Representation of Internal Structure of 3D X-ray CT in Mixed Reality

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ABSTRACT

In displaying data from a 3D X-ray CT of internal structures in a mixed reality, a new method of displaying cross sections is discussed. The combination of surface rendering and two-dimensional cross-sectional images was able to express cross-sectional information with density information of internal structures.

1 Introduction

In recent years, research have been conducted on virtual reality (VR), augmented reality (AR), and mixed reality (MR) for medical fields. So far, data captured by 3D X-ray CT was converted into the DICOM (Digital Imaging Communication Medicine) format and confirmed as 2D cross-sectional images on PC software. In recent years, meshing DICOM data as three-dimensional data has been used to display it on a tablet screen as AR and on a head-mounted display as VR [1][2]. Our previous studies have shown that proposed a system that represent information captured by a 3D X-ray CT in three-dimensions by volume rendering using a spatial reality display representation, and while observing the object with the naked eye, the object appears as if it were in front of the observer's eyes and can be moved freely by hand detecting the angles and movements of palm and fingers by motion capture, (Figure 1) [3]. In this system, a boundary surface in the virtual space as shown in Figure 2 was made, and when the object was moved and rotated by the observer and touched the boundary surface, the cross-section of the object will appear. However, data meshed by surface rendering does not contain density information in the cross section since the isosurface is rendered as surface information by CT values, that makes it difficult to grasp the internal structure in detail. In the medical field, it is necessary to grasp the part of the human body inside that is damaged or tumor area to be checked three-dimensionally, and it is necessary to check tomographic images from arbitrary positions and directions in order to grasp the internal structure. On the other hand, by simply surface rendering of the superficial layer, it is difficult to spatially grasp a specific part of the internal structure of the body. Hence, the entire 3D image should be surface rendered and the cross section should be displayed as a tomographic image.

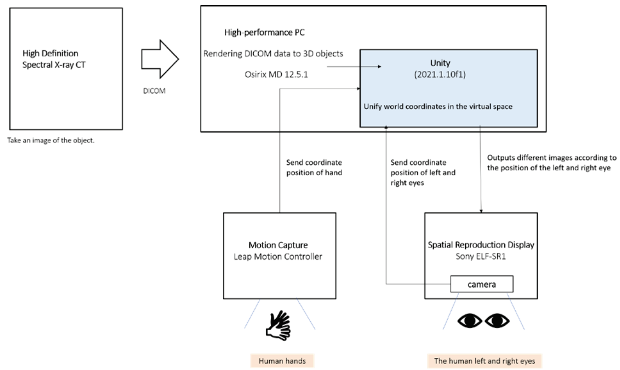

Fig. 1 System configuration diagram

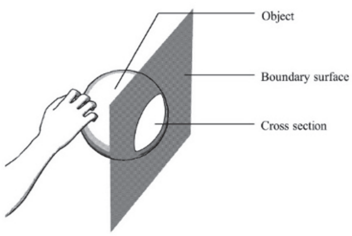

Fig. 2 Boundary surfaces and cross sections in virtual space

2 Experiment

In this study, a new method of representing cross sections in virtual space in mixed reality was proposed. As shown in Figure 3, surface rendering, which was used in the previous study, represents three-dimensional objects with shadows, so it is easy to grasp the shape and angular information of a cross-section, but it could not represent the internal structure with density. Volume rendering, shown in Figure 4, was able to express the density of the object as changing transparency, but it also displays mixing unwanted data in the depth direction of the cross section. To compensate for the advantages and disadvantages of each rendering method, a method to display a two-dimensional cross-section using DICOM on the cross-section of surface-rendered data has developed.

The following milestones were set

a. The object imaged by 3D X-ray CT must exist in virtual space and its internal structure must be expressed.

b. In gasping the internal structure, it is necessary to be able to understand the internal structure itself and where is the part of the entire object that the observer wants to check.

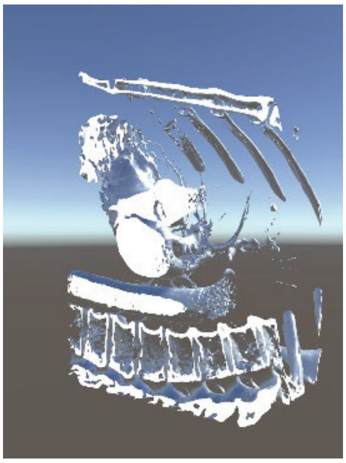

Fig. 3 Surface rendering

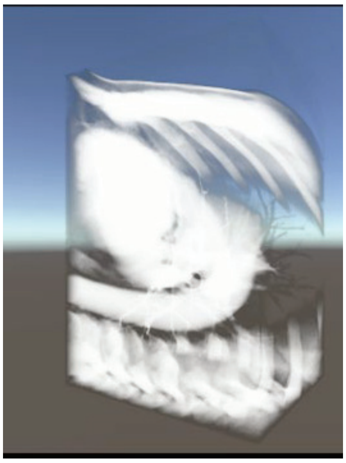

Fig. 4 Volume rendering

As a way to compensate for the advantages and disadvantages of each rendering method, a method was performed to display a DICOM image in two-dimensional orientation on the cross section of the surface-rendered data. The cross-section is not displayed in a three-dimensional view, but rather in a form that allows the observer to freely move and rotate the cross-section in a mixed reality environment. Once the cross section in the two-dimensional direction at the determined position and rotation direction is generated, it is superimposed on the 3D model.

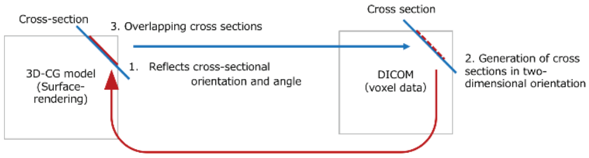

Fig. 5 System diagram of cross-sectional display

3 Result

As shown in Figure 6, two-dimensional cross-sectional image could be displayed together with the three-dimensional data. By incorporating a process to determine whether or not to draw a two-dimensional image by referring to the shape of the cross-section of the three-dimensional data (stencil buffer), it was prevented from being obscured three-dimensional data in the depth direction by the two-dimensional image. In this way, the observer can freely observe the internal structure of the object in mixed reality, including density information.

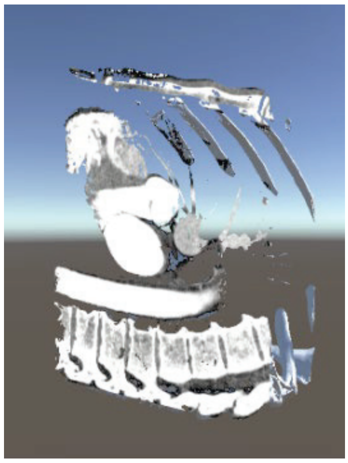

Fig. 6 Cross-section of 3D data and 2D cross-sectional image

Moreover, using the spatial reality display and motion capture, the observer can freely rotate and move the object by gesture and observe the cross-section in any direction. The observer can rotate and move the object as if they were actually grasping it, and can grasp the internal structure of the object by checking the cross-section displayed on the boundary surface.

Fig. 7 Performing a grasping gesture in front of a spatial reality display

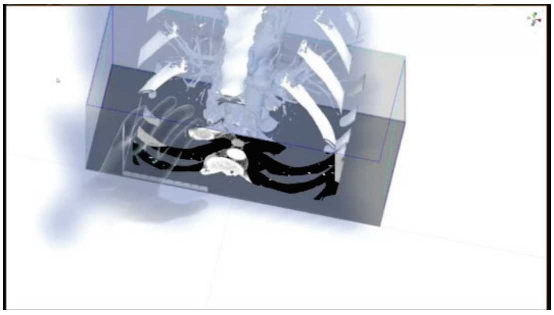

Fig. 8 Models of hands, objects and cross sections displayed on mixed reality

4 Conclusion

The following new representation methods for displaying cross sections in virtual space in mixed reality were identified.

a. CT-imaged objects can now be viewed by combining surface-rendered mesh data with 2D images generated from DICOM.

b. Using spatial reality display and motion capture, the observer can freely rotate and move the object in the virtual space as if the real object were in front of them, allowing them to understand where the internal structure to be checked is located in the entire image.

In conclusion, it is shown that the proposed method is effective as a useful 3D representation in 3D-CT, which is voxel data containing internal information, and as a method that can easily indicate the desired location in the CT image where the tomogram can be viewed.

References

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