3D Immersive Environment for Dendritic Spine Labeling in Confocal Microscopic Images

Xuerong Xiao
Electrical Engineering
Stanford University
xuerong@stanford.edu

Li Tao
Electrical Engineering
Stanford University
ltao2@stanford.edu

1. Motivation

Dendritic spines are small protrusions from neurons dendritic shaft and receive input at the excitatory synapse. They typically help transmit electrical signals to the other neuronal structures in brain. Changes in density of dendritic spines are known to be the outcome of new sensory experiences, new learning and cognitive diseases. To date, the analysis of images of dendritic spines is mostly manual. The 3D structures of dendritic spines captured by slices of volumetric images from confocal microscopes impose difficulty for neuroscientists to annotate dendritic spines that occupy multiple slices. Here, we develop a 3D interactive and immersive environment for visualizing and annotating dendritic spines by illuminating regions of interest.

2. Data Preparation

We are provided a stack of volumetric confocal microscopic images of dendrites from a mouse's brain by Prof. Carla Shatz' lab. We have around 50 slices in the stack, and each slice is a gray-scale image of size 1024×1024. The stack of images is converted to a 3D model containing information on vertices and faces described by a .json file. In this project, we first loaded the 3D model into our scenes and added interactive components to facilitate annotation.

3. Interactive Environment in VR

We used different combinations of mouse and keys to rotate and translate the 3D model. Then we replaced the mouse and keyboard interactive with an Xbox controller so that the user can examine the structure more easily when wearing a headset. The hardware setup is shown in Fig. 1. Furthermore, we added a user-controlled point light to the scene to brighten an area located by the mouse's position. In each viewport, there is a red dot at the location where the point light is positioned. A screenshot for the stereo rendering veiwport is shown in Fig. 2.

Figure 1. Hardware setup for rendering the 3D immersive environment.

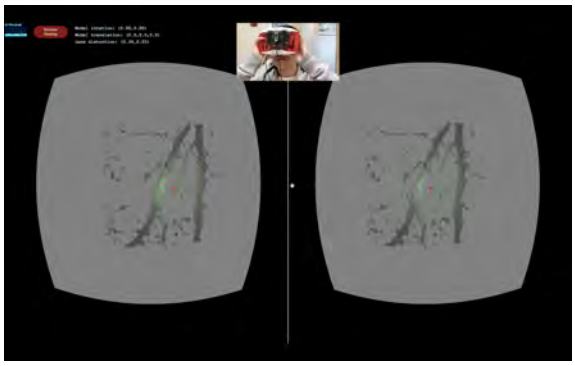

Figure 2. Screenshot for the stereo rendering of the dendrite and spines with the point light position marked by a red dot.

4. 3D Visualization and Raycasters

In a separate 3D environment, we implemented raycasters to send a ray whose direction is determined by the position of the mouse and the pose of the camera. The ray intersects the model when the mouse hovers above the model

on the screen. We then placed a point light between the camera and the model in the direction of the ray and illuminated meshes within a region of interest determined by the position, intensity and attenuation of the point light. A screenshot for this 3D environment is shown in Fig.3. This is a promising step towards making it a working annotation tool, in which we will need to extract information on certain meshes in the lightened region.

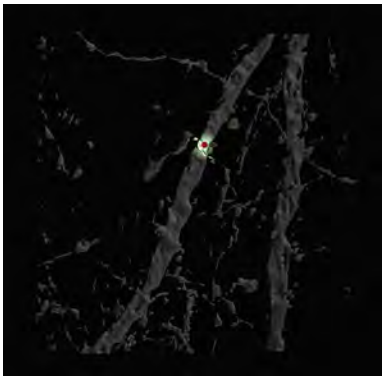

Figure 3. Screenshot for the 3D environment with raycaster implemented to only light up the region where the mouse touches.

5. Future Work

For future work, we will incorporate the raycaster implementation to the stereo rendering viewports, and allow the user to use the Xbox controller to only light up the regions of interest. We will also implement position tracking so that the user can visually "walk" in the immersive environment and change viewports accordingly. Finally, we plan to ask neuroscientists to evaluate the experience of using this 3D immersive environment for annotating dendritic spines and compare with using slices of 2D images.