1}^{m} p_i * i}{w_1} \tag{6}$$

The overall average gray value is:

$$u = \sum_{i=1}^{m} p_i * i \tag{7}$$

Among these, when the threshold is k , the average grayscale is:

$$u(k) = \sum_{i=1}^{k} p_i * i \tag{8}$$

$\mu = w_0 u_0 + w_1 u_1$ is the average grayscale at sampling pixels. The calculation of the variance between the two groups is as follow:

$$d(k) = w_0 (u_0 - u)^2 + w_1 (u - u_1)^2 \tag{9}$$

It can be derived by the overall gray value and Equation (9):

$$d(k) = w_0 w_1 (u_1 - u_2)^2 \tag{10}$$

Change the k value among 1 to m to get k^* and $d(k^*) = \max(d(k))$: then use k as the best threshold to finish the segmentation. The segmentation effect is the best at this situation.

III. THEORY OF IMAGE MORPHOLOGY

Image morphology, described by the language of set theory, is mainly used to extract shape component of interested area of the image, in order to provide shape feature of target for the follow-up work of image detection and recognition.

Morphological image processing is a neighborhood operation that aiming at foreground objects. Its operation process is continuously moving structure elements and making intersection and union operation with corresponding area in the image. Structure element, called as special definition of neighborhood, is always used to investigate the relationship between the various parts of the image. The chosen of size and shape and the operation property are all the important factors that will influence the effect of morphological operation. There are some commonly used basic image morphology operations like erosion, dilation, opening-and-closing operation and whether hit the target or not.

A. Image erosion

Erosion is the basis of morphological processing, which effect is to filter the details smaller than structure elements in the image. The result is influenced by the image itself and the origin position of the structural elements.

Assume that image collection is ***A***, structure element is ***B***. So it can be defined as $A \Theta B$ if image ***A*** is corroded by structure element ***B***. The formal definition shown as follow:

$$A \Theta B = \{x \,|\, (B)_x \subseteq X\} \tag{11}$$

In this, ***x*** represents translational displacement.

The process of erosion operation is that make structure element ***B*** move on image ***A***, and mark the location of the origin when a sub image that is same as the structure element appears. The collection of all marked points on image is the result of erosion.

B. Image dilation

Dilation is another basis morphological operation that has an opposite effect as erosion. It uses the selected structure element to make the target object in the image growth or coarsening operation. This can effectively fill the cavity after segmentation. The concept of dilation is defined as:

$$A \oplus B = \{x \,|\, (B^V)_x \cap X \neq \Phi\} \tag{12}$$

First do a map about ***B*** itself origin to get a collection B^V , and then translate B^V on the image ***A***. After translation there will be at least one element of B^V overlap ***A***, so the dilation that ***B*** to A is the collection its corresponding origin positions.

There is a dual relationship between erosion and dilation, which is:

$$A \oplus B = (A^c \Theta \overline{B})^c$$

$$A \Theta B = (A^c \oplus \overline{B})^c \tag{13}$$

C. Image opening-and-closing operation

In the morphological image processing, opening-and-closing operation is formed based on the irreversible relationship of erosion and dilation. Opening operation and closing operation also have the dual relationship with each other.

It can be defined as $A \bullet B$ when opening operation is adopted by structure element ***B*** to ***A***. The mathematical expression is shown as follow:

$$A \bullet B = (A \oplus B) \Theta B \tag{14}$$

Closing operation is a nonempty set got from structure element through reflection and translation. Its function is to fix the gap and elongated bent-gate between objects, fill the tiny crack of contours and smooth image edges.

IV. *INFRARED IMAGE SEGMENTATION METHOD BASED ON OTSU ALGORITHM AND MORPHOLOGY*

From above it can be learned that it is necessary to calculate all gray value variance from 1 to ***m*** to get the maximum variance of target and background, which means that it would take a large amount of calculation. For some images which have single background and obvious contrast between target and background, the Otsu method can finish target

segmentation better and wouldn't be influenced by the target relative area size; When background becomes more complicated or the contrast gets lower, the effect of Otsu method gets worse and would cause serious false segmentation easily. Otsu method is simple and practical but easy to be intervened by background and noise.

To solve these problems, this paper introduced mathematical morphology and combined it with Otsu algorithm for infrared image segmentation; first use Otsu method to segment infrared image, then use morphology to finish dilation, erosion, smoothing image, filling gaps and refining details to improve the segmentation quality. Its main calculation steps are as follow:

1) First, read in a picture and format conversion to turn it into a grayscale.

2) Use Otsu algorithm on grayscale for the automatic threshold segmentation to get a preliminary segmentation binarization image.

3) After the Otsu threshold, a few small area of noise zone would be existed in the segmentation result, which should be removed by the seed filling algorithm.

4) Use morphological processing method to fill contour areas and eliminate holes to the binary image after segmentation.

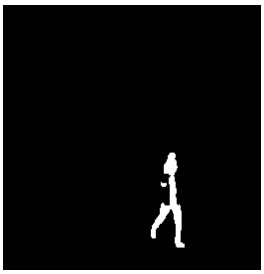
V. THE EXPERIMENTAL SIMULATION AND ANALYSIS

The IMAQ Morphology VI function, which is used to carry out the morphological operation in the LabVIEW software, includes a variety of morphological processing method and can be set structure element arbitrarily. This study, taken on the LabVIEW platform, uses graphical development language programme to verify the superiority of the algorithm.

Experiment 1: single target infrared image segmentation under simple background

There are three images in Fig.1: original infrared image, image segmented by Otsu method and image segmented by the combined effect of algorithm and morphology. It has been shown in Fig(b) that the image has fuzzy edges and some undivided parts of target. In Fig(c), the target has been reasonably divided, and image information has been kept well.

(a)Original infrared imag



(b) Otsu segmentation

(c) Combination of Otsu & morphology

Fig.1. Single target infrared image segmentation

Experiment 2: Multiple targets infrared image segmentation in near scene

There are three images in Fig.2: original infrared image, image segmented by Otsu method and image segmented by the combined effect of algorithm and morphology. Similarly, cavities appear in the target when segmented by a single Otsu algorithm. By contrast, cavities have been effectively filled after morphological dilation operation.

(a) Original infrared image

(b) Otsu segmentation

(c) Combination of Otsu & morphology

Fig.2. Multiple targets infrared image segmentation in near scene

Experiment 3: Infrared image segmentation in complex scene

The effect sketch of infrared image segmentation in complex scene with multiple backgrounds is shown in Fig.3 From experiments above, it can be learned that Otsu algorithm cannot get ideal effects in complex scene. However, use composite computation can get better effect than Otsu method, which means this algorithm can get satisfied segmentation effect in complex background.

(a) Original infrared image (b) Otsu segmentation

(c) Combination of Otsu & morphology

Fig.3. Infrared image segmentation in complex scene

From all the experiment in this article, Otsu algorithm would cause cavities in image because of the infrared image's characteristic and partitioning algorithm's limitation. The morphological processing method can keep the target information better and fix image details to improve the quality of image segmentation. Meanwhile, this method accelerates the segmentation time and meets the requirement of real-time.

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Maximum between-cluster variance algorithm (Otsu method) is a classical automatic threshold segmentation method without supervision and parameters. It has been widely used in many fields owing to its simple design and good stability. Image morphology is described by the language of set theory, and as a result it has strong mathematical tools for image processing and analysis. In this paper, infrared image segmentation has been settled through the combination of Otsu algorithm and mathematical morphology. The segmentation result of different targets in different situations goes well, which keeps the whole shape, and makes up the details.

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