3D Visualization of Multi Energy X-Ray CT Using Spatial Reality Display and Motion Capture

Hiroki Kase[1], Junichi Nishizawa[2], Kento Tabata[1], Katsuyuki Takagi[1], Toru Aoki[1,2]

kase.hiroki@shizuoka.ac.jp
[1] Research Institute of Electronics, Shizuoka University, 3-5-1 Johoku Naka-Ku, Hamamatsu, Shizuoka, Japan 432-8011
[2] Graduate School of Medical Photonics, Shizuoka University, 3-5-1 Johoku Naka-Ku, Hamamatsu, Shizuoka, Japan 432-8011
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ABSTRACT

Data for each X-ray energy band was represented in a mixed reality to achieve three-dimensional representation in material discrimination segmentation using X-ray energy information. The data were represented three-dimensionally on a spatial reality display, and the internal structure was observed from any position and angle by motion capture.

1 Introduction

Recently, augmented reality (AR), virtual reality (VR), and mixed reality (MR) representations of X-ray CT images have been studied and used for educational purposes and surgical simulations in the medical field [1]. The development of X-ray CT systems has evolved over the years, and in recent years, imaging with multi-energy X-ray CT has attracted much attention. Multi-energy X-ray imaging is characterized by its ability to discriminate materials using energy information. In the medical field, this has made it possible to distinguish three different compositions: fat, soft tissue, and contrast media. In contrast, single-spectrum X-ray CT has been used to separate two different compositions, bone and contrast media [2]. In non-destructive testing, it is also possible to discriminate between foreign substances and defective products. Suppose MR and multi-energy X-ray CT segmentation can be combined. In that case, objects imaged by X-ray CT can be represented on MR as virtual objects, and the object’s internal structure can be segmented. It can be observed three-dimensionally with the segmented composition information, and the virtual object can be interfered with.

In our research, we have previously proposed a system that uses a spatial reality display and motion capture to represent the internal structure of an object imaged by 3D X-ray CT on MR in three dimensions [3]. The system is characterized by the fact that it does not simply use surface rendering or volume rendering to represent an object imaged by X-ray CT but instead overlays a tomographic image from a two-dimensional DICOM image on a cross-section of the surface-rendered model. The object's surface structure can be grasped. At the same time, its internal structure can also be grasped by overlaying the tomographic image from the 2D DICOM image on the cross-section of the surface-rendered model. In addition, by setting the boundary surface and using motion capture, the observer can freely position and angle the tomographic image they want to observe by using their hands.

In this study, Representing the data in each X-ray energy band in a mixed reality was firstly aimed to spatially represent the internal structure toward the MR representation in the segmentation of material discrimination using X-ray energy information. The following milestones are set: 1. Data captured by the multi-energy X-ray CT are represented three-dimensionally on a spatial reality display, allowing the observer to see how the data for each energy band is transmitted and combined; 2. The object data can be observed from any position and angle; 3. The object data can be observed from any position and angular direction. 3. the boundary surface is set, and the object, cross-section, and boundary surface are arranged as shown in Figure 1. By moving the boundary surface and touching the object using motion capture, the object's cross-section can be observed at any angle and position and grasp the object's internal structure.

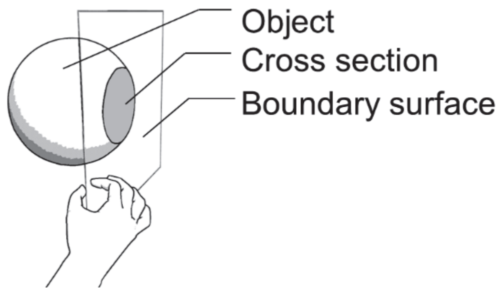

Fig. 1 Object, boundary surface, and cross-section

2 Experiment

In the experiment, the system was proposed, shown in Figure 2. After X-ray CT images of the object, the data is transferred as DICOM data to a high-performance PC, which performs surface rendering using Pixmeo's Osirix MD and transfers the data as mesh data to another PC. On another high-performance PC, the DICOM data is superimposed on a cross-section of the surface-rendered model in Unity (2020.3.44f1). The motion capture called Leap Motion Controller from Ultraleap is connected to the high-performance PC, and collision detection is set up so that objects on the boundary surface can be manipulated from hand gestures and movements. The high-performance PC is also connected to the spatial reality display from SONY, which superimposes data for each energy band and represents them three-dimensionally. In this experiment, a lithium-ion battery was imaged as the object to represent the underlying structure inside the battery. The control board in the lithium-ion battery was superimposed and represented with 50% density, with 10-70KeV data in red and 70-150KeV data in blue. The observer can observe only the 10-70 KeV data and 70-150 KeV data and can switch between them to display the part of the image they wish to observe.

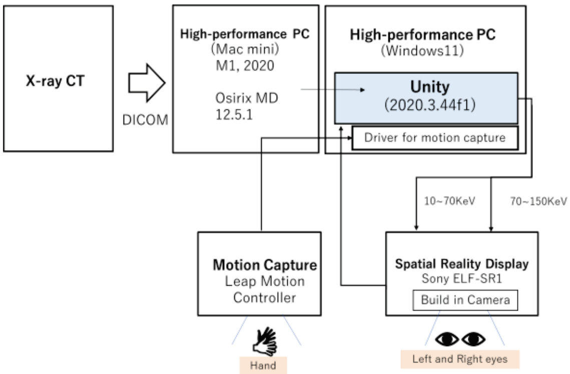

Fig. 2 System configuration

3 Result

As a result, the structure of the substrate within the lithium-ion battery can be observed in mixed reality. In Figure 3, data from 10 to 70 KeV is displayed in red, and data from 70 to 150 KeV in blue on Unity, showing the tomogram generated from DICOM is displayed according to the angle and position specified by the observer. Different parts of the tomogram are highlighted differently depending on the composition of the different materials in the substrate (silicon, aluminum, gold, and copper).

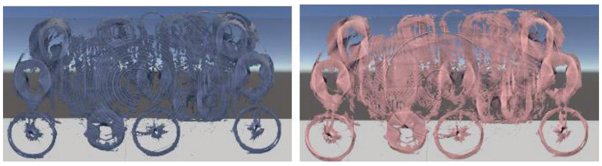

Fig. 3 Control board inside the battery represented on a spatial reproduction display

Figure 4 shows the boundary surfaces expressed on MR can be moved and rotated by hand gestures, enabling observation of the internal structure of the control board inside the lithium-ion battery. The boundary surfaces represented in MR can be moved and rotated by hand gestures to observe the internal structure of the control board inside the lithium-ion battery. As a result, red- and blue-enhanced areas were generated, from which information on the composition of different materials could be inferred.

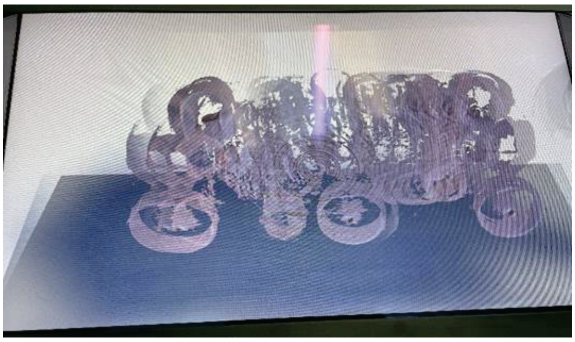

Fig. 4 The Control board inside the battery represented on a spatial reality display

4 Conclusion

Therefore, for MR representation in material discrimination segmentation using X-ray energy information, it is now possible to superimpose data for each X-ray energy band using multi-energy X-rays in MR using a spatial reality display and motion capture. The object data is represented three-dimensionally under MR and can be observed from specific positions and angles. The observer can move and rotate the boundary surface by gesture to observe the object's cross-section from any angle and position and can freely switch and composite the object's internal structure for each energy band. The amount of information obtained from multi-energy X-ray imaging is significantly increased compared to single-energy X-ray imaging. Mixed reality makes it possible to organize such information and to precisely organize and represent the information on the part that the observer wants to see.

References

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