EE267 Project proposal, Orly Liba, Spring 2017

Immersive inner-tissue visualization based on Optical Coherence Tomography scans

Motivation: Optical Coherence tomography is capable of imaging inside living animals with very high resolution. OCT scans produce 3D volumes, therefore, some of the information and the sense of depth are lost when they are displayed as 2D images. **The goal of this project is to visualize OCT scans in 3D on a head mounted display (HMD)**. Several applications for this method of visualization are:

- Diagnostics: Improved visualization of the 3D structures can produce better diagnostics.
- Education: Enable learning about tissue structure and anatomy using an immersive 3D visualization. Many current educational tools use virtual 3D models of organs. Unlike the computer-generated models, OCT will enable using real-live 3D scans of tissue structure. Because OCT is an excellent technology for the detection and segmentation of vasculature, it can be used to study the vasculature of organs such as the retina, brain, heart etc.
- Impressive display of OCT data at conferences and papers: Presenting 2D images at poster sessions and in publications is usually useful, however some of the 3D information may be lost when projected onto a 2D plane. Enabling a 3D and interactive visualization of OCT data would be an impressive ability that also conveys the OCT scans more reliably. A cool idea for a publication would be to include a supplementary 3D movie for cardboard in addition to a conventional supplementary video.
- Intraoperative OCT (long-term application): Surgeons often use high resolution optical endoscopes during certain minimally-invasive surgeries. OCT endoscopes are also being developed and will enable inherent visualization of tissue in 3D. Perhaps, in the future, surgeons will use HMDs to gain a better sense of depth and orientation in the operation region. The use of HMDs for displaying OCT data is currently being developed for retina surgeries[1] (which do not require an OCT endoscope). This is challenging because OCT scanning, reconstruction and rendering need to be done in real-time.

Summary of previous work: HMDs are already being used in medical situations. Groups at Stanford use the Microsoft HoloLens to visualize breast cancer tumors before and during surgery[2,3]. Another group from Stanford uses virtual reality visualization of the human heart to teach about normal and abnormal cardiac function[4] (Fig. 1a). Virtual reality of OCT for intraoperative use is currently mainly being developed in the lab of Prof. Izatt at Duke University[5] (Fig. 1b).

Statement on what is new: The novelty of the suggested project is to use the OCT data acquired by our lab, specifically, vasculature detected and segmented by OCT (Fig. 1c) [6], and present it using a HMD. To my knowledge, visualization of vasculature acquired by OCT has not been shown on a HMD.

Scope of suggested project: The suggested project will focus on displaying pre-acquired OCT volumes on a HMD using Unity. I intend to upload the raw volumes as .obj files, in which the OCT structure is represented as the texture on top of a uniformly sampled grid. Areas with vasculature will have a certain color, while areas which do not have vasculature will be transparent (alpha value equal to zero). This representation of the OCT data does not require modeling the structure with a grid (mesh), which is a benefit in this case because it makes use of the raw OCT information and does not require additional effort to model the tissue structure. It is also widely applicable and readily available to any volume we acquire. At a first stage, the volumes will be pre-recorded into movies that can be displayed on simple HMDs such as cardboard. Next, I will create an interactive visualization by integrating orientation detection into the display (this will make use of the base-project described in class).

Milestones and timeline:

1. Install Unity on laptop: done
2. Decide on 2-3 interesting OCT volumes to display: 5/26 (ideas are: mouse brain, mouse brain with tumor, mouse pinna…). The first scene I intend to use is shown in Fig 1c.
3. Create a script to convert voxel data to .obj files: 5/26 (already have part of the code for this).
4. Demo Unity displaying the .obj files, understand how to visualize for HMD (stereo rendering) and display: lab on 5/26.
5. Interactive display, with orientation tracking: hopefully during lab on 5/26 and during the week after.
6. Use Unity to record several movies for cardboard: 6/2.
7. I am travelling starting 6/3 but would love to continue this when I return.

Long term goals (which would be cool to do eventually):

1. Allow interactive manipulation of the display by using controls, for example, to slice the tissue and reveal vasculature inside it.
2. Use a controller to progress through time. Or render a 4D volume, meaning a volume which changes through time, for example, to visualize the propagation and clearance of a contrast agent inside the tissue.
3. Real-time OCT rendering for intra-operative purposes.
4. Use Matlab (or something else) to design a trajectory inside the blood or lymph vessels and then render a fly-through the vasculature (like a roller-coaster). It would be cool to visualize molecular targeting or lymphatic function in this manner.

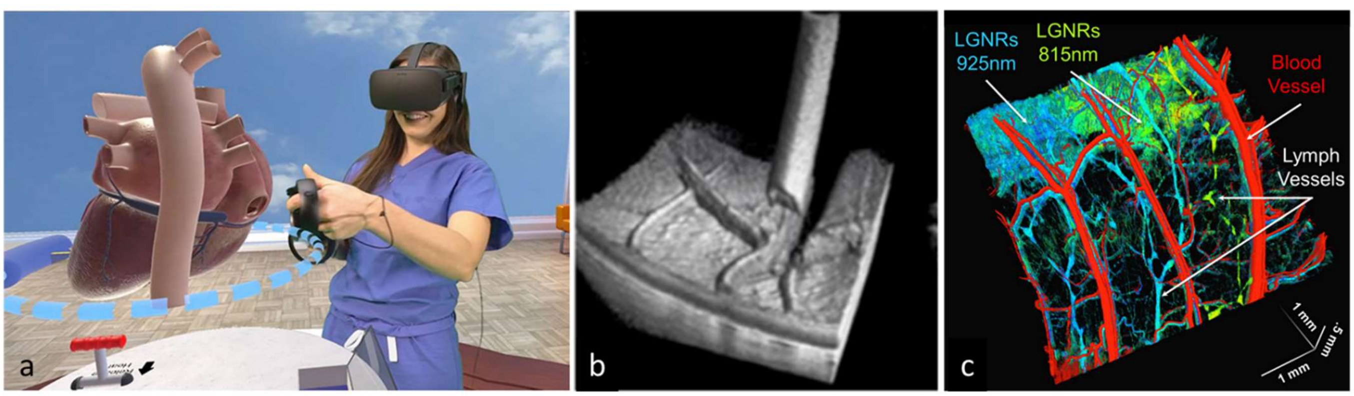

Figure 1 (a) The virtual heart project[4], for education and demonstration. **(b)** Demonstration of intraoperative OCT of a retina [5]. **(c)** Contrast-enhanced OCT[6]. One of our lab's OCT volumes that I would like to display on the HMD.

Bibliography

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