Controlling 3D Object made of CT data in Medical Training System Using Leap Motion

Atef Seif, Ryosuke Umeda and Hiroki Higa

Abstract: This paper describes a user interface of 3D (three-dimensional) object converted from 2D (two-dimensional) CT data in DICOM format using Leap Motion device that can be used as a medical training system for medical students and interns. The resultant data can be controlled in a 3D development environment of Unity software. The system consists of desktop computer, the displaying software environment and Leap Motion device. The experimental results show that we can have a desirable control over the rendered object in 360 degrees, and that we can check the details of the object using zooming feature in the system.

Keywords: 3D visualization; Leap Motion; Medical training system; DICOM; Unity

I. INTRODUCTION

With the assistance of progress of computer technology, medical imaging plays an absolutely essential role in diagnosis and treatment. A medical training system using mixed reality [1] has been recently developed. DICOM, which is short for digital imaging and communications in medicine, is an international standard format used to handle in medical imaging and implemented in cardiology, radiology and dentistry imaging [2], such as X-ray, CT and MRI. Example of DICOM data can be seen in Fig. 1. As virtual reality (VR) world is invading our life in every aspect, it became necessary to use this technology in the medical field as well. For that, we thought in developing augmented reality (AR) environment for medical practitioners to decrease errors during surgeries and for medical school students, medical interns, and resident physicians to facilitate training process instead of using real cadaver. Recently, some results of navigating through a 3D model human skeleton were presented using a device called Leap Motion [3].

An AR based medical training system has been developed in our study. As our pilot study which focuses on the medical training system, this paper presents a conversion method of CT data from DICOM format (2D) to .obj format (3D) to be used in medical training system. User can virtually control the object in an AR development environment using Leap motion assets.

II. METHODOLOGY

A. Experimental location and participant

Fig. 1   2D image of the DICOM dataset of CT heart scan [4].

This experiment was conducted in our research laboratory room in University of the Ryukyus. A normal male subject (age 24) participated in the experiment. The subject was seated on a chair placed in front of a PC monitor, with showing 3D object in the Unity3D platform. We set the Leap Motion controller at the front of the monitor and ask him to manipulate 3D object as moving his hand over the Leap Motion controller.

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B.   **Experimental equipment**

Fig. 2 shows the system configuration we used in our experiment. In this experiment, we used a simple system composed of a desktop computer, several softwares, and Leap Motion device (Leap Motion, Inc.). We started our experiment with 2D CT data in DICOM format (.dcm file extension). We chose CT data for heart's region as it is a vital place in surgeries and its operations need a high percentage of accuracy. The DICOM dataset we used consists of 263 images of heart's region [4]. One of images is shown in Fig. 1.
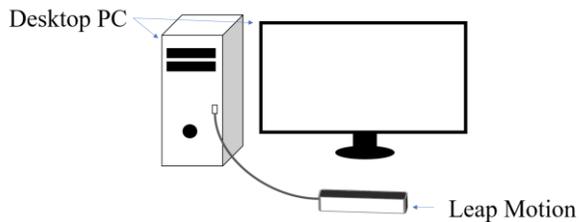

Fig. 2 System Configuration.

C.   **Experimental Procedure**

The Process on transforming the DICOM data from 2D into 3D format passes through different stages as shown in Fig. 3. We used three software programs to obtain the desired format for importing the data inside the 3D development environment. Software programs used in our work are as follows: 3D Slicer, MeshLab and Unity3D.

3D Slicer software is a free software platform for the analysis and visualization (including volume rendering) of medical images and for research in image-guided therapy [5]. It enables the user to process medical data and render it into visible volume data [6]. Meshlab, which is an open source software that has tools for editing, inspecting and converting meshes [7], is used in the experiment. For the final visualization of the results, Unity3D (Unity Technologies) software is used. This offers a platform for creating and engaging 3D, VR, and AR games and scenarios through programmable scripts [8]. For AR interface, we used an additional hardware of Leap Motion controller device and its software assets. Because of the two infrared cameras and three infrared LEDs, Leap Motion controller can be used to sense motions of the hands and fingers and translate it into virtual motion on computer [9].

In the beginning, the data which comes in DICOM format is first loaded onto the Slicer software. As shown in Fig. 4 where the volume-rendered object appears along with the coronal, sagittal and axial views of the medical data [10]. The next step is to extract the desired part of the CT data in a form of usable format. The extracted data is exported from the Slicer as a surface rendered 3D model in .stl format. As Unity3D software program does not allow to import .stl data format [11], we need to find an intermediate transition software that can allow us to change the format of the 3D object from .stl format to .obj format. Meshlab software is one of those that can provide us with this feature.
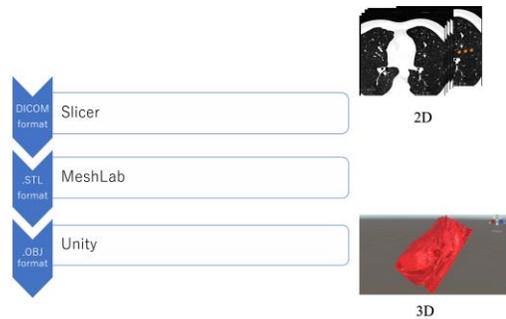

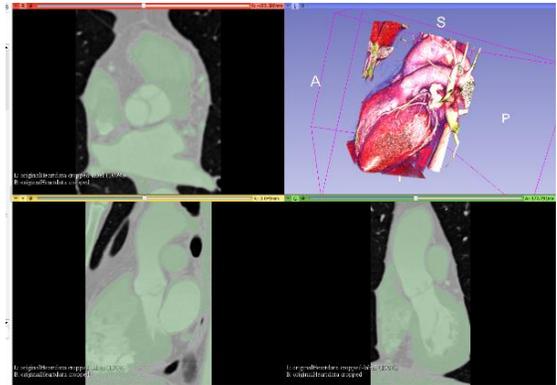Fig. 3 Transformation process of the DICOM data.

Fig. 4 Heart object inside Slicer software [10].

The exported model from Slicer is then imported into Meshlab which can convert the dataset from .stl format to .obj format. An example of rendered object of our dataset is shown in Fig. 5. Meshlab is able to remove artifacts and decrease the object's overall size as well by using the texture decimation feature that enables controlling the object easier in 3D environment and decrease its loading time and lag in other platforms through decreasing the number of meshes in the objects.

After we converted the data successfully, we were able to import the data conveniently in Unity3D scene in the form of .obj format and combine it with the assets of Leap Motion software.
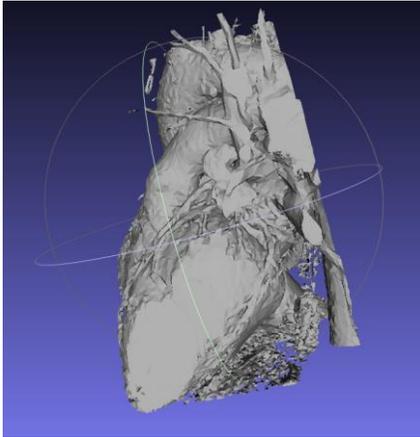

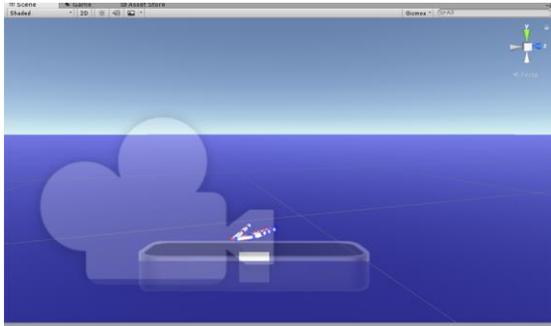Fig. 5 Rendered object inside Meshlab Software [10].

Fig. 6 Leap Motion controller asset with the virtual hands Unity scene in editing mode [10].

Using Orion asset has increased the Leap Motion controller's viewing range from 60 cm to 80 cm which gives the user a better experience [12]. One of Orion assets we used was Interaction Engine module. As it allows users to work with their VR/AR applications by interacting with physical or pseudo-physical objects [13]. The Interaction Engine module enabled us to freely grab the object, zoom-in and out and have a look inside it as well. Fig.6 shows the preparation of the Unity scene with the virtual hands and importing the interaction scripts to be used in our experiment afterward [10].

To define the transformed medical object to the Unity system, two physics' components were attached to the object. One is '*Rigid body*' that applies the physics rules on our object to emulate its reaction to gravity [10], [14]. The other one is '*Box Collider*' which defines the rotation perimeter of the 3D object to make the hands sense it and help in grabbing scenarios as well. Under the Visual Studio environment, one programming script in C# language was attached to the 3D object for the interaction scenario. Another point that must be taken into consideration is that the 3D object needs to be covered by the hemispherically-shaped pattern of Leap Motion controller to be sensed by the software and allow user to control over the object(s). Fig. 7 shows the beam pattern of the controller we used in our experiment [10]. Fig. 8 illustrates our final transformed object inside Unity editor scene being attached with the box collider (the box in the green color).
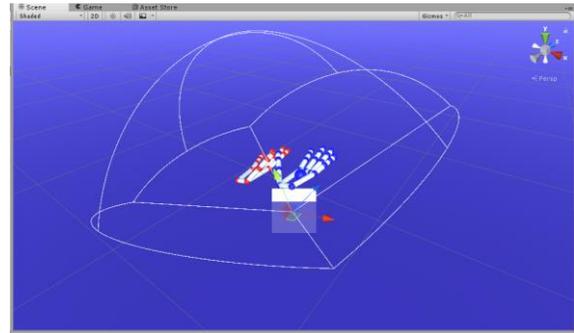

Fig. 7 Leap Motion controller's pattern in the Unity3D scene [10].

Fig. 8 The transformed 3D object inside Unity scene.

III. RESULTS AND DISCUSSIONS

Experimental results when controlling the object and when zooming in/out with it are shown in Fig.9 and Fig.10 respectively. Fig.9 shows the virtual hand of

Leap Motion assets with the attempt to grab the 3D heart object, while Fig. 10 shows that the zooming feature performed in the heart object in the Unity platform.
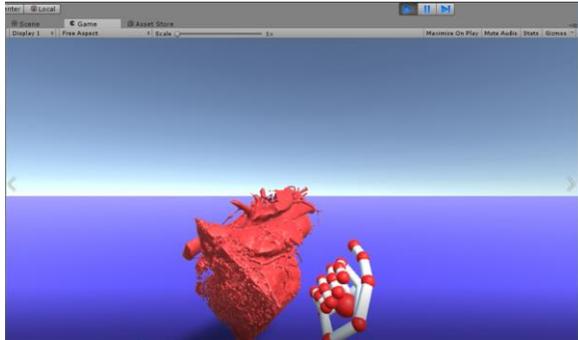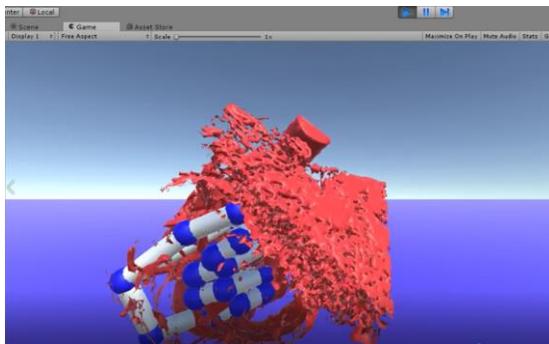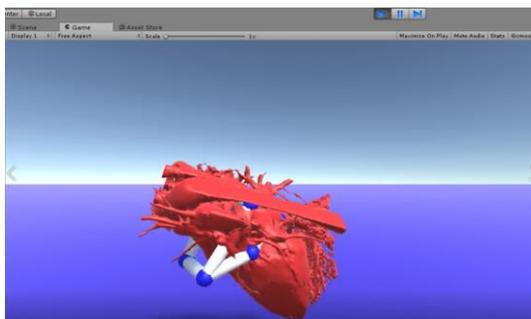

Fig. 9 The heart object with virtual hand of Leap Motion in Unity3D software (Game mode).

(a) When zooming in the heart object.

(b) When zooming out the object.

Fig. 10 Example of experimental results.

The experimental subject could grab the heart object using one hand (left or right hand one at a time) and

examine it from different points of view. In addition to that, he was able to get through the object and look inside it.

The DICOM dataset has been transformed and imported successfully into Unity3D environment. The size of the original heart model in .stl file format resulted from Slicer was 222 MB. After using Meshlab, the size has been decreased to 5.4 MB [10] and the data has been transformed into .obj file format. VTK (Visualization ToolKit) is one of the most essential tools that are used in 3D modeling nowadays [15]. As it supports intermixing the surface geometry with volume rendering, using this tool can help us build a better object that has more details of the organ's information.

IV. CONCLUSION

It was demonstrated that the conversion of the medical CT data from DICOM format to a stable 3D object in .obj format was performed, and that the transformed object was viewed from every direction using the Leap Motion controller device in AR environment in this paper.

Further development of a tool that allows us to navigate through the CT dataset images besides the 3D object in the Unity environment will be very useful for the physicians for better understanding of the patient's case. Also making progress in a better quality of 3D object should be considered for our future work.

ACKNOWLEDGEMENTS

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