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Infrared image segmentation using growing immune field and clone threshold

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HIGHLIGHTS

- An infrared image segmentation algorithm using growing immune field and clone threshold is proposed.
- The algorithm applies the growth immune field which is the combination of immunology and image processing.
- This method uses a regulated growing immune field to prevent the overgrowth.

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ABSTRACT

Fast and accurate segmentation of infrared target is the basis of automatic target recognition, but there is a problem that it is easy to appear the significant differences of target areas in segmentation. In order to solve this problem, in this paper a new method based on growing immune field and clone threshold for segmentation of infrared targets is introduced. First, according to the global gray information, obtain the best threshold of the image using the clonal selection algorithm for global threshold segmentation. And the seed region is selected based on global threshold segmentation. Second, the source seeds are obtained by comparing the similarity threshold with seed region. Third, the growing immune field is adjusted automatically for region growing through the source seeds. Finally, the segmented image is obtained by immune region growing. The simulation results show that the target information gained by the proposed method is complete and exact. This resultgreatly facilitates the target recognition.

1. Introduction

Infrared imaging system is widely used in the field of automatic target recognition and tracking because of its advantages such as good function, long distance, environment adaptability and anti-stealth ability [1,2]. And infrared and thermal imaging sensors, which provide excellent visible cues in unconventional settings (e.g., night time visibility), have historically found their use limited to military, security and medical applications [3]. So fast and accurate segmentation of infrared image targetsis very important.

Image segmentation aims to partition a given image into a number of constituent regions so as to extract objects of specific, distinctive features from image background [4]. Segmentation techniques can be generally categorized into two frameworks, edge-based and region-based approaches [5].

As a segmentation technique, the mathematical morphology process is an application based on lattice theory in spatial structures. Understanding the relationship between pixels and sorting them according to their characteristics becomes crucial [6]. Reference [7] combines the mathematical morphology transform and morphological gradient transform for infrared image target under complex background extraction, but, the target information will have the mistakewhen the interference of similar targets and background.

As the simplest technique for image segmentation, image thresholding usually only needs the information embedded in gray levels of pixels in an image [8]. Regarding the threshold segmentation, an adaptive threshold segmentation method [9] based on Otsu algorithm and iterative algorithm can segment images in complex background, but this threshold segmentation may cause threshold error when the scene changes drastically in some special images, which results in the reduction of segmentation effect. Reference [10] introduces a novel threshold method for segmentation. This algorithm has good segmentation effect on color image seg-

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mentation. But for some images with special image features, the effect is not obvious.

Region growing method is a method that uses the similarity of the gray levels in the region, and has a good segmentation effect on the image with uniform feature information. Reference [11,12] suggests combining region growing and edge detection for image segmentation. As a result, the connected region has very good segmentation effect, but these algorithms don't segment infrared images or special feature images.

The limitations of a single method can improve the segmentation effect by combining a variety of ways, reference [13] determines to remove the background interference by using morphology and use automatic region growing segmentation. Reference [14] presents a method that combines region growingand edge detection for image segmentation. And an integrated segmentation technique [15] proposed combines the strengths of the square-error clustering algorithm and the technique of applying an edge detector.

Compared withinfrared images which have obvious global difference for the target and background, in some cases, due to the imaging conditions and the environment, there are still significant differences in the target area, and the edge of the infrared image is blurred. At this time, single segmentation method and some segmentation ways for specific features have been very difficult to get good results. Reference [16] has proposed a threshold segmentation approach based on immune clonal algorithm. The segmentation can be significantly, but for the image in this paper, due to significant differences in the target area, the threshold obtained is too low to lead to over segmentation. There will be a lot of noise spots around the target area. And using another adaptive threshold segmentation approach based on Otsu [9], its result shows the significant difference of target region and the fuzzy of edge influencethreshold which is too large to segment only some of the targets.

In this paper, a new method based on growing immune field and clone threshold for segmentation of infrared targets is proposed, to extract the region seed, firstly obtain the optimal threshold using clonal selection, and then a threshold technique is applied to obtain region seed candidate, after a special seed region growing, the source seeds are obtained. Finally, the growing immune field is applied in immune seed region growing to segment image. This approach involves the concept of immune clonal theory, which can segment images accurately for images with significant differences in target regions.

The main contributions of our work can be summarized as follows: (1) a method is proposed using clonal selection algorithm to obtain the optimal threshold for threshold segmentation, which can remove image noise effectively; (2) a regulated growing immune field is designed, which can prevent the overgrowth due to the increase of growth threshold in region growing; (3) an infrared image segmentation using growing immune field and clone threshold is proposed, and the improvements offered by this algorithm are demonstrated through a series of experiments.

The remainder of this paper is organized as follows. In Section 2, the full design of the proposed infrared image segmentation using growing immune field and clone threshold is described, including the step of the algorithm and the design of the growing immune field. Section 3 presents the results of experiments using different infrared images and common segmentation algorithm, which demonstrate the improvement given by the proposed method. Finally, our conclusions are stated in Section 4.

2. A segmentation method based on and clone threshold

The approach obtains the optimal threshold using clonal selection for threshold segmentation to extract the region seed. Then, using RGB color distance as the criteria, these seed points are grown at one time to obtain the source seeds. And source seeds and growing immune field is used in seed region growing, in the same way, the color distance is used as the criteriato compare the neighborhood of the candidate seeds in the growth process with the source seeds. Finally, complete image segmentation. The realization algorithm flow chart is shown in Fig. 1.

2.1. Obtain the optimal threshold using clonal selection algorithm

Artificial immune system [17] is an intelligent method developed according to the mechanism, characteristics and principle of immune system. It simulates highly evolved, parallel, and adaptive distribution characteristics of the human immune system and provides a new idea for the search strategy [18]. And clonal selection is an important theory in the theory of biological immune system.

In 1955, Jerne proposed the principle of clonal selection first and then the famous clonal selection theory was proposed by the development and perfection of Burnet and others in 1958. The central idea is that antibodies are present on the surface of cell in the form of receptors, and antigens react selectively with them. The corresponding antigen and antibody response will lead to cell clone value-added and the group has the same antibody specificity, some cells clone differentiate into antibody producing cells in immune response to invading antigens, other cells formed immune memory cells to participate in the secondary immune response.

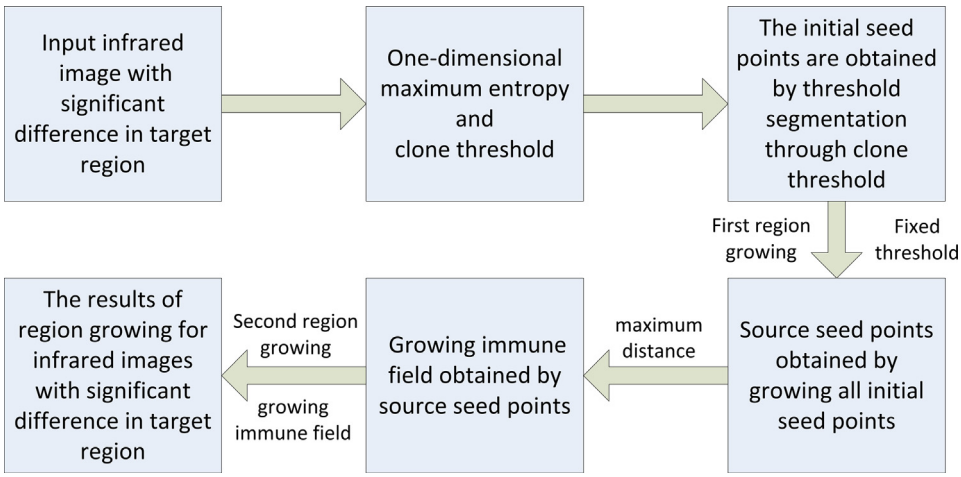

Fig. 1. The flow chart of proposed algorithm.