Experimental Head Mounted Display for Visualizing Cell Motion in a Collagen Matrix

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Abstract

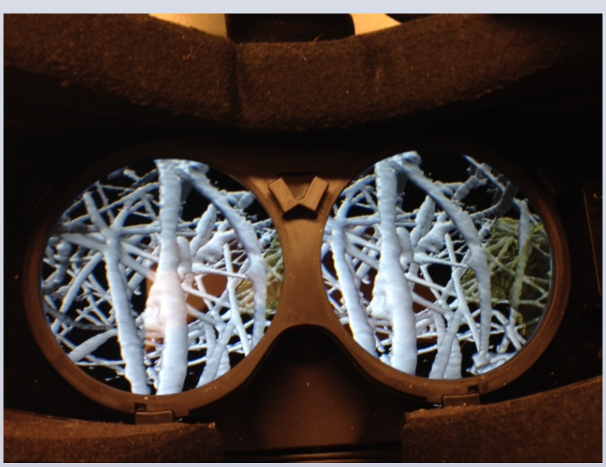
We present an experimental technology demonstration of the interactive exploration of a HL60 macrophage cell moving through a collagen matrix using an inexpensive virtual reality head-mounted display (HMD) known as the Oculus Rift. This HMD, featuring stereoscopic display and head tracking, is driven by a MacBook Pro laptop running an early next generation version of UCSF Chimera. A consumer-oriented version of the Rift is in development, which will be aimed at a general market and have improved head tracking, positional tracking, and 1080p resolution. Despite the excitement and high levels of enthusiasm for both the technology and the scientific data being examined, the usefulness of the Rift display for detailed data analysis is limited because the typical 2-D windows required during interactive analysis are not available.

Introduction

Molecular visualization and analysis typically looks at molecules from the outside. Views of the guts of a molecule are often obtained by clipping away part of the structure. An alternative approach is to view the molecular structures from the inside, an immersive view. A wide field of view is useful since the molecule is then all around the viewer.

Oculus Rift [1] is an inexpensive ($300) stereo display that provides a wide field of view, ability to look in any direction by turning your head, and full depth perception. It is currently only available as a software developer kit, with an expected release of a consumer product late in 2014.

We added Oculus Rift head tracking and stereoscopic rendering to our next generation Chimera software [2], and tested it on views inside the influenza M2 ion channel (PDB 2kwx) and also of macrophage cells moving in a network of collagen filaments. We also enabled flying around inside the structures using a 6-degree-of-freedom Space Navigator. The rendering code does optical corrections for the Rift that we describe in an on-line report [3].



Why use Oculus Rift for Molecular Visualization?

Graham Johnson originally acquired the Oculus Rift developer kit in order to preview videos he was creating for planetarium domes since access to an actual planetarium dome is usually quite limited.

The Rift gives a wide field of view (about 90 degrees) and stereoscopic depth, and tracks head orientation allowing you to look in all directions. Your vision is entirely filled with the virtual scene. This is significantly different from traditional stereo visualization on a desktop computer display or projector image because those technologies typically give a narrow field of view (typically 30 degrees), with no head tracking to allow viewing in other directions. The traditional methods show the molecules floating near the screen and cannot get too close to the observer because of limited screen width.

Conclusions

Despite the unique capabilities of the Rift display, we have not come up with compelling applications for molecular visualization and analysis. The basic problem is that just looking at models or image data has very limited use. Researchers need to analyze the data -- align models, fit molecular structures in image data, evaluate sequence conservation, setup docking or electrostatic calculations. All of this requires a user interface beyond simply looking at the data. The Rift doesn't provide a way to interact with conventional 2-D user interfaces such as interactive menus and controls. A large effort would be needed to create software to display user interface controls in the Rift 3-D view. The very low resolution of the display allows only simple interfaces with large text. The Rift configuration utility is an example of this. Even with a higher resolution display, the inability to see your keyboard, mouse, track pad, and use other applications like e-mail or a web browser make it highly doubtful that an adequate user interface to do detailed analysis of molecular structures would be possible.

Thus, the most plausible use is to show others features of 3-D data sets from an immersive viewpoint, for example, as demonstrations to students, or showing research collaborators findings obtained with more conventional computer analysis. The Rift generates lots of excitement about both the technology and the scientific data being viewed, and this inspirational role may justify using this new immersive display.

Acknowledgements

Live cells of dendritic collagen were prepared by Lillian Fritz-Laylin in Dyche Mullins' lab at UCSF and 3-D data sets were obtained using a Bessel beam microscope under development by Eric Betzig at the Janelia Farm Research Campus [4].

References

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