MINNESOTA iV LAB

USING VIRTUAL REALITY ENVIRONMENTS FOR MEDICAL DEVICES DESIGN

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Introduction

There is an urgent need for improved design methodologies and tools that give designers meaningful and accurate feedback early in the design process, virtual reality can be used to fill this need. Virtual Reality provides a highly engaging environment that allows user to experience and comprehend abstract concepts. It can allow designers to broadly explore the space of potential design alternatives, and to expand the boundaries of complex designs that are possible given today's computer assisted tools.

Medical device researchers seek to better understand the complexities of cardiac anatomy, visualize how surrounding structures affect device function and deployment, and ultimately design more effective devices. Virtual representation combines visual graphics, virtual reality applications, finite element analysis based on the architecture of a 3D model. Introducing virtual reality based tools into the process of medical device design can significantly improve the process.

We present our initial work aimed at developing new immersive visualization and interactive design tools for improving the medical device design process. Our initial work focuses on developing 3-dimensional visualizations of simulated blood flow through mechanical heart valves (Figure 1). Our goal is to develop 3D user interfaces for refining medical device designs within the context of patient-specific anatomy and simulated flow data.

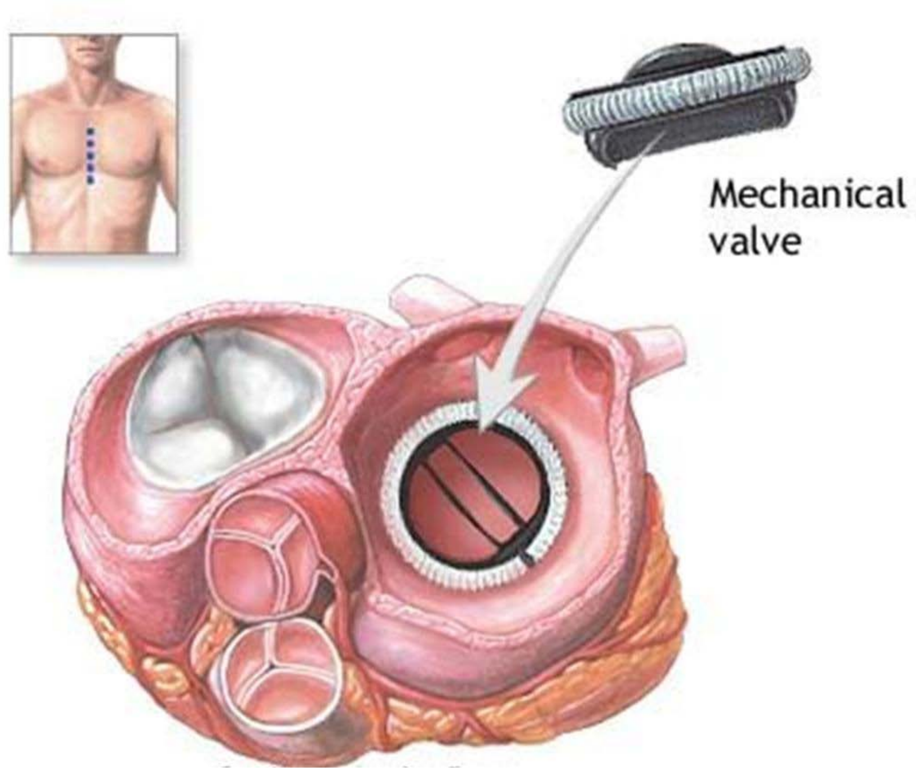

Figure 1: Illustration of mitral valve replaced with a mechanical valve (Courtesy: www.nlm.nih.gov)

Background – Current Work

Methods

➢CT scans of the heart were obtained from a live patient. MIMICS® was used to segment the images, clear artifacts, and make 3D heart model.

➢The fluid flow scientists from St. Anthony Falls Laboratory were able to successfully simulate pulsatile blood flow through an anatomic aorta with a bi-leaflet heart valve. The data has been saved into 2500 time steps through one cardiac cycle on a grid with around 10 million nodes.

Results

➢**The surface of the heart model has been geometric analyzed and color coded based on local curvature**, this might give us insight into important geometric features of heart. (Figure 2)

➢**Surface geometries of artery and bi-leaflet valve were generated** from the fluid flow data and loaded into a virtual reality environment. Streak lines were also generated for a small subset of flow data. (Figure 3,4)

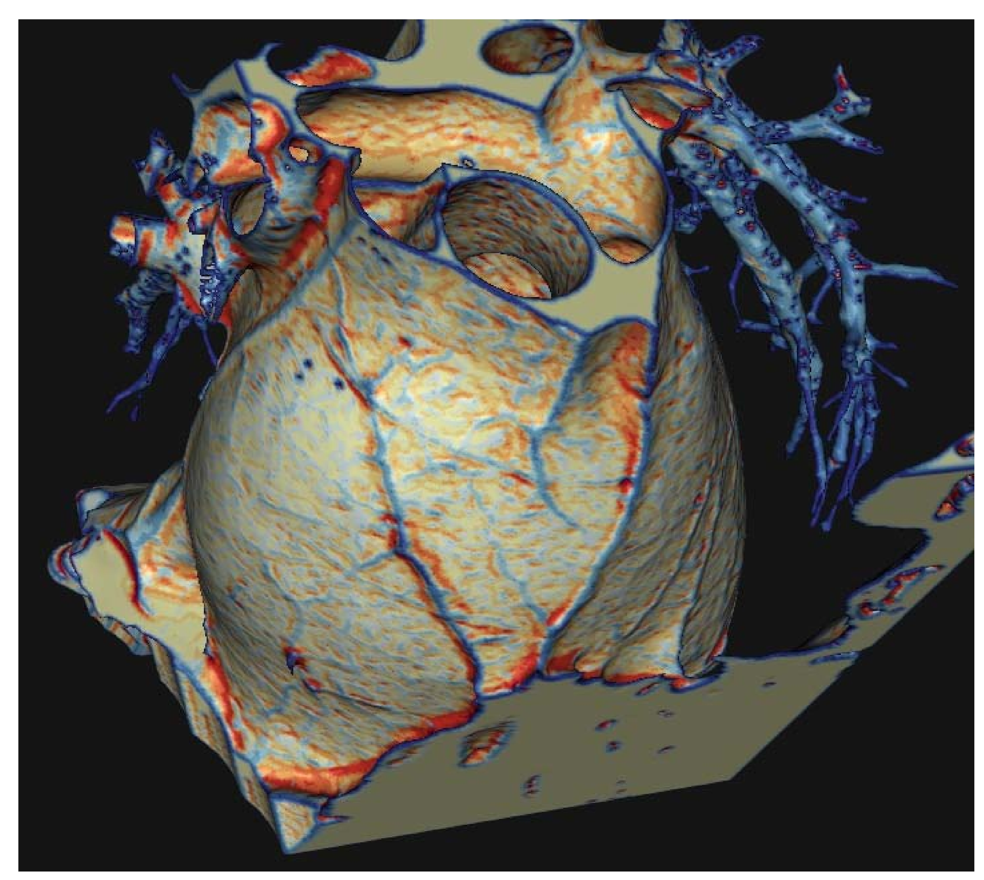

Figure 2: Curvature analysis of 3D heart model

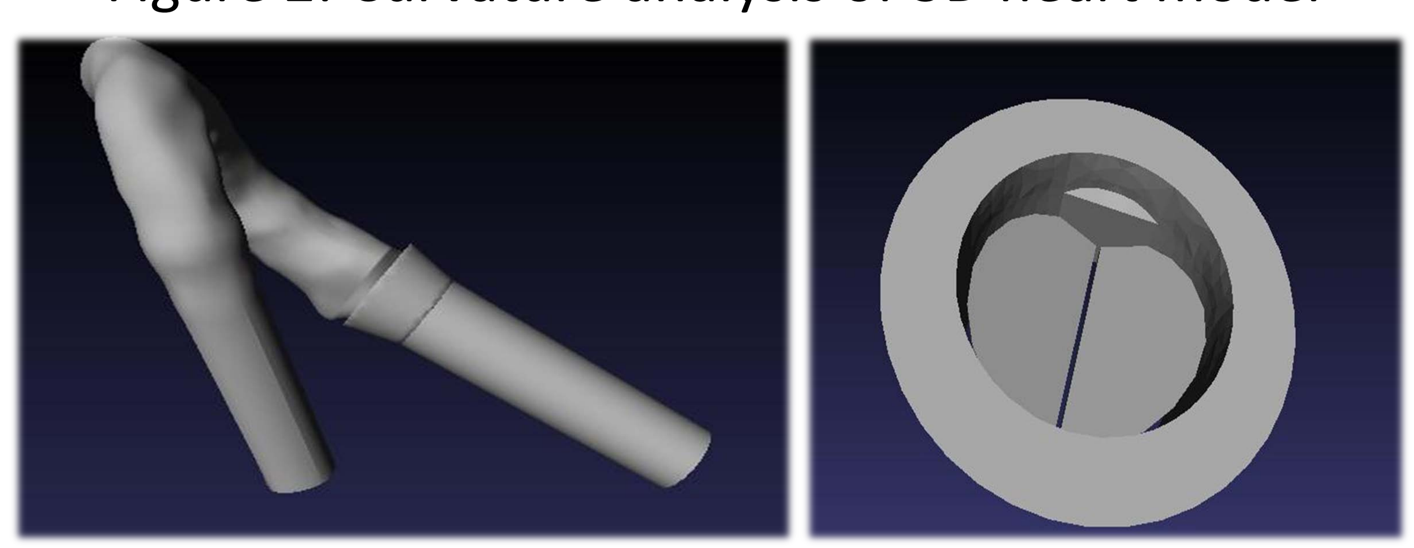

Figure 3: Surface geometries of the artery and valve extracted from the flow data

Future Work

Moving forward, the team will focus on individual expertise to advance this virtual design environment. **Our immediate goal is to develop an immersive visualization that can represent all the flow features of the blood flow through artery and valve in an interactive way**.

Other important goals of the project are:

1) **Develop new interaction techniques to explore through the huge data set we have.**
2) **Design and run perceptual studies to improve the ability to accurately visualize complex spatial data in a virtual reality environment.**
3) **Develop new human-computer interaction techniques using 3D force-feedback technology to allow designer to edit and refine design within the 3D visualization environment in real-time.**
4) **Integrate various components of medical device design process into an interactive design environment where testing is done via computer simulation, results are interpreted using perceptually accurate visualization, and design refinements are made within the environment using new 3D input techniques**

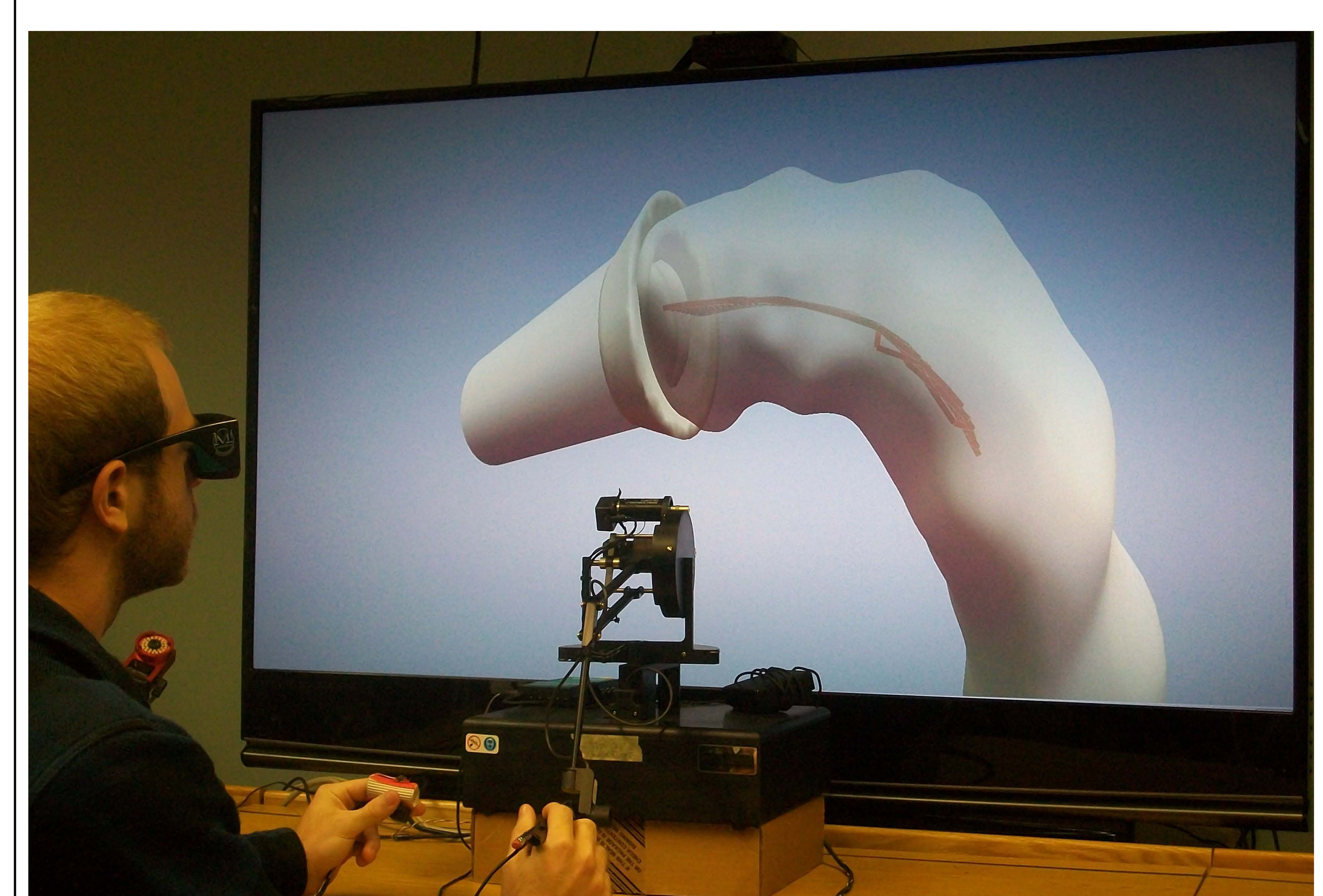

Figure 4: Surface geometries and a subset of streak lines loaded in a stereoscopic VR environment

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