Optimization of Reconstruction of 2D Medical Images Based on Computer 3D Reconstruction Technology

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ABSTRACT: *Computer 3D reconstruction consisting of reconstruction of 3D point clouds and images plays an important role in computer graphics, computer image processing and computer vision research. Image based 3D reconstruction includes reconstruction of single image and multiple images. Compared to obtain 3D mode by modeling software or scan tester traditionally, image-based 3D reconstruction is featured by strong sense of reality, low cost, vivid image and broader market demand. Moreover, image-based 3D reconstruction is practically an inverse problem of computer graphics. In medical field, 3D reconstruction of medical images is to create 3D information based on a 2D image and then form a vivid 3D image. It transforms 2D fault data sequence obtained from Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) into 3D data, which is valuable in demonstrating tissues and organs of human body. 3D reconstruction technology concerning medicine is widely applied in medical diagnosis, surgical planning, analog simulation and plastic surgery. Therefore, computer 3D reconstruction technology is of important academic and practical value to reconstruction of 2D medical images. Research of 3D reconstruction of medical images focuses on preprocessing of medical images, such as filtering and interpolation, and segmentation and extraction of tissue and organ. This study analyzes design concept and method of cross-platform medical image 3D reconstruction system, development status, market demand and prospect of computer 3D reconstruction technology, medical volume data visualization technology, acquisition of medical images and several kinds of medical image preprocessing technologies. In the study, region growing algorithm is used to segment liver tissues. Volume rendering technology provides 3D special description for 2D medical fault images, to make its internal 3D structure become clearer. Principles and application scope of marching cubes based surface rendering algorithm is emphatically introduced. Based on traditional edge extraction theory, a new edge measurement and calculation method is designed, which makes edge smoother.*

Subject Categories and Descriptors
I.4.5 [Reconstruction] Image reconstruction; **I.4.6 [Segmentation]** Image segmentation

General Terms: Three-dimension Technique, Region-Growing Algorithm

Keywords: 3D Reconstruction, 2D Medicine, Region Growing Algorithm, Marching Cubes Ology, Critical Control Point, Food Safety, Workflow Model

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1. Introduction

Computer 3D reconstruction technology is operable in different fields. It is difficult to acquire a clear stereo perception of 3D space, because 2D fault image is only limited to images with incomplete information description and relative position of organs in the space is fuzzy. Thus people require to optimize 2D medical images by develop them into 3D. Medical image 3D visualization technology means to develop 2D images into 3D by reconstructing them through consideration, calculation and other processes [1]. Doctors can know more about data, have a wider view, and make accurate diagnosis if computer 3D reconstruction technology is used in observation and detection 2D images. Computer 3D reconstruction was attached importance since 1990s, and then applied more. In recent two years, it is a hot spot in international medical research. Till now, computer3D reconstruction algorithm for medical images can be mainly divided into two categories, i.e., surface based 3S rendering method which describes 3D structure by jointing and fitting subject

surface through geometry elements and volume data based volume rendering method which projects voxel onto plane directly [2]. Surface rendering method refers to extract edge or contour line of 2D images and then use them to assist traditional graphic technology; while volume rendering method obtains 3D images by resampling data with visual principle.

2. Segmentation of Medical Images

In the past, doctors usually segment lesion area manually. Image segmentation acts an important role in computer medical field; however, an effective and complete solution has not figured out. Therefore, medical image segmentation is quite important in medical research [3]. Here, we introduce several kinds of commonly used segmentation methods.

2.1 Thresholding Segmentation Method

Thresholding segmentation method is commonly used in scalar volume data. Voxel is divided into two parts, i.e., voxel with gray values larger than threshold and voxel with gray values lower than threshold. This method can be developed level figure, targets and backgrounds are corresponding to different peaks, and valley between two peaks can be taken as threshold. Sketch map is shown in figure 1.

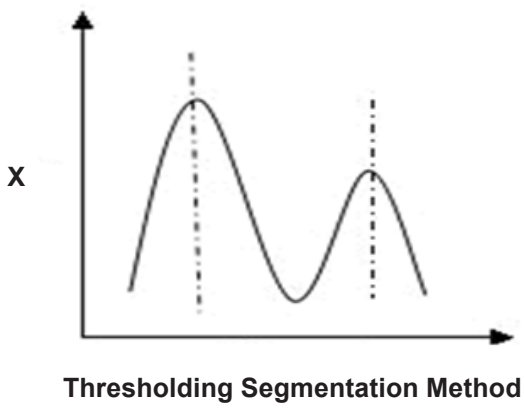


Figure.1 Sketch map of threshold segmentation

But the algorithm has a drawback, i.e., segmentation results rely too much on the selection of threshold. Changes of threshold will affect other areas.

2.2 Seed Region Growth Method

Seed region growth method decomposes segmentation process into several procedures in order. But it is easy to result in excessive segmentation [5]. Moreover, boundary and cavity are liable to occur as measures for boundary is not included in region framework during decision making stage. Therefore, we try to segment gray level image combining method based on region information with other methods such as edge detection method [6]. This approach can rapidly change parameters and is relatively stable and convenient compared to other algorithm.

As shown in Figure 2, similar pixels together form an area, and multiple seeds become the starting points of growth; then they are distributed in the current area according to specified standard; then new pixels merge into new seeds. The procedures are repeated until no pixels are available for mergence.

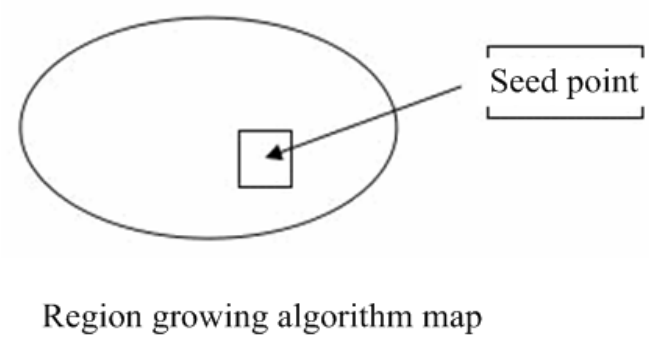
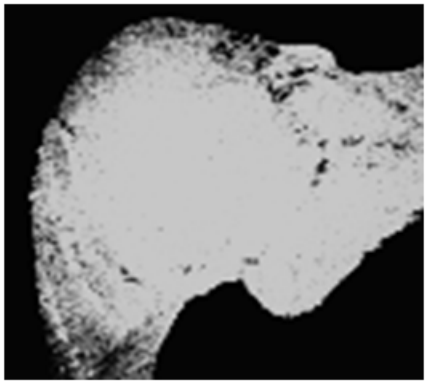


Figure 2. Sketch map of region growth algorithm

2.3 Experimental Results of Seed Region Growth Method

3S segmentation is performed on data of medical images from clinical practical medicine with computer with high-performance graphics card ATIFireGLV3100. In the process, seed region growth method is used. The data is about sections of abdominal CT scan (resolution: 525*525, pixel pitch 0.676 mm, totally 327 layers, space between layers: 1.1 mm). Liver is the target for segmentation. At first, seed region growth algorithm is used to make initial segmentation on volume data of abdomen, and then a rough result is obtained. Then, mathematics morphology is used for calculation. After processing, a segmentation result is worked out, as shown in figure 3.



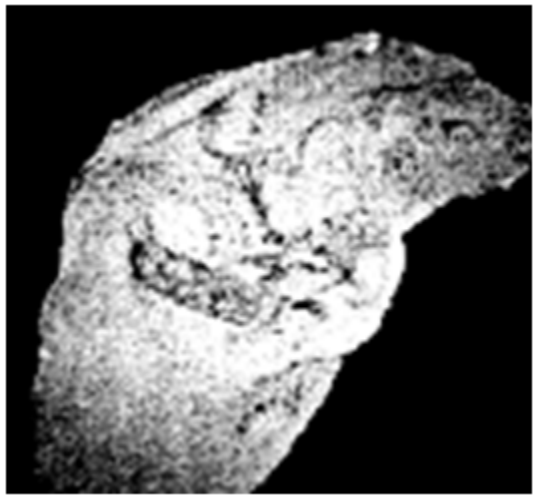


Figure 3. Demonstration of liver CT image processed by 3D segmentation

3. Introduction of Marching Cubes Algorithm

Marching cubes algorithm is generated by contour surface of 3D data field. So far, marching cubes enjoys a wide application due to its relatively simple principle and strong realizability. In marching cubes algorithm, suppose original data is discrete 3D orthogonal data field, it can be expressed as:

$$F_{i,j,k} = F(x_i, y_j, z_k), (i = 1: N_x, j = 1: N_y, k = 1: N_z)$$

To create a contour surface in the data, value of contour surface (threshold) is first given, set as S0. Then cubes intersected with contour surface are classified, and point of intersection is calculated. Intersection of contour surface and edge of cubes are connected to form contour surface. Finally, surface rendering function provided by graphics software package is used to draw contour surface.

3.1 Advantages of Marching Cubes Algorithm

Marching cubes algorithm is a method for generating standard defined elements and contour surfaces within elements. Volume element is defined as data unit composed of eight net points between adjacent layers, and marching cubes algorithm generates a more general definition of volume element. In view of construction, all 3D scalar fields are allowed to be formed by volume elements or units with such general significance. Therefore, contour surface in scalar field can be generated in order within volume elements which constitute scalar field, which can convenient construction of contour surface in scattered data field and cambered data field. But in the progress of constructing contour surface, the algorithm relies on visual construction to some extent. In the period of constructing volume element model, processing of symmetry and rotation has not been comprehensively considered. Boundary contour points are connected into triangular plate based on rough volume element model, without considering circular structure that may exists within cubes and critical point. The algorithm is being concerned all the time and is still being improved by now.

3.2 Disadvantages of Marching Cubes Algorithm

3.2.1 Triangular Patch Constructed by Marching Cubes Algorithm is Only Confined to Approximate Expression of Contour Surface

In marching cubes algorithm, intersection boundary of contour surface and voxel boundary is figured out from that assumption that functional value varies linearly on voxel boundary. When data field is with high density and small voxel, this assumption is close to actual situation. But in data field with low density and large voxel, large error will be resulted in if we still consider function value varies linearly on voxel boundary. Thus contour surface can be figured out when we make different eligible assumption on the changes of function value along voxel boundary based on different background.

3.2.2 Redundant Calculated Amount Existing In Marching Cubes Algorithm

Marching cubes algorithm is calculated based on orderly moved cubes. 25% ~ 68% time is spent on testing blank cell. Thus it is necessary to design a data structure that can strengthen test of blank cell.

3.2.3 Ambiguity of Connection Means of Contour Surface

In marching cubes algorithm, in the same surface of voxel, there will be two possible connection means if an angular point whose value is 2 and an angular whose value is 1 are respectively located on two ends of diagonal. That is called ambiguity.

3.3 Improvement of Marching Cubes Algorithm

3.3.1 Improvement for Triangular Patch Constructed By Marching Cubes Algorithm Only Limiting to Approximate Expression Of Contour Surface

Results that come from data field of original image processed by edge extraction are processed with binaryzation at first. Then a group of binary data obtained (o refers to background and 1 refers to objects that require

reconstruction) is used for constructing contour surface. Contour surface index is constructed as standard marching cubes algorithm, but calculation of intersection point of contour surface and cubes is different. In this study, we take the midpoint on the edge of cubes as the intersection of contour surface and cubes rather than make liner difference calculation. This is because threshold cannot be chosen from binary image for intersection; moreover, though 0.5 error is allowed in midpoint calculus process, it is not suitable for CT. In standard marching cubes algorithm, there will be at least 9 times of calculation before final determination of coordinate of interpolating point. But using midpoint, intersection can be confirmed only by three times of calculation.

3.3.2 Improvement for Redundant Calculated Amount Existing in Marching Cubes Algorithm

In the process of 3D surface reconstruction, we perform binaryzation on images. Cubes are constructed for pixel points with value of 1 in image space. The construction can only be operated on edge of space pixel, as the selected pixel is only limited to bounding volume which is intersected with contour surface.

3.3.3 Removal of Ambiguity

M. J. Durst once proposed ambiguity problem of connection means exists in C algorithm [7]. Intersection point between contour surface and voxel boundary is confirmed based on midpoint on the edge of cubes. When one surface only has two equivalent points, they can be connected by straight line. Counterpart connection of equivalent points needs to be considered when there are four equivalent points. Matveyev once discussed over the problem of inter ambiguity. He solves the problem by trilinear interpolation of diagonal of voxel unit [8]. Generally, intersection line between contour surface and voxel boundary surface is hyperbolic curve. When two branches of hyperbolic curve are intersected with some boundary surface, ambiguity of connection means comes up. At that time, two branches of hyperbolic curve divides boundary surface into three areas. It can be observed that, intersection point of asymptotic line is bound to locate in the same area along with a pair of intersection points on diagonal in boundary surface. In marching cubes algorithm, query table is used to joint internal surface of cubes. As there is more than one way to joint same structure, ambiguity of construction emerges. When topological structure cannot be consistent, i.e., one pair is positive and the other is negative, ambiguity of surface emerges, as shown in figure 3. a and c are positive peaks and b and d are negative. Ambiguity of surface can be removed based on F(a) F(c)- F(b)F(d).

4. Results and Discussion

Figure 4 demonstrates 3D reconstruction effect picture processed by improved marching cubes algorithm. CT section used in the study has a resolution of 267*267, totally 92 layers, and space between layers is 3.17 mm.

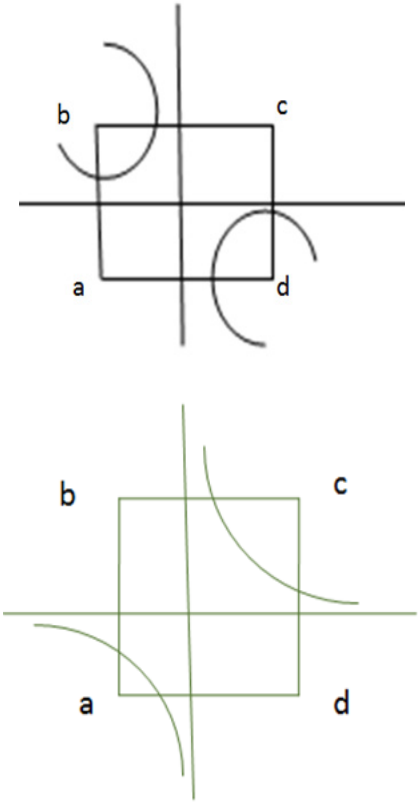


Figure 4. Ambiguity of surface

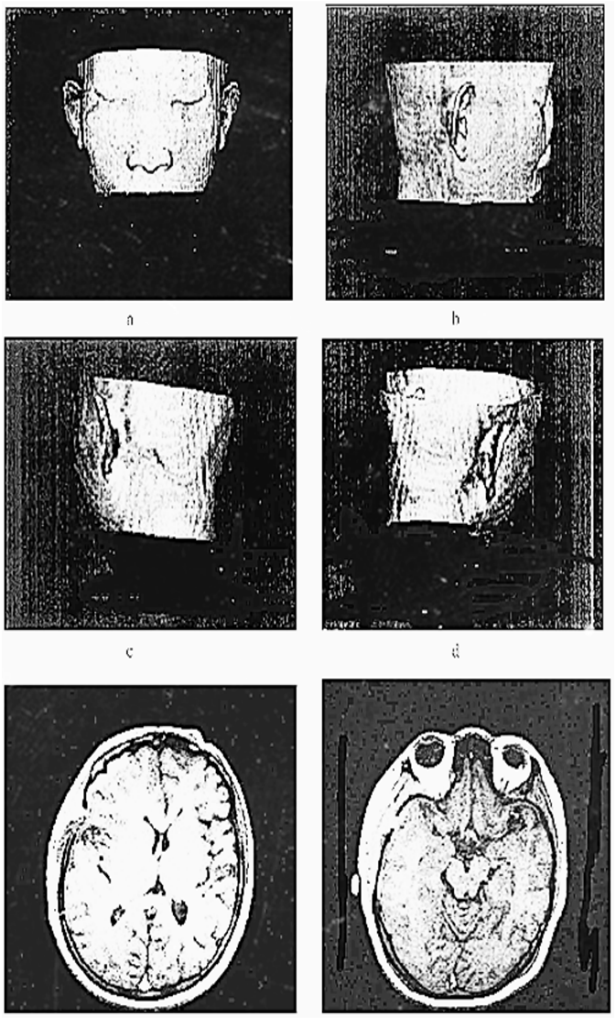


Figure 5. 3D reconstruction effect of skull

Using marching cubes algorithm, we first measure pixel points extracted from image edge, reduce the amount of peaks, and make use of midpoints on edge of cubes, thus shorten reconstruction time.

	Amount of peaks (n)	Amount of trian gular plate (n)	Recon struction time (s)
Traditional marching cubes algorithm	174596	93647	2.7
Improved marching cubes algorithm	143654	86954	2.2

Table 1. Comparison of improved marching cubes algorithm and traditional marching cubes algorithm

It is concluded from the above comparison that, the improved marching cubes algorithm can not only clear the demonstration of skull and improve reconstruction effect, but also can speed up surface reconstruction. Thus the method proposed in this study is feasible to be used in practical medicine.

5. Conclusion

This study introduces the basic principle and method of marching cubes algorithm, find out disadvantages of marching cubes algorithm based on deep study, and meanwhile mentions several kinds of common medical image segmentation algorithms. Region growth algorithm is used to segment liver tissue and moreover, volume rendering technology provides 3D space description for 2d medical fault image to make 3D structure clearer.

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