Construction of the head model for the operation simulation system targets the brain aneurysm

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Abstract: In this paper, we propose a system that is necessary for an operation simulation system targeting a brain aneurysm. In traditional clinical training, the doctor has acquired medical skills through experiences of medical operation. But, these training contain some problems that are security and burden to a patient. And so, as a new approach for the medical training, researches of the operation simulation system using Virtual Reality are worked. So, we aim a development of operation simulation system targeting a brain aneurysm, we construct the necessary function for this system such as a detection of blood vessel and brain aneurysm and construction of head model use at simulation.

Keywords: Virtual Reality, Operation simulation, Brain aneurysm, Image processing

I. INTRODUCTION

In traditional clinical training, the doctor has acquired medical skills through experiences of medical operation. But, these training contain some problems that are security and burden to a patient. And so, as a new approach for the medical training, researches of the operation simulation system using Virtual Reality are considered promising.. As a back ground, points that human body is possible to rebuild from high resolution image obtained by CT or MRI, and advancement of computer's processing speed, are adduced. Especially, the purpose of this research is development of the simulation system which targets brain aneurysm that is occurred at inside of blood vessel of the head. The purposes of this research are the detection of the operation target, and modeling the head including the operation target.

Advantages of this system are possible visualizing the position of target and to increase the reality by using actually patient's image data.

In this paper, the methods are shown which detect blood vessel and brain aneurysm, and construct the head model used when the medical operation is conducted not to have aneurysm burst away.

This research is conducted based on our experience on both diagnosis of lug cancer or structural analysis of tracheole from CT images [1][2], how to cut a virtual surface model [3] or a virtual voxel model [4] with a scalpel, and simulation of medical manipulation ICSI using a deformable surface model [5].

II. Detection of the blood vessel

First, we mention about the detection method of blood vessel. When we want to detect the brain aneurysm, it is postulated that blood vessel is detected. Images that we use are MRA, so the brightness value of the artery is higher than else parts. Then, we apply the growing region method to image and decide as blood

vessel when the brightness value of the part that is near blood vessel is higher than threshold value. The threshold value is decided based on the experience.

And, the start point of this process is setup by following method; raster scanning the image and picking up the point that brightness value is higher than threshold as a start point.

Fig. 1 shown the how to growing the region when this process.

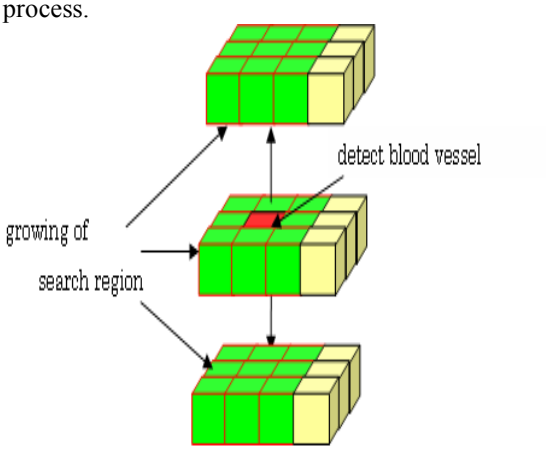

Fig.1. The region growing for detect blood vessel

III. Detection of the brain aneurysm

If it is possible to make the location of a brain aneurysm clear in advance before training or diagnosis, it will help not only a trainee confirm a target but also a doctor determine if medical operation is needed or not.

In this system, the detection method of the brain aneurysm is based on facts that a brain aneurysm is a lump (1) and it occurs near the divergent point between blood vessels (2).

First, we focused the fact 1 and examine the expanse appearance of the local area of the blood vessel by apply the region growing method to the blood vessel that is detected by the method shown in chapter 2. And, we detect the part that the expansion area is larger than else area as a brain aneurysm.

But, this method comprehends the mis-detection, so we apply the fact 2 to detection method; when the area A and B are detected by the method based on the fact 1, we examine the distance from the bifurcation to point A and B. If the distance is near compare with the set up value, this point is detected as a brain aneurysm. This method is shown in Fig. 2.

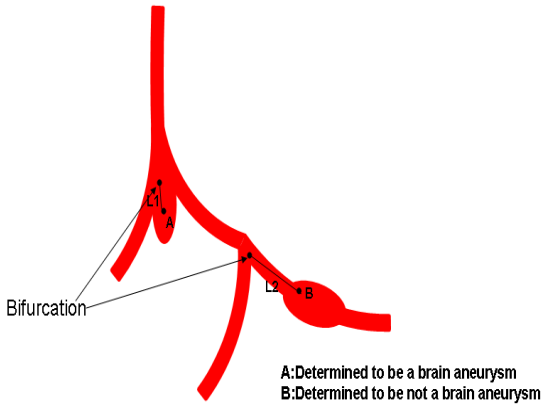

Fig. 2. Detection with the bifurcation distance

IV. Construction of the head model using a CT images

When we simulate an operation, construction of the head model to be operated is needed.

In this system, the head model is restored based on CT images taken from a patient who will be receive medical operation. This allows the operation simulation that meets each patient's medical condition.

In this system, three types of CT images shown below are used.

1, Image extracting only bone
2. Image extracting both bone and artery
3. Image extracting all bone, artery and vein

It seems apparent to obtain artery and vein region can be extracted with difference operation from these images,

$$\text{artery} = \text{Image2} - \text{image1} \quad (1)$$
$$\text{vein} = \text{Image3} - \text{image2} \quad (2)$$

As shown method above, we extract the artery and vein. Additionally, we extract the bone using the growing region method explained in section 2.

V. Execution result

In this chapter, we show detection result of blood vessel, detection result of brain aneurysm and construction result of head model based on CT images.

Detection result of blood vessel and brain aneurysm are shown the result applied to 4 MRA images. Construction result of head model is shown the result applied to CT image.

1. Detection result of the blood vessel

In this section, we show the detection result of blood

vessel. Fig. 3 shows original image and Fig. 4 shows detection result.

As shown in Fig. 4, it is confirmed the detection is successfully.

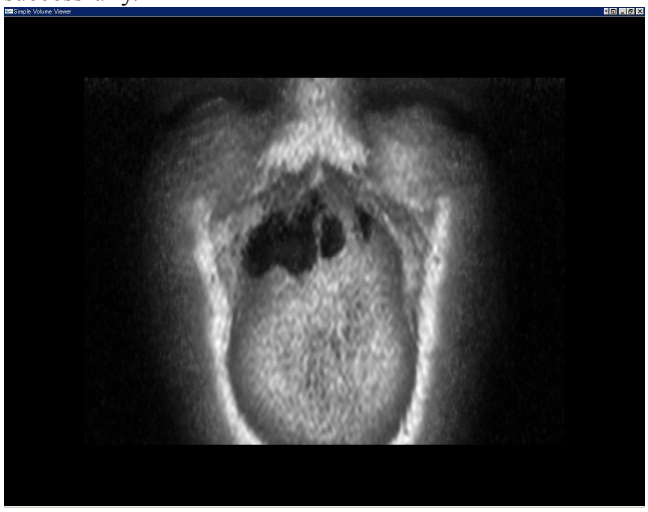

Fig. 3. An original image

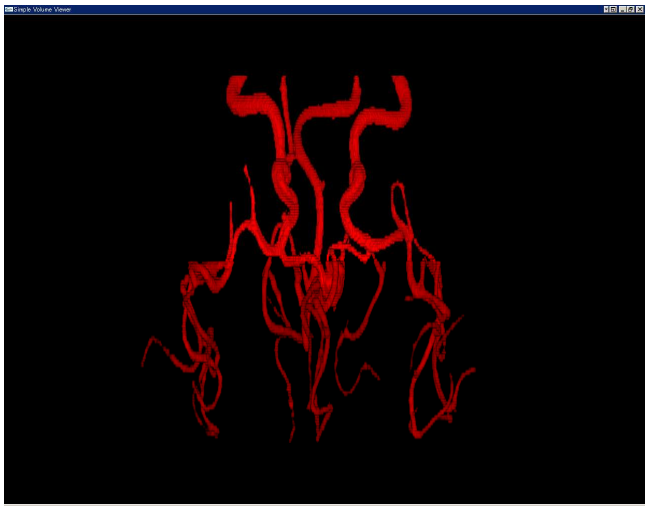

Fig. 4. Detected result of a blood vessel

2. Detection result of brain aneurysm

Next, we show the detection result that is detected by the proposed method in Fig. 5. The yellow part is shown the candidate part that is detected as brain aneurysm.

Table 1 shows result that the one uses only the fact 1 and the other uses the fact 1 and fact2. Table 1 shows each one is possible to detect the brain aneurysm, additionally, it is possible to decrease a false positive using the fact 2 about 48[nodules/case].

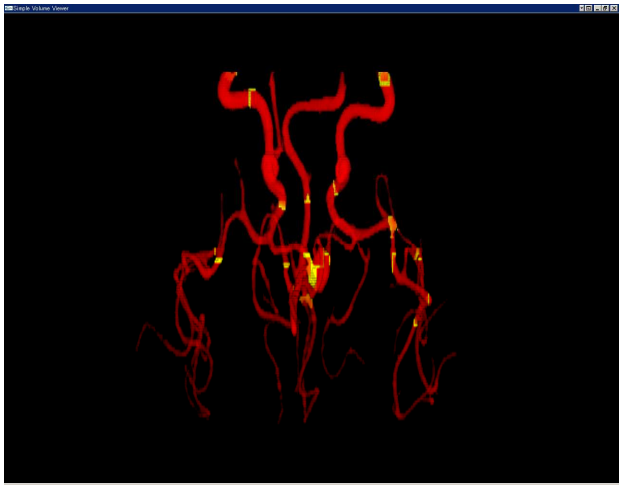

Fig. 5 Detection result of brain aneurysm

Table 1 Detection result of brain aneurysm

	True positive	False Positive [nodules/case]
Not use distance	100%(4/4)	82.25
Use distance	100%(4/4)	36.25

3. Construction result of head model

In this section, we show the construction result of head model using CT images. In fig.5, the white, red and blue region correspond to bone, artery and vein, respectively..

As shown in Fig. 5, artery and vein region are detected to a certain degree, but artifacts or leakages are found, so the improvement is needed.

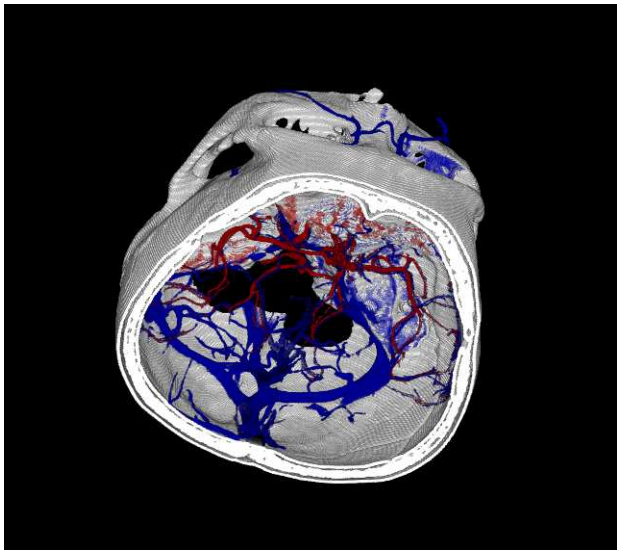

Fig. 6. Constructed head model

VI. Conclusion

In this article, functions necessary for the system to be used for medical training, detection of both blood vessel and brain aneurysm are shown, Then how to construct a head model which will be expected to help trainees experience virtual medical operation is shown. At present, it is not perfect owing to misdetection of critical parts inevitable for the operation necessary to pinch a brain aneurism.

In a future, it is necessary to simulate the process in which an aneurism is pinched with a clip. .In this problem, reducing calculation time taken to simulate object deformation is one of major challenge in our work. As the resolution of this problem, parallel computation with GPU is under construction.

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