Three-Dimensional Model Extraction and Parameter Measurement of Cerebral Hemangioma Based on Mimics

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Abstract. In this paper, Mimics is using to reconstruct the 3D model of hemangioma from 2D cerebral angiography images. The process of 3D model reconstruction is formulated. The hemangioma model is extracted and the parameters of the hemangioma are measured, which provided a model basis for the structural design of the spring coil. The shape and structure of the coil are very important for the therapeutic effect. During the treatment, the coil is implanted into the hemangioma from outside the body through a catheter.

1. Introduction
Microcoil embolization treatment of cerebral hemangioma is to implant the soft precious metal embolization coil into the hemangioma, which from the outside of the body through the microcatheter to form hemangioma blood coagulation embolization, to prevent blood overflow or inhibit the rupture of the hemangioma. Therefore, the shape and structure of the coil are very important for the embolization effect. The existing spring coil structure is single, it is hard to meet all kinds of cerebral aneurysms. In order to design the shape structure and embolization method of the coil personally, so that the coil can be targeted for better treatment of hemangioma. It is necessary to obtain a three-dimensional hemangioma model, and this model is used as an example to complete the design of the micro-spring coil for embolization. In this paper, 2D medical images (CTA images of cerebral angiography) are used to reconstruct the 3D cerebral angio image model based on Mimics software.

2. Method of 3D Model Reconstruction
CT 3D reconstruction technology is to extract the characteristics of the target tissue information after a series of image processing techniques such as filtering and segmentation, and finally to complete the reconstruction of the model by using 3D imaging algorithm, which greatly improves the accuracy and scientficity of medical diagnosis. This paper uses two-dimensional medical images and mimics software to reconstruct the three-dimensional model of hemangioma, which is convenient for doctors to observe the size and shape of the aneurysm from any angle for embolization treatment. At the same time, it also plays a vital role in the theoretical design and selection of coil shape, which is used in the treatment process.

3. Technology of Medical Imaging
3.1. CT and CTA Techniques
Mimics software is an interactive medical image control system. The 3D model reconstructed by MIMIS can be enlarged, rotated and translated, which can make people observe the reconstructed area
more comprehensively and carefully. Next, this paper will use Mimes software to solve and establish a relatively accurate 3D model of cerebral hemangioma, by taking CTA angiography images of patients with cerebral hemangioma in hospitals as an example.

CT angiography (CTA, CT angiography) is a kind of intervention detection method. It is mainly used for the diagnosis and adjuvant treatment of brain, central nervous system diseases and cardiovascular diseases. Because X-ray can't penetrate the contrast agent, CT angiography still needs to inject a contrast agent into the blood vessel to enhance the display of blood vessels, by using the blocking effect of contrast agent on X-ray.

3.2. The DICOM Format
DICOM standard is a general standard agreement covering almost all information of medical image collection, archiving, communication, display, printing, and query. It defines standard network interfaces and data models, simplifying the development of medical images. Images and patient data can be received and exchanged using DICOM data structures and file formats among multiple medical devices, which can accept DICOM format.

![Figure 1. Faultage of 2-D DICOM](image)

DICOM format has a high definition, relatively stable data range in medical images for different tissues and organs. The medical images used and saved in this paper are all in DICOM format. As shown in Figure 1, the two-dimensional reconstruction of DICOM format tomography not only stores image information but also multiple information such as the time, place, patient name and number of the image, which provides a richer basis for doctors.

4. 3D Model Reconstruction of Cerebral Hemangioma

4.1. The Process Technology of 3D Model Reconstruction
This paper, based on Mimes software, using the 2D cerebral angiography images to reconstruct the 3D model of cerebral angioma. The image of cerebral angiography is taken from the radiology department of a hospital and the CT machine is gemstone CT which is come from GE company. Data group I is a bypass aneurysm in cerebral arterial hemangioma. The following is a detailed process for modeling using Mimes software. The flow chart of the 3D model reconstruction of cerebral hemangioma is shown in Figure 2.
Figure 2. Flow chart of 3-D reconstruction of the intracranial aneurysm

For angiography images themselves, compared with other images (such as B-ultrasound, etc.), their signal-to-noise ratio is low, that is to say, noise has a certain influence on the segmentation accuracy, but not much. Therefore, in the process of blood vessel segmentation, the filtering method is chosen not only for noise reduction, but also for highlighting the image boundary and enhancing the contrast between the target and the background. In the following part of this paper, the 3D model of the cerebral hemangioma is reconstructed according to the above process.

4.2. Image Reading
Starting mimics and using the import images function to import DICOM format CT tomographic images into Mimics software. At this time, the software will automatically define the coordinates of anterior, posterior, left and right directions, and the operator will manually define the top and bottom directions of the image. Then the software will automatically generate sagittal and coronal images of the target tissue according to the CT sectional images, as shown in Figure 3. A hemangioma can be faintly seen in the middle of the brain in the following three views, but the image quality is low and the tissue contour is fuzzy, so it is necessary to pre-process the image.

Figure 3. Three-view drawing of the aneurysm model(pre-treatment)

4.3. Preprocessing and Extracting the Contour
Pretreatment is a very crucial step in hemangioma model extraction, the Contrast functions of the software (i.e., linear Contrast stretching processing) is to adjust the Contrast of the image, using it for image Contrast enhancement, the purpose is to make hemangioma of the tumors had contour more
prominent, and suppress other redundant parts. In order to achieve the effect of improving image quality, this step is very important. After contrast adjustment, figure 4 below is obtained, in the three views drawing editable interface can clearly see the existence of hemangioma and the location of the aneurysm, which lays a good foundation for extracting the contour of hemangioma.

![Figure 4. Three-view drawing of the aneurysm model](image)

The noise generated by the disturbance of electronic devices and the level of the operator in medical images. In this paper, in the process of extracting cerebral aneurysm, by adjusting the threshold left interval to observe the corresponding three views, it is found that when the threshold left interval is set to 125, the contour of the target image (aneurysm image) is the clearest, there is no tissue loss and the noise around the aneurysm is the least. It is completed the threshold interval set, as shown in figure 5. the threshold setting, hole processing after brain three-view drawing as shown in figure 6.

![Figure 5. Selection of the threshold interval in the pretreatment](image)

![Figure 6. Three-view drawing of the brain model after pretreatment](image)

4.4. Generate 3D Model
After extracting the contours of the hemangioma, using the 3D calculation tools in the software, and using the Calculate3D option in the menu toolbar (segmentation). And then, the two-dimensional image is converted into a three-dimensional model of hemangioma by direct calculation, as shown in
The reconstructed brain skull model has a lifelike appearance and can reproduce the three-dimensional shape of the reconstructed tissue intuitively and clearly. The three-dimensional image of hemangioma in the brain can be clearly seen. The view can be translated, scaled, rotated at any angle, and cut in any plane. This provides the feasibility for the next cutting and extraction of hemangioma.

As shown in 3.6 above, because the gray value of blood vessels and skull tissue is very similar, there are redundant tissue data such as blood vessels and skull in the image, which needs to extract the hemangioma part. Therefore, through the cut orthogonal to screen function in the software, the skull, and other unnecessary vascular tissues are removed, and the three-dimensional model of hemangioma is extracted, as shown in figure 8.

4.5. Extraction and Parameter Measurement
The obtained hemangioma is imported into 3-Matic 8.0 for smooth modification, and the smooth function in the software is used to obtain a relatively smooth hemangioma model. When the reconstructed hemangioma model is output and saved in STL format, the reconstructed 3D visualization model can be obtained. The 3D model obtained can be translated and scaled and can be used to observe hemangioma intuitively from multiple angles and measure its parameters, which is of great significance to doctors' accurate diagnosis of the disease and to guide the design and manufacture of the embolization spring coil.

In this paper, the hemangioma model is extracted, and the main parameters of the hemangioma are obtained through the measurement tool in the software, as shown in Table 1. The parameters in the table are of great significance to the design of the coil for embolization of hemangioma.
Table 1. Parameters of the aneurysm

| Parameter                        | Character | The numerical |
|----------------------------------|-----------|---------------|
| Maximum diameter of hemangioma   | Dmax      | 16.67mm       |
| Minimum diameter of hemangioma   | Dmin      | 14.27mm       |
| Tumor neck diameter              | Dj        | 10.84mm       |
| Height of hemangioma              | H         | 14.73mm       |
| Vessel inlet diameter            | Din       | 3.01mm        |
| Hemangioma outlet diameter       | Dout      | 2.87mm        |
| Hemangioma volume                | V         | 1436.2mm³     |

5. Conclusion
The three-dimensional model of hemangioma is reconstructed based on Mimics software for medical images (CT angiography images). The reconstruction and extraction of the three-dimensional hemangioma model are completed through a series of steps in the software, such as preprocessing (image denoising, image enhancement, etc.), extracting contour, generating three-dimensional model, smoothing, and so on. The parameters of hemangioma are measured, which laid the foundation for the structural design of micro coils for embolization.

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7. References
[1] Kyung Se Cha, Elias Balaras, Baruch B. Lieber, Chander Sadasivan, Modeling the Interaction of Coils With the Local Blood Flow After Coil Embolization of Intracranial Aneurysms, Journal of Biomechanical Engineering, 2007, 12, pp. 873–879.
[2] Alvaro A. Valencia, Amador M. Guzmán, Ender A. Finol, Cristina H. Amon, Blood Flow Dynamics in Saccular Aneurysm Models of the Basilar Artery, ASME, 2006, 20, pp. 516–526.
[3] Chen Jinrong, Comparative study of CTA and DSA in the diagnosis of intracranial aneurysms and discussion of CT angiography technology [D]. Master's thesis of engineering, Southern Medical University, Guangdong, 2014.
[4] Liu Jia Hao, Research on cerebrovascular image processing and numerical simulation [D]. Zhejiang University of technology, 2014.
[5] Zhang Bianka, Segmentation and 3D reconstruction of angiographic images [D]. Master's thesis of engineering, Kunming University of technology, Yunnan, 2012.
[6] Wang Jiao, Liu Yang, Zhang Xiaoling, et al. Application of Mimics software in 3D reconstruction of medical images. Medical and health equipment. 2015, 2 (36): 115-118.
[7] Song Ziguo, Research on Preprocessing Algorithm of 3D reconstruction of medical images [D]. Master's thesis of Guangdong University of technology, Guangzhou, 2012.
[8] Du Yongsheng, 3D reconstruction of small cerebral vessels based on CT data [D]. Master's thesis of engineering, Yanshan University, Hebei, 2011.