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Research on Medical Image Segmentation Based on Watershed Algorithm

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Abstract: Medical image segmentation is a hot issue in recent years. The accuracy of segmentation results directly affects the correctness and professionally of doctors' diagnosis of disease. At present, there are many methods for medical image segmentation, and the watershed algorithm has been paid much attention because of its fast segmentation and accurate segmentation, but it has serious over-segmentation. Based on the characteristics of medical images, this paper studies an improved watershed algorithm, which mainly studies the following aspects: First, the medical image is affected by medical imaging equipment imaging technology, the prevalence of target and background contrast The edge of the target is blurred and the noise is large. An extended mathematical morphology algorithm is proposed to extract the edge of the medical image to obtain the gradient before the segmentation, which effectively reduces the noise and improves the accuracy of the segmentation. basis. Secondly, it is discussed that in the process of the implementation of the traditional watershed algorithm, the introduction of dynamic merging criteria to suppress the formation of over-segmentation area, effectively solve the problem of over-segmentation. Finally, the improved algorithm is applied to the PACS system of the hospital and the feasibility, practicability and the accuracy of the segmentation scheme are verified.

Key words: learning image segmentation; mathematical morphology; watershed algorithm

1. An overview of watershed algorithm

Watershed algorithm (Watershed algorithm)[1] is a mathematical morphology based image segmentation method, which extracts the image content has achieved very good results. The watershed algorithm was originally introduced by Digabel and Lantujoul into the field of image processing for the analysis of simple binary images[2]. Then Beucher and Lantujoul and others have improved and improved, so that the theory of watershed can be established, get a more general model, is used for a large number of gray image processing.

There are two main ideas of dividing the watershed algorithm: one is to simulate the flooding process. It takes the gradient amplitude image as a topographic map, and the gradient amplitude corresponds to the altitude, and the area of the different gradient values in the image corresponds to the basin between the mountain and the valley. Imagine a hole in the local minimum point of the hole, and then gradually penetrate the topographic map of a lake, the global minimum point of the basin of advanced water. The water level gradually rose over the basin, when the two adjacent basin of water is about to merge, in the two basins between the dam to intercept. This process divides the image into a number of valley basins that divide the dams of these basins, which correspond to uniform areas in the image to be segmented, respectively. The other is the simulated precipitation process. The idea of this method comes from geography, the image as a ups and downs of the mountain model. When the raindrops fall on the surface of the mountain, they tend to fall along the slopes, and if the raindrops that land at different points eventually flow to the same local minimum altitude, these points belong to the same area. The top points of these elevations form a region, and the watershed is the boundary of these areas.

2. Mathematical description of the watershed algorithm

In this paper, the idea of watershed algorithm is put forward. In order to realize its application in computer, it is necessary to give the mathematical description of watershed algorithm. Before giving a rigorous mathematical description, first look at several definitions of the watershed algorithm.

[Definition 1]: geodesic distance. Let A be a simple connected region, and the path p between two points x and y is completely contained within A. The geodesic distance between x and y is the lower limit of all path lengths connecting these two points. X, y), which is defined as:

DA (x, y) = inf {l (p), p is the path between x and y} (1)

[Definition 2]: geodesic influence zone. Is expressed as iZA (Bi), where B1, B2, B3, ... Bk are the connected regions included in A, then iZA (Bi) is the geometric distance from Bi to Bi less than Bj (j∈ 1 ~ k, J ≠ i) of the geodesic distance of all the pixels of the collection, which is defined as:

iZA(Bi)={p∈ A,j∈ 1~k and j≠i,dA(p, Bi)<dA(p, Bj)}(2)

[Definition 3]: Joint of geodesic affected areas. Is represented as a set IZA (B), which is defined as:

(3) $$IZ_A(B) = \bigcup_{i=1}^{k} iZ_A(B_i, B)$$

[Definition 4]: skeleton by influence zones. Expressed as SKIZ, is composed of a point in the A that does not belong to any geodetic affected area and is a supplement to the geodesic affected area joint IZA (B), which is defined as:

SKIZA (B) = A \ IZA (B) (4)

Is a gray image to be processed, indicating any pixel in the image, the maximum and minimum values of the pixels are represented by the sum of the pixels. Let's represent a set of catchment basins calculated at the gray level, and the pixels in the set of thresholds at the gray level are either the minimum values of the gray values or the flooding of the pixels. While the latter is in the geodesic area,let the pixel set in all the minimum values of the gray scale value.

[Definition 4]: Simulation flooding algorithm. First define the following recursive calculation process

(5) $$\begin{cases} X_{h_{\min}} = \{p \in G \mid G(p) = h_{\min}\} = T_{h_{\min}} \\ X_{h+1} = MIN_{h+1} \bigcup IZ_{T_{H+1}}(X_h), \qquad h \in [h_{\min}, h_{\max}] \end{cases}$$

3. Realization of watershed algorithm

The above definition of the watershed algorithm is given, and the two kinds of watershed algorithm ideas are realized by two different algorithms: one is the simulated flooding algorithm from bottom to top[4] and the other is the simulated precipitation Algorithm[3]. And the existing algorithms are mostly based on the simulation of flooding model, which is the most classic application is Vincent and Soilleproposed simulation immersion algorithm, the algorithm to achieve fast, high efficiency, and accurate segmentation, so Get a wide range of applications.

Vincent's simulated submerged watershed algorithm is divided into two steps: first, the gray values of the image pixels are sorted in ascending order; second, the immersion process. Use a first-in, first-out pixel queue to perform the entire immersion process from the minimum. The following are the specific steps of the algorithm:

(1). sorting: in the process of gradually submerged, not every need to deal with all the pixels. In order to facilitate the need to deal with the need to access the pixels, the first image of the gray value, and then according to the pixel point of the gray value in ascending order to sort, get a sorted pixel matrix, so you can speed up the

calculation.

(2). immersion: according to the image pixel gray value in ascending order to access the previous sort of pixel matrix. Starting from the minimum pixel gray value of the entire image, assigning different markers to each of the minimum values and its corresponding water basins, sequentially submerging by repeating the breadth-first algorithm, using the data structure of the first-in first-out (FIFO) Ho_add (queue): the top of the queue to increase the pixel p; fifo_remove (queue): return and remove the first element of the queue; fifo_empty (queue) : Test whether the queue tail is empty, if it is empty, it returns true, otherwise it returns false. The exact result can be obtained by extending the tagged poly water basins through a circular queue.

4. Improvement of watershed algorithm

4.1 The research direction of watershed algorithm

At present, the research on watershed algorithm is mainly focused on the following three directions[4]:The first is to study the accuracy of the results of watershed algorithms. The watershed algorithm has been developed for twenty years since its introduction, and many experts and scholars have carried on the thorough research to this algorithm and proposed many improvement methods. In the end a variety of watershed algorithm on the image of the results of the division is consistent, whether to achieve the desired accuracy, which is a worthy of study areas. According to Lin et al[5]. it is shown that the simulated flooding algorithm from the bottom up and the simulated precipitation algorithm from top to bottom can achieve exactly the same segmentation results. In addition, Hieu Tat Nguyen[6] proposed a water snake algorithm based on the energy function. The innovation of this method is to introduce the energy function into the watershed algorithm and prove that when the energy function obtains the minimum or maximum watershed the result of the algorithm segmentation is consistent.

The second is to solve the problem of dividing the watershed algorithm. The main reason for the over-segmentation of the watershed algorithm is that the algorithm is very sensitive to noise. There is always a certain amount of noise in the digital image to be segmented, so that any region minimum in the image at the time of division corresponds to a divided area, which results in excessive segmentation. So in the practical application of the traditional algorithm must be improved.

The third is the parallel technology of the watershed algorithm, which is the rise of the past decade, a research direction. Some researchers put forward their own views and attitudes towards the parallelization of watershed algorithms. For example, Roerdink[7] gives a parallel computing strategy for watershed algorithms based on sequential scanning pixels, while Zhou Haifang[8] gives an optimized parallel computing method, which is mainly used to combine pseudo-seed points with regional growth achieve.

4.2 Improvement of watershed algorithm

The traditional watershed algorithm is carried out on the gradient image. The algorithm first extracts the minimum value of the gradient image, then uses these minimum values as seed points, and finally grows the region according to the gradient value of the gradient image. In general, the gradient graph has noise, and the watershed algorithm is particularly sensitive to noise, so the traditional watershed algorithm has a serious over-segmentation problem. In this section, according to the characteristics of medical information in the details of the rich, before the division, the division of the comprehensive use of a variety of methods to obtain the results of the segmentation: First, the algorithm before the implementation of the mathematical morphology of noise reduction pretreatment, followed by the algorithm itself Watershed formation process. The specific segmentation scheme is shown in Figure 1.

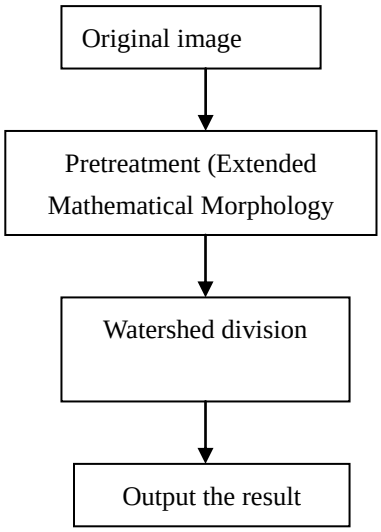

Figure 1 watershed algorithm

4.2.1 Filter the image

This paper focuses on the division of medical images. Because of the diversity of human organs and the technical characteristics of medical imaging equipment, compared with the images in the natural background, the medical images have the characteristics of poor contrast between target and background, fuzzy edges and large noise. In order to reduce the noise of the image and the influence of other unfavorable factors, it is proposed that the medical image can be used to denoise the medical image before the segmentation, which laid a good foundation for the implementation of the next level of the watershed algorithm.

Through the analysis and experimentation of several mathematical operations, we know that corrosion and expansion are still useful for edge extraction, but are not suitable for additive images. Morphological opening and closing operations are better for denoising, so the noise can be eliminated by opening and closing. The effect should be theoretically possible, but because of its use of the complementarity of corrosion and expansion, Image edge of the concave, convex at the relevant, can not reflect the image of all the edge characteristics, the difference between the image can only get the image of the bump features[9]. Based on this theory, this paper proposes an algorithm to extend the mathematical morphology to extract the edge of the image. The algorithm uses the following operations:

$(M \circ B) \oplus B - M \bullet B$ (6)

Where M = (FB) B, B is a 3 × 3 square structure element, F is the original, first by the shape of the operation and the shape of the closed operation to complete the pretreatment to filter out the noise, then do the shape of the operation to smooth the image, and then do Expansion of the operation, take the expansion of the image and filter out the noise to do the shape of the closed image of the difference between the image edge is better.

§4.2.2 Inhibition of over-partitioned areas by dynamic merger criteria

Through the previous steps, the edge information of the target in the image and the gradient image reflecting the height of each pixel are extracted, the details of the small target or the object inside the image are ignored, and the gradient image after filtering is denoted as a watershed The input image of the algorithm. However, for image segmentation based on the watershed algorithm, due to the natural background, noise, object edges, and small changes in the interior of the image, the same object in the image is divided into several parts[10], that is, The influence of the quantization error, the local minimum of the image will be considered as a bottom, each valley will lead to the use of watershed algorithm for the division of the introduction of a catchment basin, the

number of bottom will appear how many sinks Water basin, which will make the image of the same uniform area is wrongly divided into multiple small areas, in appearance appears to be chaotic, resulting in a large number of false boundaries, not the purpose of segmentation, which is what we often said Segmentation phenomenon.

Therefore, this paper combines the dynamic merge criterion in the process of implementing the watershed algorithm, and adopts the method of suppressing the formation of the wrong small area at the same time, and obtains the ideal effect effectively, which effectively restrains the over-segmentation phenomenon.

§4.2.3 Definition of Dynamic Consolidation Criteria

The dynamic merge criterion is a measure of the difference in the gray scale of the image based on the information of the image structure. It is essential to understand that it should be a concept of difference. Its measurement of the image contains the gray point of the extreme point of the structure, rather than measuring the extreme point itself or extreme points corresponding to the area. In the division of the use of this criterion can be eliminated at the end of the valley, that is, can be removed due to misplaced and the formation of small areas. The dynamic merge criterion does not need to take into account the information such as the shape and size of the image, that is, without knowing the prior knowledge of the image, and therefore has a strong versatility and applicability [11].

5. Conclusions

In the gray image processing, an extended mathematical morphology operator is proposed to extract the edge of the image. In the experiment, the image is divided into two kinds of noise and no noise to deal with the situation, and other mathematical morphology edge extraction method for comparative analysis, the results are stronger than other methods have anti-noise performance, in the details of the realization of the details Also get better results.

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