Medical Image Processing Based on Mathematical Morphology

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***Abstract*—In the thesis, the author proposes an approach of image processing based on the features of medical image. First, using the space domain to enhance the image and improve clarity. And then process it by using mathematical morphology. Mathematical morphology is a method of nonlinear filters, which could be used for image processing including noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc. the method has been more and more widely used.**

Keywords-Medical image, Feature extraction, Edge detection,Image processing

I. INTRODUCTION

With the variety use of image equipments in medical diagnosis, the technology of medical image processing plays a more important role and an increasing impact on medical research and clinical practice. The result could make clinicians observe the lesion inside the body more direct and clear, and these leads to a higher confirmation rate. Therefore, the technology of medical image processing has long attracted attention of relevant experts, home and abroad, and the computer-aided diagnosis based upon medical images developed soon.

Computer-aided diagnosis can improve the diagnostic accuracy of radiologists, and help doctors to determine and identify medical images. In consequence, Medical Image Based Computer Aided Diagnosis (MIBCAD) has developed rapidly. At present, many hospitals use PACS (Picture Archiving and Communication System), and collect a large number of patients' image data. How to make full use of previous confirmed cases and doctors' clinical experience, and how to make the computer help doctors to diagnosis quickly and efficiently, is the goal to achieve for computer-aided diagnosis system.

II. MEDICAL IMAGE FEATURES 2.1 AICA GLORITHM

All images referred in the thesis are medical images. Compared with common images, medical images essentially have the characteristics of unevenness and fuzziness.

(1) Medical image has the vagueness on grey levels. The CT values could appear dramatic changes on the same tissue.

(2) Local body effect. There are usually two elements in a voxel on the boundary: boundary itself and the object. It's quite hard to describe accurately about the edges of objects in the image and the relationship between the corner and the area. Some lesions could not be identified clearly because of infiltration to surrounding tissues.

(3) The uncertainty knowledge. Generally, new structure appears when normal tissues or parts have pathological changes, such as tumor on the organs' surface, or spur on the bone surface. These bring unpredictable difficulties to the mathematical modeling of Biology.

Due to the features of medical images, medical image processing issue has always been a challenging research topic. Preprocessing medical images by the approach of mathematical morphology over the above features is for the purpose of achieving better edge detection results.

III. MATHEMATICAL MORPHOLOGY

Mathematical morphology is a method of nonlinear filters, which could be used for image processing including noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc. the method has been more and more widely used in the area of image processing. Mathematical Morphology is changed from traditional morphology to order morphology, soft mathematical morphology and fuzzy soft mathematical morphology. In reference, mathematical morphology is usually been generalized as traditional morphology and image morphology. Image morphology mainly refers to order morphology and percentile morphology. Mathematical morphology process binary image firstly. It treats binary image as a set, and detective the set by structural elements. The essence of mathematical morphology algorithm is an expression of the interaction between the collection of objects (or shapes) and the structure elements. The latter determines the information of the signal's shape extracted by the operation. Structure element, which is equivalent to "filter window" in signal processing, is a collection smaller than the image and could shift on the image. The basic

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mathematical morphology operation will shift structure elements within the image, and at the same time will do basic operations on sets of intersection and union. The erosion and dilation of binary pattern is this set of arithmetic logic, which is suitable for binary image segmentation, thinning, skeleton extraction, edge extraction and shape analysis etc. The choice of structural elements' shape and scale directly affect the operation results.

Binary morphology naturally extends grayscale images to gray-scale morphology. The operation of intersection and union used in binary morphology were replaced by the maximum and minimum extreme value. The operation expression of grayscale morphology's erosion and dilation are quite similar with convolution integral in image processing. And the sum and difference value of grayscale morphology is an extreme value filter. So that grayscale morphology is a nonlinear and irreversible transformation. The opening and closing operation can constitute the edge detection of gray level morphological gradient, filter noise of Top-Hat transformation and hybrid filter etc, but with watershed transformation could segment image effectively.

There are four basic operations of mathematical morphology: dilation, erosion, opening and closing. They have their own features in binary image and grayscale (multi-value) image. What based upon these basic operations could be derived and combined into various practical algorithms of mathematical morphology. The following will introduce the basic operations of binary morphology, and then extended to gray-scale morphology.

A. Dilation Operation

Dilation operation is one of the bases of morphology processing. Dilation is the operation of "lengthening" or "thickening" in binary image. This special way and the extent of thickening are controlled by structure elements.

Mathematically, dilation is defined as set operation. A is dilated by B, written as A $\oplus$ B, is defined as (1):

$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \varnothing\} \tag{1}$$

Among them, ϕ is for the empty set, B is for the structure element, and $\hat{B}$ is for the reflection of collection B. In short, that A is dilated by B is the set composed by the origin positions of all structure elements. There into, after mapping and translation, B at least has some overlap with A.

B. Erosion operation

Erosion operation is also one of the bases of morphology processing. Erosion "shrinks" or "thins" the objects in binary image. As in the dilation, the way of shrink and the extent is controlled by a structure element.

The mathematical definition of erosion is similar to dilation. A is eroded by B, recorded as A Θ B, and defined as (2)

$$A \Theta B = \{z \mid (B)_z \cap A^c \neq \varnothing\} \tag{2}$$

Among them, ϕ is for the empty set, B is for the structure element, and A^c is for the supplement of collection A. In another word, that A is eroded by B is the set composed by the origin positions of all structure elements, in which the background of translation B does not overlay on A's.

C. operations of opening and closing

As mentioned above, dilation makes image larger while erosion makes image smaller. Another two important operations of morphology considered blow is operations of opening and closing. Opening operation generally makes the contour of objects smooth, and disconnects narrow discontinuous and remove thin protrusions. Similarly with opening operation, closing operation also makes outline smooth, but the opposite is that it usually eliminates discontinuity and narrows long thin gap, clears up small holes, and fill the ruptures of the contour line.

Using the structure element B to do the open operation on the set A, expressed as A ∘ B, definite as

$$f \circ b = (f \Theta b) \oplus b \tag{3}$$

As the same case with binary image, opening operation first using b to erode f plainly, and then using b to do dilate operation on the results obtained. Also, using b to do closing operation on f, expressed as f • b, definite as

$$f \bullet b = (f \oplus b) \Theta b \tag{4}$$

The opening and closing operations of image has simple geometric interpretations. Assuming observe an image function f(x,y) in a three-dimensional space, in which x-axis, y-axis is the usual sense of the space coordinates, and the third axes is the gray value. In this coordinate system, the image rendering does not form a continuous surface; the surface at any point (x, y) coordinate value is the value of f. Assuming use the spherical structure element b do opening operation on f, and we could see the element as a "rolling" ball. The principle of using b to do opening operation on f could be interpreted as in geometry that push forward the ball rolling along the lower side of the surface so that the ball could move back and forth on the entire lower sphere surface. When the ball rolls over the entire lower side of f, sphere's highest points touched by any part of the ball form the sphere of opening operation f ∘ b.

The following series of illustrations is for the concepts. In order to simplify the instructions, as shown in Figure 1, gray image scan lines appear as a continuous function.

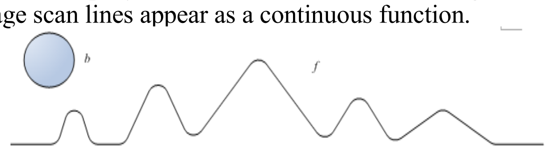


Figure 1. f is line of gray image; b is structuring element

Figure 2. Result of opening

Figure2 shows the complete result obtained by using b to open f along with the scan lines. All peaks narrower than the sphere's diameter are reduced in the magnitude and sharpness. In practical applications, opening operation often used to remove the smaller (compared with the size of structure element) bright details, while relatively maintaining the overall grey level and the bigger bright area unchanged. To do erosion operation first can remove the small image details, but this will darken the image. Then the dilation operations will enhance the overall image brightness, but will not reintroduction the parts moved by erosion operation to the image.

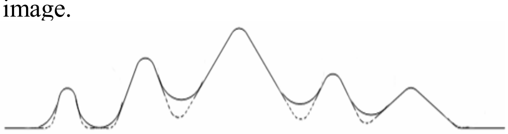


Figure 3. Result of closing

Figure 3 shows the complete result obtained by using b to close f along with the scan lines. At this time, the ball sliding on the upper surface of the curved surface, and the wave crests basically maintained their original shape. Practically, closing operation is often used to remove the dark details in the image, and relatively keep the bright parts unaffected. To do dilation to remove dark image details first, while increase the brightness of the image, and then erode the dark image, but not reintroduce the part removed by dilation to the image.

IV. SIMULATION EXPERIMENT RESULTS

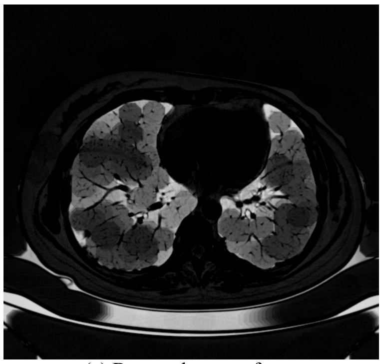
The image subtracted from the original image after opening operation is called top-hat transformation (type 5):

$$Th = f - (f \circ b) \tag{5}$$

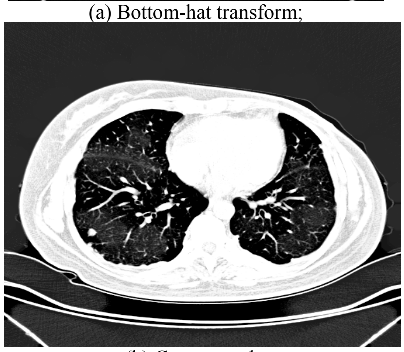
The image subtracted from the original image after closing operation is called bottom-hat transformation (type 6):

$$Bh = f - (f \bullet b) \tag{6}$$

These two transformations can be used to enhance the contrast, as shown in Figure 4



(a) Bottom-hat transform;



(b) Contrast enhancement

Figure 4. The example of Mathematical Morphology Transform:

V. CONCLUSION

Compared with common images, medical images essentially have the characteristics of unevenness and fuzziness. In the thesis, the author proposes an approach of image processing based on the features of medical image. First, using the space domain to enhance the image and improve clarity. And then process it by using mathematical morphology. After differ the top-hat and bottom-hat transformation of grayscale morphology, the edge features are strengthened. mathematical morphology is a method of nonlinear filters, which could be used for image processing including noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc. the method has been more and more widely used.

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