Original Article

Design of Three-dimensional Visualization System for Medical Image Based on Magnetic Resonance Angiography Data

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Abstract

Objectives: The objective of the study was to discuss the design method of medical image three-dimensional (3D) visualization system based on magnetic resonance angiography (MRA) data. **Methods:** Using 3D visualization of the carotid artery as an example, the three-position reconstruction algorithm on the basis of volume rendering was discussed. Moreover, if 3D carotid artery is extracted, based on this, we could combine Visualization Toolkit and Image Segmentation and Registration Toolkit with it to construct a 3D visualization system of medical images based on MRA data using C++. **Results:** The 3D visualization system of medical image data can be read on the MRA based on Digital Imaging and Communications in Medicine images and can be displayed completely. At the same time, a series of interactive operations can be carried out on the 3D image, and three-position blood vessel segmentation and enhancement on the basis of volume rendering can be realized. **Conclusions:** The medical image 3D visualization system based on MRA data can read and display 3D images and can realize a series of interactive operations, which can achieve better blood vessel enhancement effect and carotid artery extraction. It has important function and significance for a three-bit visualization of medical image.

Keywords: Carotid artery, Digital Imaging and Communications in Medicine images, magnetic resonance angiography, three-dimensional visualization

Introduction

Three-dimensional (3D) visualization of medical images involves digital image processing, computer graphics, and human–computer interaction. It is a cross-disciplinary research field and an application of visualization technology in the medical field. Visualization technology is the use of computer graphics and digital image processing techniques to scientific computing or data acquisition of a large number of abstract data images, intuitively expressed in the form of graphical image information, and through human–computer interaction technology combined with analysis.[1] Visualization technology is widely used in the medical field. The research and development of visualization technology and visualization system for medical images is one of the research hotspots in the medical field.

3D visualization of medical images utilizes medical sequence images acquired by medical imaging devices such as nuclear magnetic resonance (MR) and computed tomography (CT) to reconstruct 3D image models of human tissues and organs. Through the interactive operations such as rotation, reduction, cutting, and magnification of the 3D model, the morphology and the spatial position relationship with the surrounding tissues and organs of the tissues and organs of interest are observed and analyzed from any angle and any position. The use of 3D visualization techniques can provide physicians with quantitative analysis and qualitative diagnosis of lesion sites and areas of interest.[2] Since the 3D medical image provides a 3D display effect of human tissues and organs, compared with two-dimensional slice images, it can provide richer internal details of tissues and organs, thus greatly improving the accuracy of medical analysis and diagnosis performed by doctors. In the field of clinical medicine, by combining

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3D visualization technology with virtual reality technology, doctors can perform virtual endoscopy and develop surgical planning and virtual surgery. Medical image 3D visualization technology fills the gap of medical imaging equipment and can be used as an effective aid. Providing 3D display of medical images for doctors and medical researchers is beneficial to observation and analysis and has important application value in clinical fields such as medical analysis and diagnosis.[3]

Overview

Medical imaging technology has developed rapidly since the 1970s, and medical image 3D visualization technology has also achieved great development. The development of visualization technology has solved many technical problems and greatly promoted the development of medical image 3D visualization technology. At present, 3D visualization technology of medical images, i.e.,[4] 3D reconstruction technology, is one of the research hotspots in the field of medical image processing.

At present, Stanford, Massachusetts Institute of Technology, and other universities and research institutes in the field of medical image 3D visualization technology are at the leading international level. Some of the world's leading medical device manufacturers, such as GE in the USA, the Siemens company in Germany, and Philips in the Netherlands, are in commercial applications. The field is in a dominant position. Internationally, there is no uniform standard for 3D image reconstruction algorithms, and the treatment algorithms in clinical applications are kept confidential.[5] Therefore, the effects of 3D rendering on devices of different medical device manufacturers are not exactly the same.

The domestic research on the 3D visualization of medical images started late, and there is a certain gap between the theoretical research and practical application. Many universities and research institutions in China have absorbed a great deal of experience from abroad and have done a lot of research on 3D visualization technology of medical images. After years of hard work, good research results have also been obtained. At present, China has set up a visible human data set. The medical image processing software MITK (Medical Imaging Interaction Toolkit) develop by German Cancer-research centre and the 3D medical image processing software 3D Med developed by the Institute of Automation of the Chinese Academy of Sciences provide a set of integrated medical image registration, segmentation, and visualization functions for medical image processing. It has a unified interface and supports multiplexing. High efficiency and flexibility have a greater influence in the country. The domestic commercial medical image 3D visualization system is not yet mature.[6] The domestic research level in the field of 3D visualization of medical images is close to the gap between foreign countries, but there are still many problems to be solved.

Methods

The main task of the 3D visualization of carotid arteries is to segment the carotid arteries from the original Digital Imaging and Communications in Medicine (DICOM) medical sequence images and perform 3D display and interactive operation for easy observation and analysis. The realization of the 3D visualization of the carotid artery mainly includes the 3D visualization of the medical image and the extraction of the carotid artery. Take the first 3D visualization of medical images and then use the 3D regional growth algorithm to achieve the extraction of the carotid artery on the basis of blood vessel enhancement. The general process of 3D visualization of medical sequence images is shown in Figure 1.

The first is to read medical sequence images, i.e., DICOM sequence images acquired by CT, MR, and other scanning devices. Then, the data are preprocessed. If the image quality is relatively poor, image filtering is required. To obtain a better rendering effect, interpolation processing is required, and a trilinear interpolation method is commonly used. After the preprocessing, visual mapping is performed, such as mapping the optical values such as color and opacity of the data values, then performing 3D rendering, selecting an algorithm for 3D reconstruction, generally a surface rendering algorithm or a volume rendering algorithm, and finally displaying on the screen,[7] and can be interactive, such as 3D image reduction, magnification and rotation, and other interactive features.

According to the flowchart and system design of 3D visualization of medical images, a 3D visualization system for carotid arteries with multiple volume rendering algorithms, vessel enhancement, vessel segmentation, and interoperation is designed. The block diagram of the implementation is shown in Figure 2.

Results

The extraction of carotid arteries needs to be performed with vessel enhancement first and then using the region growing algorithm. The Hessian matrix multiscale vascular enhancement algorithm is used. There are several parameters that need to be set in the algorithm, such as α, β, and c, in the

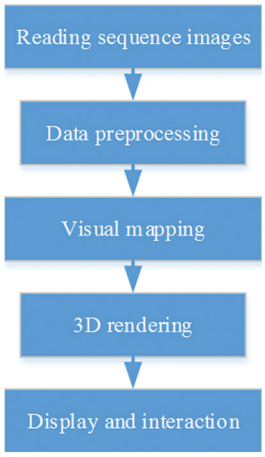

Figure 1: Flowchart of three-dimensional visualization of medical sequence images

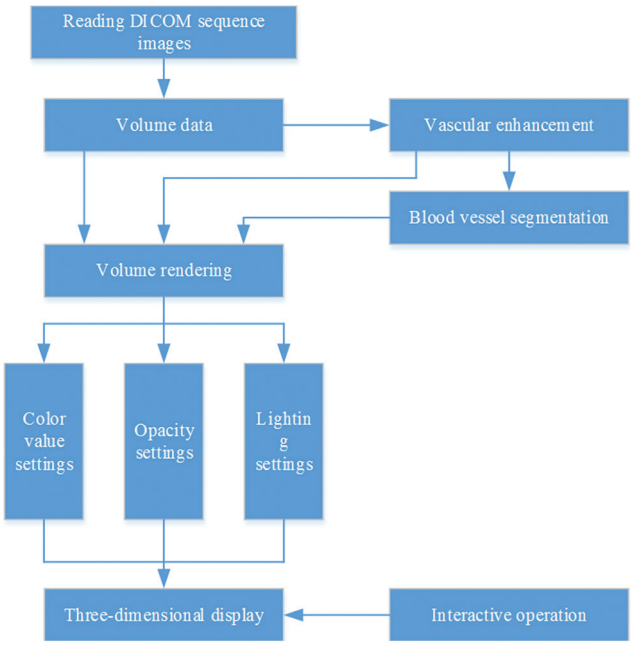

Figure 2: Block diagram of carotid three-dimensional visualization system

vascular similarity function and the scale range. Wait. Since c can usually take half of the Hessian matrix F norm, you do not need to set it artificially. Therefore, you need to set the α, β, and scale ranges. The scale range can be set with three parameters: the smallest scale, the scaled step, and the scale number.

The parameters of the blood vessel enhancement setup and the volume rendering effect after the enhancement treatment are shown in Figure 3. In the image processing parameter settings, α represents alpha, β represents beta, min scale represents the minimum scale, stepping represents the scale step, scale number represents the number of scales, and k represents the threshold parameter in the segmentation.

From Figure 3, it can be seen that the blood vessels in the corresponding scale range have a better enhancement effect, and the nonvascular structure and background are well suppressed, and the enhanced blood vessel structure is clearly visible.

Conclusions

Based on the analysis of Image Segmentation and Registration Toolkit and Visualization Toolkit which are widely used in the field of medical image processing, this article makes a deep analysis and research on the 3D visualization

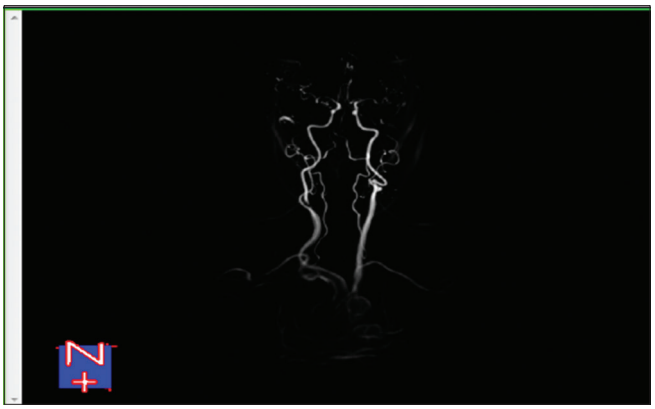

Figure 3: Vascular enhancement

technology of medical images through 3D reconstruction, blood vessel enhancement, and blood vessels. The realization of segmentation completed the 3D visualization of medical images and the extraction of carotid artery vessels. A 3D visualization system of the carotid artery based on magnetic resonance angiography data with good interaction performance was designed and implemented.

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Conflicts of interest

There are no conflicts of interest.

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