Virtual Reality Modeling of Patient Arterial Anatomy

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ABSTRACT

Virtual Reality (VR) is seeing wide use in many facets of industry and education. The medical field, in particular, has made advancements in visualization technology thanks to both VR and AR (augmented reality). In conjunction with advancements in computational 3-D modeling, VR has allowed for anatomical structures to be rendered in high details, in immersive 3-D virtual spaces: which can make for more interactive and effective teaching tools. The Visible Heart® Laboratories (VHL) in the Department of Surgery at the University of Minnesota, has created a suite of VR scenes which can be used to assist in the design of medical devices, train future professionals, and educate users about human anatomical features. Yet, a current obstacle of the platform is the user's lack of experience in effectively navigating through virtual environments; causing them to spend more time learning how to move through the scene instead of learning the anatomy itself. Here, we present new functionalities to the VR platform, that allows for an "on a rail" approach; which restricts the user's movement to 1 spline, while still allowing a 360-viewing experience. This functionality drastically reduces the learning curve for navigating in VR, enabling new users to focus on learning. Specifically, the technology created here uses a model of a Transcatheter aortic valve replacement (TAVR) procedure; which can be used to help train medical professionals and medical device innovators.

METHODS

The anatomical 3D models were generated using MIMICS and 3Matic software from Materialise. The 3D models were then imported into Unity3D which was utilized to create the VR environments for each 3D model. We employed HTC Vive and Vive Pros VR headsets in our VHL 3-D VR studio. We also used Steam VR as the software interface between the headsets and Unity Scripts. All of the existing technologies and those developed here were written in C#. To build our updated approach, we first looked online to see if any existing open-source software could be used as a base from which to start. After some searching, we found an existing Bézier path creator[1] that we determined would work well, as a template for the "on a rail" system we wanted to generate. This Bézier system uses a chain of quadratic Bézier curves to create paths The locations of an object between any two anchor points on the path can be computed using Equation 1. After deciding on this approach, we built out the necessary C# scripts so that we could interface between the Bezier path and the VR system by using Steam VR's software interface libraries. To test the scripts in the expected environment, we also segmented a few existing anatomical models into descending aortas.

$$B(t) = (1-t)^2 P_0 + 2(1-t)tP_1 + t^2 P_2, 0 \leq t \leq 1$$

Equation 1: Quadratic Bézier Path

RESULTS

The most difficult part of the project was becoming familiar with how SteamVR worked and how it could be integrated into the existing VHL software. After writing the scripts which worked as an interface between the Bézier path creator and the VR system (which took a significant portion of the time for this project) we started setting up example scenes. Due to the timing of this project, to date, we were unable to get feedback on various user experiences between a "free-form" and an "on a rail" system, but in our testing, we determined that the "on a rail" system would greatly simplify the VR learning experience, and thus made it a significantly more effective learning and teaching tool.

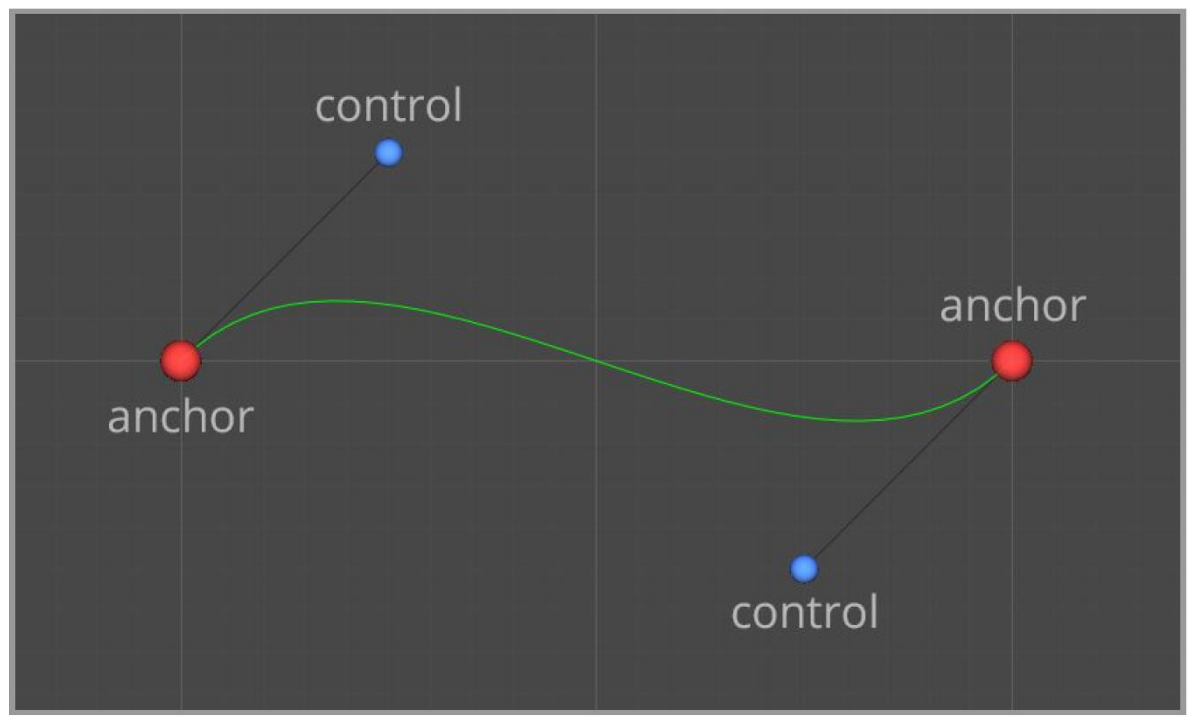

Fig. 1: Basic Example of a Bézier path

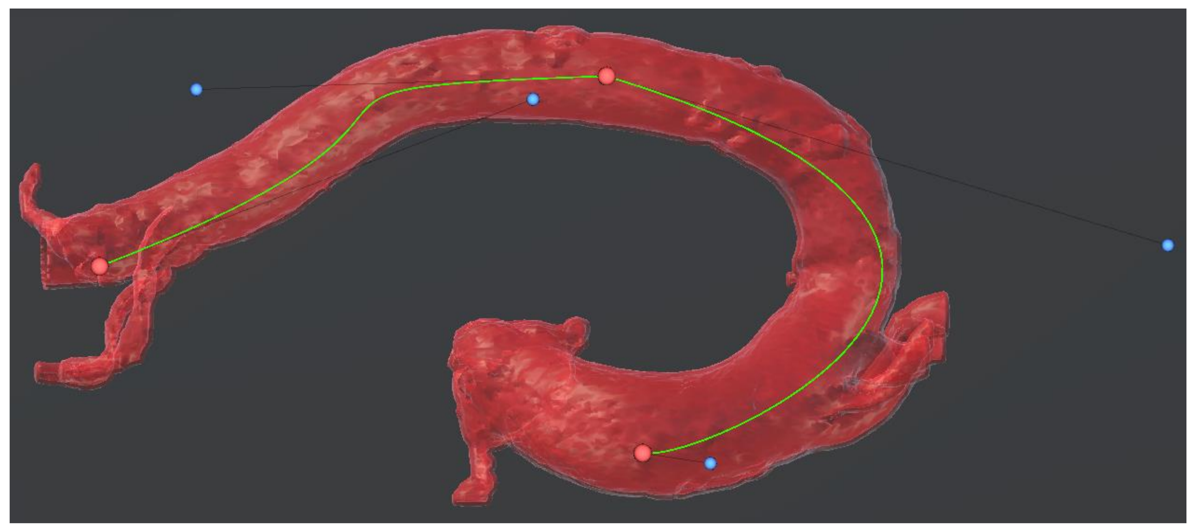

Fig. 2: Side and Front view of an example of a Bézier path in a descending aorta

CONCLUSION

Our generated software scripts allows for more precise controls over a virtual reality learning environment. Importantly, by restricting a given user's movements to a predetermined line of a given scene, educators can create more precise, effective and engaging learning environments. Future directions of this project will include getting more user feedback of the on a line system along with possibly adding more options to the software such as a "hop-on/hop-off" feature where we could integrate the "free-form" and "on a rail" movement styles into one cohesive system.

REFERENCES

[1] Lague, S. (2019, June 26). Bézier Path Creator: Utilities: Unity Asset Store. Retrieved March 30, 2020, from https://assetstore.unity.com/packages/tools/utilities/b-zier-path-creator-136082