Research on the Image Segmentation based on Improved Region Extractions

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Abstract. Image segmentation is one of the classic methods of image signal processing. It is widely used in the scientific research, biomedical engineering, military guidance and so on. Based on the region extraction, this paper introduces three typical image segmentation methods: region growth algorithm, watershed algorithm and split and merge method. Computer simulation and the comparison of results show that, Region growth method can be used to break up complex image segmentation, but the cost of time and space are very high, the efficiency is low. By using watershed segmentation, adhesion of the image can be separated, but a watershed method greatly influenced by the noise, easy to excessive segmentation. The effects of split and merge segmentation method and region growth method are similar; there is no significant difference between them.

Key words: Image segmentation, region extraction, regional growth method, watershed method.

INTRODUCTION

The image segmentation algorithm based on region extraction has some common features, such as texture and gray level of pixels in a region (target), while other regions do not have these commonalities, and the target and background are separated by this difference [1]. The mature segmentation algorithms based on region extraction include: region growth algorithm, watershed transformation algorithm and split merging algorithm [2].

REGION EXTRACTIONS

Regional Growth Method.

When the region growth algorithm is used to segment the image, a seed pixel is first selected in the object to be divided, then according to the correlation rule of the region growth, the surrounding pixels and the seed pixels are measured, the pixels in accordance with the conditions are merged into the region of the seed pixels, and then the merged pixels are new. The seed pixels repeat the previous steps until the new seed pixels that meet the criteria are not found.

The main idea of regional growth algorithm is [3]:

(1) Starting from a seed pixel, the property (color or gray) of adjacent pixels is compared with the seed pixels. If the property is similar, the adjacent pixels are merged into the region where the seed pixels are located.

(2) Repeat step (1) until there is no new pixel that meets the requirement to be merged into the region, and then we will get a region when the growth stops.

(3) If the last growth cycle ends, there is still a pixel without being crossed into any region, then a seed pixel is selected, (1), and (2) is repeated until all the pixels are divided into a specific area.

The three problems that need to be solved by the regional growth law are:

<1>Determination of seed pixels

The strategy used to determine seed pixels in multi region growth and single region growth is different. In the case of single region growth, a single seed pixel is selected to cycle for growth; for multi region growth, multiple seed pixels are selected and the growth is started at the same time.

<2>Determination of attribute similarity criterion of adjacent pixels

In general, the growth of the region is carried out by the growth criterion of the difference of the gray level of the region (or pixel), that is, when the difference between the gray value of the adjacent pixels and the gray value of the seed pixels is not greater than the threshold, the adjacent pixels are merged into the region where the seed pixels are located. The interregional gray distribution or shape can also be used for regional growth, that is, when the image is color, the monochromatic criterion is not applicable. It is necessary to consider the proximity and connectivity between pixels, otherwise the results are meaningless.

<3>Determination of the stopping conditions of growth process

Usually, all pixels are divided into only specific regions, and the growth process is terminated.

The basic steps of the region growth algorithm:

Step 1, scan the image in order to find the first pixel (x0, y0) that is not divided into regions, as seed pixels.

Step 2, (x0, y0) is used as the center to compare the 4- neighborhood of the pixel (x0, y0) or the 8- neighborhood pixels (x, y) with the pixels (x0, y0), to meet the adjacent pixels of the adjacent pixel attribute similarity criteria, to merge into the region of the seed pixels, and to enter the stack (x, y) at the same time.

Step 3, remove a pixel from the stack as a new seed pixel (x0, y0) and repeat step 2.

Step 4, repeat steps until there are no pixels in the stack.

Step 5, repeat steps 1 ~ 4 until all pixels are divided into a specific area, and the growth process is terminated.

Watershed Method.

Watershed transform algorithm integrates the knowledge and theory of topography and hydrology into image segmentation and has good segmentation effect in the region of adhesion. First, the grayscale image is regarded as a terrain, and the gray value of each pixel is regarded as the ground height of the point, thus the geomorphic features, such as the highland, the basin and the watershed, are known in our daily life. There are always some smallest points in the terrain. We call them low-lying. If the rain falls into it, it will not flow elsewhere. At some points, because of the relatively high terrain, the rain falls into the other lower places, but eventually it will flow to the same low-lying basin, which is the basin related to the low-lying water. At other points, the rain falls on the top, and the probability will flow to different low-lying areas. We call these points the dividing line [4].

The main purpose of watershed transformation algorithm is to find out the waterline between catchment basins. Submergence method and rainfall method are the two most commonly used algorithms.

The basic idea of the rainfall method is to find low-lying images in the image by gray value, give each low-lying a different mark; for the rain on the unmarked point, it will go to a lower neighbor, and finally to a low-lying area, then the low-lying mark is given to the point; if an unmarked rain flows to a number of low-lying areas, marking this point as a water diversion point will eventually form a waterline with different markings between regions and regions.

The basic idea of submergence is that every low-lying area has a hole, which gradually sink the whole terrain into the lake, then the low-lying below the horizontal plane will pour into the water, and the basin areas associated with the low-lying water will gradually fill up; when the water from different low-lying water converge at certain points, the water will overflow from a basin. At this point, the dam is dammed to prevent the flow of water from spillover; when the water is flooded to the highest point, the dam is stopped; finally, all the dams are the water lines we are looking for, and the terrain is divided into different basins and regions by the water line. Morphological expansion is the simplest way to build a dam. From the place where the gray value is the lowest, the gray value is expanded to the low-lying areas, and the two basins are converged to each other until the expansion is made, and these points are marked as the waterline points. The expansion will be confined to the connected area, and the final waterline will separate the different regions.

The following are several basic concepts:

Concept 1: off function

A dist is one distance function that sets x. For each pixel that belongs to x, p and dist x(p) represent the distance from p to background (x^c).

Concept 2: Watershed

The watershed refers to the dividing line between the basin of the grayscale image.

The watershed uses the following three feature points:

(1) When the water level rises, when the water drops from these points, it will eventually flow to the local minimum point.

(2) The point on the watershed is the point at the edge of segmentation that we ultimately need to get.

(3) It is the point on the local minimum area.

The point that conforms to (1) conditions is called a regional marker; the bright line that conforms to the surface topology of the (2) condition is the dividing edge that we eventually need to get, called the waterline; the point conforming to (3) conditions we call it a basin.

The water catchment basin of stage n is represented by C[n],

$$C[n]=U_{(r \neq 1)}[C(M_r)] \tag{1}$$

Then, the collection of all catchment basins is C[max+1].

$$C[max+1]= U_{(r \neq 1)}[C(M_r)] \tag{2}$$

Concept 3: a water catchment basin

In the gray image, the minimum, most M set of the basin C (m) is the area formed by the track of a point falling to the m point along the surface.

Split Merge Method.

When there is a lack of prior knowledge, it is very difficult to select seed pixels, so the region growth algorithm is difficult to use. At this point, the purpose of regional detection can be achieved by splitting and merging regions. The split merge algorithm is divided into several sub regions. In each sub region, the sub region continues to be divided into a number of sub regions if it is not satisfied with a certain consistency principle (usually measured by the mean of variance and gray value), otherwise the sub region will stop splitting. The adjacent sub regions satisfying some consistency principle are merged into one sub region. Until no sub region can be split or merged [5].

The basic steps of the split merge algorithm:

(1) When an image in a region is inconsistent, the image is divided into four equal regions.

(2) When the adjacent area accords with the principle of similarity, the two regions should be merged into one area.
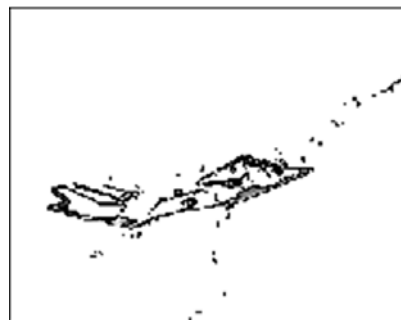
(3) Repeat the above two steps until there is no area to merge or split.

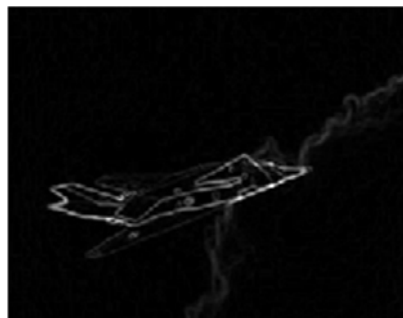## COMPUTER SIMULATION RESULTS

The effects of split and merge segmentation method and region growth method are similar; there is no significant difference between them. So here are 2 simulation results about regional growth method and watershed method.
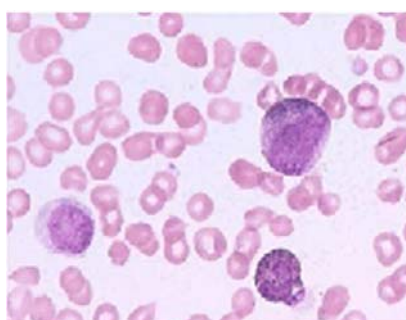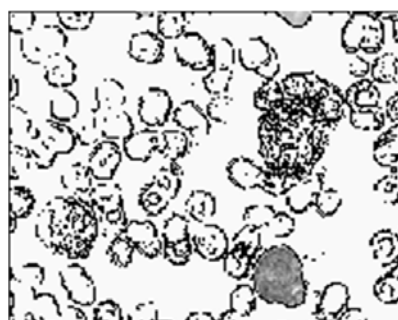

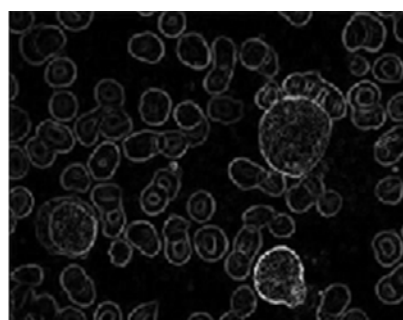(a)Original image   (b) Result of region growth method

(c) Result of watershed method

FIG. 1. Computer simulation results of the first image

(a)Original image

(b) Result of region growth method

(c) Result of watershed method

FIG. 2. Computer simulation results of the second image

The region growth method has a good segmentation effect for the connected region (Fig. 1(b)). For the complex image (Fig 2), it can distinguish each element, and there will be no blurred phenomenon.

However, the average running time of each program is counted: 0.562132 seconds of iteration, 1.346867 seconds of Otsu method, 0.833500 seconds of local threshold method, 1.660169 second of regional growth method, 0.435218 seconds of watershed, 2 to 4 times the region growth method, low efficiency, not suitable for use in actual production research, and time and the waste of space resources is too great. At the same time, when the noise is disturbed, the segmentation effect is obviously reduced.

The watershed method has a good segmentation effect on separating the images from the adhesion (Fig. 2(c)). But for noisy images (Fig (1)), the effects of watershed method are not so good.

SUMMARY

Several algorithms introduced are simulated, compared with the original image, the segmentation results are analyzed, the advantages and disadvantages of each segmentation algorithm and the applicable situation are obtained. According to the simulation results, the region growth method can divide the more complex images, but the cost of time and space is also very large and low efficiency. The watershed method can separate the images from the adhesion, but it is greatly influenced by the noise and is easily over divided.

REFERENCES

1. Yonghong Jia. Digital Image Processing. Wuhan University Press, 2015, p. 145-169.
2. Mingjie Chen. Experimental Technology of Digital Image Processing. Tsinghua University Press, 2014, p. 82-98.
3. Bingquan Chen, Hongli Liu, Fanbin Meng. Current Situation and Development of Digital Image Processing Technology. Journal of Jishou University (Natural Sciences Edition). Vol. 30(2009) No.1, p. 63-68.
4. Eschrich S, Ke J, Hall LO, Goldgof DB. Fast accurate fuzzy clustering through data reduction. IEEE Trans. Fuzzy Systems. Vol. 11 (2003) No.2, p. 262-270.
5. Yan Jiang, Tiesong Hu, Chongchao Huang, et al. An improved particle swarm optimization algorithm. Applied Mathematics and Computation. Vol. 193 (2007), p. 231-239.