Modeling and Printing Technology Based on 3D Registration Algorithm of MIMICS Software Applied to Hip Fracture

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Abstract. Hip fracture is the most common and serious fracture in the elderly. Because of the complicated types of acetabular fractures and the curved surface of acetabulum, the surgical treatment of two rows of acetabular fractures has proved to be challenging. Operation is the best treatment for hip fracture in the elderly. However, the elderly patients complicated with a variety of complex medical diseases and the decline of various organs increase the risk of operation, and the incidence of postoperative complications and mortality are also extremely high. The 3d reconstruction adopts MC algorithm. The basic idea is to treat the 2d slice sequence data as a 3d data field, process the voxels in the data field one by one, compare the value of each vertex of the voxel with a given threshold value to determine the construction form of the internal isosurface of the voxel, and connect it into a triangular patch to fit the surface in a certain topological form. Finally, connect the isosurface of each voxel to form the whole isosurface, which is used to represent the surface of the object. The hip joint model is established by imaging and 3D printing. The 3D solid model can truly express individual cases and the actual state and actual stress environment of individual cases, which makes the formulation of hip joint disease treatment plan faster, improves the prediction and prevention of long-term curative effect, and provides valuable clinical research.

Keywords: Hip fracture · Image segmentation · 3D modeling · 3D printing

1 Introduction

Hip fracture is the most common and serious fracture in the elderly. Because of the complicated types of acetabular fractures and the curved surface of acetabulum, the surgical treatment of two rows of acetabular fractures has proved to be challenging [1]. In America, the probability of hip fracture in women is equal to the sum of breast cancer, ovarian cancer and uterine cancer, while the probability of hip fracture in men is higher than that of prostate cancer [2, 3]. With the aggravation of population aging, the incidence of hip fracture in the elderly in the world is increasing at a rate of 1%–3%

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every year. It is estimated that the number of hip fracture patients in the world will rise to 6.26 million in 2050, of which more than half will occur in Asia [4]. The incidence of hip fracture in China is also increasing year by year: during 1990–1992, the incidence of hip fracture was 83/100,000 for men and 80/100,000 for women over 50 years old, and it has increased to 129/100,000 for men and 229/100,000 for women during 2002–2006, with a sharp increase in medical expenses [5]. Therefore, hip fracture in the elderly has become one of the most important public health problems in the world [6].

With the aging of China's population, the proportion of osteoporosis in the elderly is increasing, which leads to an increase in the number of patients with hip fractures year by year. At present, there are non-surgical treatment and surgical treatment for elderly patients with hip fracture. However, due to poor resistance and many basic diseases, non-surgical treatment needs to stay in bed for a long time, which is prone to complications such as pressure sores, lung infection and deep vein thrombosis, which seriously affects the quality of life of patients and even endangers their life safety [7–9]. Therefore, surgery is the best treatment for hip fracture in the elderly. However, the elderly patients complicated with a variety of complex medical diseases and the decline of organs in various systems increase the risk of surgery, and the incidence of postoperative complications and mortality are also extremely high [10–12].

2 Research Status

The principle of imaging and the optimized modeling of 3D algorithm of imaging images: The development of digital imaging and the digital construction of hospitals are the products of the combination of electronic industry, computer technology and medicine, which is the inevitable development of imaging and the whole scientific development [13]. With the development of science today, electronic information and computer technology have been fully developed, and the product of their combination is the origin and foundation of the development of digital images [14]. The main advantages of digital imaging are as follows: it can turn simulated dead images into reusable or data, and further change two-dimensional planar images into multidimensional stereo images; It can make image quantitative diagnosis possible. Completely changed the traditional medical image viewing, use, storage and management methods [15, 16].

Digital image is to turn past analog images into reusable data. In the past, hospitals gave patients an X-ray film, which could only record the images of patients under current conditions, but could not see new things through it [17]. Digitalization turns the image into a kind of living data, which can change the past two-dimensional plane image into a multi-dimensional three-dimensional image, from only one plane and length and width in the past to a long, wide, high or front and back, left and right, up and down three-dimensional image [18].

Because of the different functions, medical imaging itself not only reflects the three-dimensional structure, but also includes elements such as time and resolution. In the functional change, we call it a four-dimensional image. In the past, we could only make qualitative judgments, and there was no exact data to make quantitative judgments on patients' films. With the help of digital images, we can make accurate measurements. For example, by measuring the CT value of the patient's image, the tissue type of the lesion can be clearly obtained, so as to make a diagnosis [19].

By introducing highly integrated and easy-to-use 3D image generation and editing software, it can input various scanned data (CT, MRI), build 3D models for editing, and then output general CAD (Computer Aided Design), FEA (Finite Element Analysis) and RP (Rapid Prototyping) formats, which can be used for large-scale data conversion processing on PC. Scan input data can be processed quickly, and the corresponding file format can be output for FEA (Finite Element Analysis) and CFD (Computer Simulation Fluid Dynamics). Users can build 3D model with scan data, and then mesh the surface for FEA analysis. The mesh re-division function in FEA module optimizes the input data of FEA to the maximum extent. Based on Heinz unit of scanned data, materials can be assigned to volume meshes [20].

Development of 3D printers and printing materials: In 1990, Sachs of Massachusetts Institute of Technology first proposed the concept of 3D printing. Since 1990s, 3D printing technology has made vigorous development. In 2003, Mironov of the University of Southern Carona put forward the concept of 3D printing of biological tissues and organs. Compared with the traditional plane printing, 3D printing makes the printed object three-dimensional. In the aspect of three-dimensional forming, 3D printing is a typical additive manufacturing, that is, stacking layer by layer to form a three-dimensional structure [21]. As one of the disruptive technologies that will determine the future economy and human life, 3D printing effectively integrates materials, machinery manufacturing, information processing, electronic equipment and engineering design, and breaks through the dilemma that traditional manufacturing processes are limited by structural complexity and difficult to process and manufacture. Customizing personalized products through 3D printing will reduce production costs and lead a new industrial revolution. At present, 3D printing is widely used in biomedicine, aerospace, architectural design, cultural industry, industrial manufacturing and military equipment, etc. Especially in biomedicine, 3D printing plays an increasingly important role.

The predecessor of 3D printing technology is rapid prototyping technology. The basic idea is based on the digital 3D model, the objects are digitized and layered, and the information such as the 2D processing path of each layer is obtained. By using appropriate materials and processes, the objects are printed layer by layer along the set path through automatic control technology, and finally accumulated into 3D objects. Application of 3D printing in biomedical field Because it is suitable for small batch and highly customized occasions, 3D printing is quickly combined with biomedicine to form biological 3D printing. Biological printing can be divided into broad sense and narrow sense. Generalized biological 3D printing refers to 3D printing that directly serves the biomedical field. In the narrow sense, biological 3D printing refers to the operation of biological ink containing cells to construct living tissue structure, which is the advanced stage and ultimate goal of biological 3D printing. From the development process, the generalized biological 3D printing can be roughly divided into four levels, namely, medical AIDS, non-degradable implants, degradable implants and cell-carrying printing.

3 Research Contents

Mimics is the abbreviation of Materialise's Interactive Medical Image Control System, which can provide user-defined input modules and support various file input formats such as BMP, JPG, TIF and RAW. It has irreplaceable advantages in basic image processing, segmentation, extraction and visualization.

3.1 MIMICS Software Image Import and Preprocessing

The reconstruction of bone model has always been an important task in biomechanical engineering analysis, and it is also the prerequisite for the accuracy of model reconstruction. It is not only a requirement for the model, but also a special need for the subsequent finite element analysis and the following work.

Medical image three-dimensional reconstruction technology refers to the use of visualization technology to convert two-dimensional image data obtained from medical imaging equipment into three-dimensional data, so as to display the three-dimensional shape of human tissues and organs and make qualitative and quantitative analysis. In this study, based on DICOM format file of hip joint medical image of clinical patients, interactive medical image control system software (MIMICS) was used to reconstruct hip bone.

(1) Raw data collection: collect DICOM format image data of a hip fracture patient, and apply MMCS new project guide command (import the image data into MIMICS software, which automatically virtualizes the cross-section, coronal plane and sagittal plane according to the fault sequence, and obtain the perfect angle of image processing by adjusting the visual angle and fault sequence.
(2) After importing hip joint data into image processing, the software displays the image sequence of axial view, and at the same time, automatically virtualizes coronal view, sagittal view and three-dimensional display viewport. In different viewports, the indication information of images is expressed by tick marks, intesection lines, slice position, etc.

Image preprocessing: Image preprocessing is a process before sorting out CT images and handing them over to the segmentation model. This process is called image preprocessing. In image analysis, the quality of the image directly affects the design of the recognition algorithm and the precision of the effect, so preprocessing is needed before image analysis (feature extraction, segmentation, matching and recognition, etc.). The main purpose of image preprocessing is to eliminate irrelevant information in the image, recover useful real information, enhance the detectability of relevant information, and simplify data to the maximum extent, thus improving the reliability of feature extraction, image segmentation, matching and recognition. See Fig. 1.

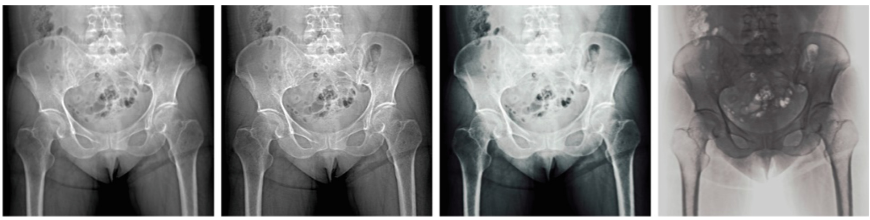

Fig. 1. Image preprocessing schematic diagram

3.2 Algorithms for 3D Modeling of Mimics Software

The 3d reconstruction adopts MC algorithm. The basic idea is to treat the 2d slice sequence data as a 3d data field, process the voxels in the data field one by one, compare the value of each vertex of the voxel with a given threshold value to determine the construction form of the internal isosurface of the voxel, and connect it into a triangular patch to fit the surface in a certain topological form. Finally, connect the isosurface of each voxel to form the whole isosurface, which is used to represent the surface of the object. The essence of 3D reconstruction is to fit the boundary of mask voxel, and the distance between contour lines is the distance between fault slices. Three-dimensional reconstruction is a process of calculating masks based on three-dimensional models, that is, voxelization. Three-dimensional reconstructed hip joint model. See Fig. 2.

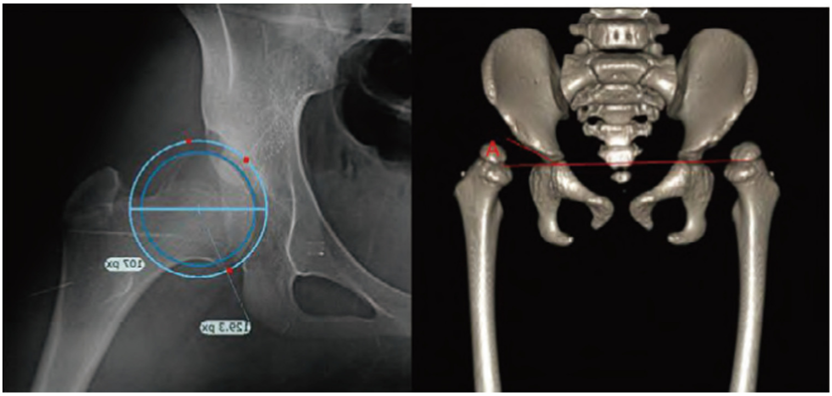

Fig. 2. Schematic diagram of 3D model generation

In order to give doctors sufficient information for diagnosis of orthopedic diseases, this paper studies two ways of visualization technology and quantitative index calculation, and proposes an evaluation method for auxiliary diagnosis of orthopedic diseases based on visualization technology and quantitative index calculation, which displays useful information through quantitative index values, two-dimensional images and three-dimensional models to assist doctors in diagnosis. In order to realize 3D visual evaluation of multi-target areas, this study proposes an improved MC 3D reconstruction algorithm based on multi-region labels and a 3D model rapid prototyping file export algorithm. The former can provide 3D model images, while the latter can be used to print 3D solid models.

3.3 3D Printing of 3D Registration Model with Mimics Software

Through the export algorithm of 3D model rapid prototyping file of MIMICS software, the STL of hip bone model file is generated. The 3D printer can print 3D through 3D model CAD data. The 3D reconstructed image and 3D physical model before operation can help to achieve fracture reduction, plate bending and position determination more accurately in clinic. Therefore, preoperative planning is conducive to the smooth operation, and can obtain satisfactory surgical results. See Fig. 3.

Fig. 3. 3D printing skeleton model schematic diagram

4 Key Technologies

(1) Through image preprocessing algorithm, the image is optimized to solve the problems of CT image quality, boundary registration, coordinate error and so on.
(2) 3-D registration of preprocessed images by software, so as to achieve accurate and rapid reconstruction of CT image skeleton solid model.
(3) The hip joint model is established by image and 3D printing, and the 3D solid model can truly express individual cases and the actual state and actual stress environment of individual cases, which makes the formulation of hip joint disease treatment plan faster, improves the prediction and prevention of long-term curative effect, and provides valuable clinical research.
(4) Three-dimensional solid model can guide patients to avoid secondary fractures caused by new imbalance of strength during rehabilitation training, as well as postoperative nursing care.
(5) Provide teaching guidance for clinical teaching of hip fracture research. The experience of hip fracture research can be extended to other orthopedic diseases.

5 Discussion and Summary

In this paper, an image preprocessing model is proposed, which can preprocess CT images to overcome the gray-scale inhomogeneity that often exists in images, and is also robust to noise and contrast, thus improving the accuracy of 3D modeling. Furthermore, the CT-based bone threshold segmentation is proposed, and the advantages and disadvantages of the Segment- Threshold algorithm and the Advance segment- CT Bone algorithm are compared. Aiming at the segmentation accuracy of the target region, the Advance segment- CT Bone algorithm is more suitable for bone image segmentation. The 3D modeling adopts MC algorithm, which regards the 2D slice sequence data as a

3D data field, processes the voxels in the data field one by one, compares the value of each vertex of the voxel with a given threshold to determine the construction form of the internal isosurface of the voxel, and connects them into triangular patches to fit the surface in a certain topological form. Finally, the isosurface of each voxel is connected to form the whole isosurface, which is used to represent the surface of an object. The 3D reconstruction is mainly carried out by surface rendering, which has the advantages of high 3D reduction and small error. Finally, the 3D model is printed by the generated STL file, and the 3D hip joint model is applied to clinical application.

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