PURE Award Final Report

The Giant Walkthrough Gut: Virtual Reality Simulation of the Digestive System

Ryan M. Lee

Date of Submission: September 10, 2018

Location: Main Campus ICT

Project Duration: May 1, 2018 – August 31, 2018

2018 Supervisor: Dr. Christian Jacobs

Supervisor Signature: _____

Introduction

The use of VR has become increasingly popular in recent years with novel technology making it much more accessible and affordable than before. Once used to train pilots in the military [1], this technology is now being used in a variety of applications, ranging from space exploration and surgery simulations to everyday entertainment and gaming. VR programs have such a diverse reach because they establish a sense of realism and immersion that many fields can benefit from.

Figure 1: View of the Giant Walkthrough Gut digestive system model in its entirety with different textures applied.

In biology, students can remain engaged through laboratory work for many lessons, but not all, namely those involving humans and ethics. In learning about human anatomy and organ systems, education is typically comprised of standard lessons, textbook work, and sometimes videos. None of these methods allow for a hands-on experience and have the tendency to promote a culture of memorization rather than a culture of learning. While dissections and cadavers can address these areas, they have their own limitations including the costs and ethics of having every classroom be able to participate. This is why VR should be acknowledged as a pragmatic solution – the required headset and controllers are a one-time purchase, there is no limit on the number of times a program can be run, and the sense of realism and immersion remains.

The digestive system lends itself well to VR technology because it is comprised of many distinct parts, each with their own unique functionality and design. By travelling through each organ, the user experiences the journey of food entering through the mouth and exiting the rectum,

all while learning pertinent information. This concept of exploring body systems from the inside has been implemented by the company "Medical Inflatables" [2], in which giant inflatable organs are set up as exhibits for people to tour and interact with. While these inflatables are excellent crowd-pleasers that marry education and entertainment, they are not feasible for mass consumption because of size and cost. Therefore, the use of VR may be an economical solution to this problem, allowing users to be in any size room and participate collaboratively with the click of a button.

Process

The *Giant Walkthrough Gut* was built using Unreal Engine, a game engine gaining more traction as the world-renowned game Fortnite [3] grows in popularity. The program has the functionality necessary for rendering video and keyframe animations using the plugin Sequencer and can also set up level-based play with actors as one would expect of a game engine. Unreal Engine is unique in its design in that one could program using C++ or their node-based interface, Blueprints Visual Scripting [4]. Nodes can be functions, operations, variables, and any other object-oriented class [4]. For the sake of simplicity, Blueprints were used to construct the *Giant Walkthrough Gut* instead of C++. A video component and exploratory mode made for VR and desktop users was created to allow for the greatest accessibility and shareability.

Figure 2. The video version of the Giant Walkthrough Gut depicting an antacid tablet entering the stomach.

The camerawork for the video component proved to be the most difficult and time-consuming task of the two versions of visualization for the *Giant Walkthrough Gut*. Various methods were experimented with to no avail – manually directed camera movement, translational guidance using a rig rail, and manually inputted keyframes. The first two resulted in issues with rotations in that after playback, the camera would take a convoluted path. For example, a rotation 270˚ to the left would be displayed instead of a rotation 90˚ to the right. Although the endpoint was the same, the camerawork ended up being jerky, with wild spinning motions, rendering the video unusable. The rig rail still fell short in this area, but it was the best at maintaining smooth camerawork. This was because the distance travelled through the digestive tract could be quantified and thus, allow for keyframes at equal intervals so that the speed the camera moves remains relatively constant. Later, it was discovered that enabling quaternion interpolation would have made the camera take the shortest route to its intended endpoint location and orientation, rectifying the tremulous motion. However, this was after the video was finished via the last method which entailed manually inputting the individual values for rotation at each keyframe.
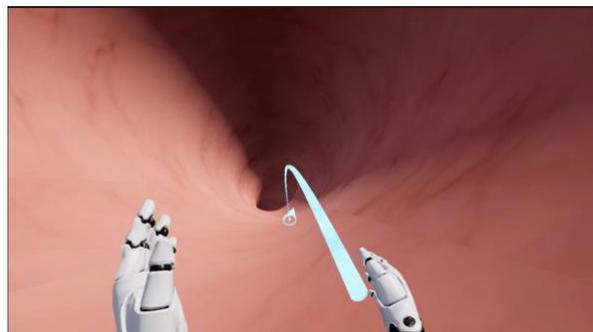

Figure 3. A teleportation arc is sent out from the motion controllers as a projectile until it collides with a collision mesh in the esophagus.

The VR component required that the user be able to have full control over their exploration, so teleportation functions were designed to be used with the HTC VIVE [5] motion controllers. Teleportation is a common practice used in VR games because it reduces the amount of simulation sickness the user experiences [4]. Although it was difficult to implement at first because of the

complexity of the digestive system model that had to be traversed, it was eventually operational by duplicating and inverting the static mesh to ensure all surfaces had a collision mesh to teleport to and by reconfiguring the nodes to not require a NavMesh to determine valid teleportation locations.

(a) Interactive switch

(b) Commentary box

(c) 3D mini map

(d) VR user interface menu

Figure 4. Various forms of interaction within the Giant Walkthrough Gut. (a) Interactive switches act as stations to provide further illustration. (b) Commentary boxes flip open to reveal information regarding its surrounding area when the player moves in range. (c) A 3D mini map of the digestive system displays the user's current location in the model. (d) A watch with menu options appears when the user looks at their wrist using the motion controllers.

To increase interactivity in the VR and desktop versions, interactive switches and commentary boxes were introduced throughout the gastrointestinal tract from the "Blueprints" project by Epic Games [4]. The commentary boxes reveal their information [6] regarding the surrounding area of the digestive system when the user gets within range. The switches further illustrate this information by activating an animation when triggered. Additionally, a user interface was specifically developed for each version to allow for more options such as background music [7], help, instant teleportation to key areas, and the ability to view a 3D mini map displaying the user's current location in the model. By looking at the user's wrist, a VR watch adapted from that

of Unrealty Simon's [8] appears, displaying the user interface in a realistic manner. Since mini maps are generally 2D and of relatively flat terrain, an alternative method to using a camera at a distance had to be developed. Instead, a tracker Blueprint was created to receive the distance between the user and the giant model and translate that on a smaller scale relative to a mini model that appears in front of the user. To ensure that the tracker was always visible in the mini model no matter where the user was in the giant model, it was given an emissive material.

Knowledge Gained

This has been such a rewarding experience working with the Lindsay Virtual Human Team to develop my program. I would never have known about Unreal Engine if it had not been suggested to me as the medium for my idea. Having to develop such an extensive project in a short time-frame with a program I had never used before was daunting, but I developed upon my ability to learn quickly and troubleshoot independently thanks to the large community of Unreal Engine users online. What made it fairly easy to learn was that there was minimal coding due to the use of nodes in Unreal Engine. Though the logic remains the same, it does a lot of the work for you and provides an organized, visual approach to coding. I am now well-versed in Unreal Engine to develop future projects in. In addition, I have gained knowledge over other areas of bioinformatics related research that appeal to me because they are more graphical and creative in comparison to standard research with genome sequencing. Lastly, I have learned a lot about researching in general and the work that goes on behind the scenes in a dry lab. While everyone's projects are individual and unrelated, a collaborative environment still exists, allowing us to bounce ideas off each other and receive instant feedback. This was beneficial because I had so many ideas, but I needed help determining what was pragmatic with the time I had. Not only did I have to share what I was working on to those in my lab weekly, I even had

the opportunity to present my work to children in a demo the computer science department was hosting. Through this, I learned how to explain my research concisely and tailor each presentation to my audience as I spoke to elementary, junior high, and high school students as well as the adults supervising them. Going into this process, I was not sure if research was for me, but I am beginning to see it as a potential career thanks to this process.

Acknowledgement

References

[1] D.P. Inman et al. VR Education and Rehabilitation. Communications of the ACM, 40(8): 53-58, 1997.

[2] Medical Inflatables. https://www.medicalinflatables.com, 2018.

[3] Fortnite. https://www.epicgames.com/fortnite/en-US/home, 2018.

[4] Unreal Engine. https://www.unrealengine.com, 2018.

[5] HTC VIVE. https://www.vive.com/eu, 2018.

[6] R. Seeley et al. Digestive System. Anatomy and Physiology. McGraw-Hill Boston, Massachusetts: McGraw-Hill 6 edition, 2003.

[7] B. Tissot. Slow Motion. https://www.bensound.com, 2018.

[8] Unrealty Simon. VR Interactive Watch Menu. https://www.unrealtysimon.co.uk, 2018.

Instruction for Accessing Files

In order to read the program files, Unreal Engine must be downloaded from:

https://www.unrealengine.com/en-US/what-is-unreal-engine-4

Unzip the file *GWG.zip*. Afterwards, you can simply double click on the appropriate folder to open the application without opening Unreal Engine itself.

For Macs:

Use the folder named *ucalgary_2018_lee_ryan_Mac_GWGDesktop* to access the standalone desktop version of the Giant Walkthrough Gut. Double click the application *GWGDesktop*.

For Windows:

Use the folder named *ucalgary_2018_lee_ryan_Windows_VRGWG* to access the standalone VR version of the Giant Walkthrough Gut. Double click the application *GiantWalkthroughGut.exe*. For the standalone desktop version of the Giant Walkthrough Gut, use the folder named *ucalgary_2018_lee_ryan_Windows_GWGDesktop*. Double click the application *GWGDesktop.exe.*