N° 3118
ARVO Annual Meeting
May 6-10, 2012
Fort Lauderdale

Three-Dimensional OCT Reconstruction in an Immersive Virtual Reality System

Claudia Schulze-Döbold [1]
Ramin Tadayoni [1]
Ali Erginay [1]
Jürgen P. Schulze [2]

[1] Ophthalmology Department, Lariboisière Hospital, University Paris 7, APHP, Paris, France
[2] Calit2, University of California San Diego, La Jolla, CA, USA
Contact: claudia.schulze@lrb.aphp.fr, jschulze@ucsd.edu

Purpose

Three-dimensional (3D) reconstruction of optical coherence tomography (OCT) images is a modern technique that helps interpret the acquired images and understand the underlying disease. However, the 3D reconstruction displayed on commercial devices is often of limited quality: it can be difficult or impossible to adjust the view point and see the data set from a meaningful perspective. We did a preliminary study to evaluate applicability and concern of a novel, 3D TV-based virtual reality (VR) system and interactive volume rendering software to clinical diagnostics and research.

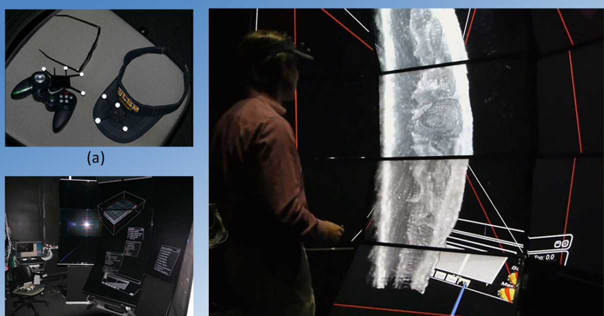

Figure 1: (a) VR equipment: 3D glasses, wand (gamepad with tracking target), head tracker (visor with tracking target). (b) NexCAVE VR system. (c) User in NexCAVE viewing OCT data set.

Methods

We use the images of a tightly spaced (11-30 µm) macular cube of different retinal pathologies acquired with the Heidelberg Spectralis OCT (Heidelberg Engeneering, Inc, Carlsbad, California). For the 3D reconstruction we use our own volume rendering software [1], which is part of the VR framework COVISE and can drive PC cluster-based VR display systems. No segmentation or pre-classification is required. Data from an OCT can be viewed within minutes of scanning the patient's eye. Changes of opacity, brightness and contrast can be made in real-time directly from within the VR system using an interactive 3D dialog window, which the user can interact with using a hand-held 3D wand.

The data is displayed in a novel, 3D television (TV) set based VR system, which consists of ten 46" diagonal passive stereo displays from JVC, which require the viewer to wear circularly polarized 3D glasses. Our VR system, the NexCAVE [2] at Calit2, is brighter and has an order of magnitude higher contrast than high end projector-based VR environments, which makes it particularly attractive for medical use. We compared the images in the VR system with individual OCT slice images and the 3D reconstruction available on the OCT scanning device and found that the images in VR show details more clearly and are much easier to view thanks to head-tracked stereo, which allows more intuitive interaction than with mouse and keyboard alone.

In the results section of this poster, we show three 3D reconstructions in anaglyph 3D, which need to be viewed with red-cyan stereo glasses.

Results

1) Macular Hole III°: Detailed visualization of the hole's rim and the retinal pigment epithelium. The irregularity of the rim and the elevation of the outer retinal layers are clearly visible.

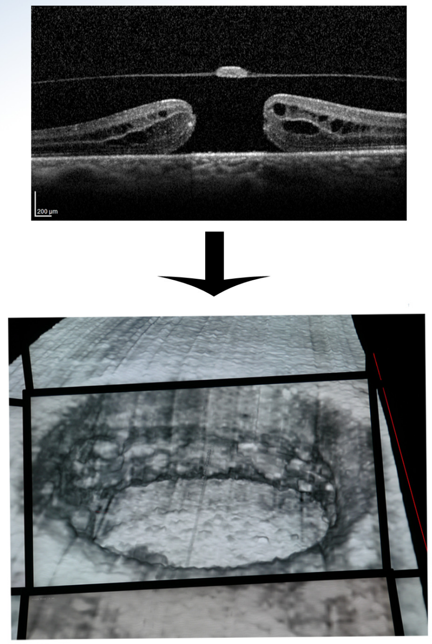

Figure 2: Macular Hole: cross-section (top), 3D reconstruction in the NexCAVE (bottom).

References:
[1] J. Kniss, J.P. Schulze, U. Wössner, P. Winkler, U. Lang, C. Hansen, "Medical Applications of Multi-field Volume Rendering and VR Techniques", In Proceedings of the Joint Eurographics-IEEE TCVG Symposium on Visualization, Konstanz, May 19-21, 2004, Published by Eurographics Association, ISBN 3-905673-07-X, pp. 249-254
[2] T.A. DeFanti, D. Acevedo, R.A. Ainsworth, M.D. Brown, S. Cutchin, G. Dawe, K.-U. Doerr, A. Johnson, C. Knox, R. Kooima, F. Kuester, J. Leigh, L. Long, P. Otto, V. Petrovic, K. Ponto, A. Prudhomme, R. Rao, L. Renambot, D.J. Sandin, J.P. Schulze, L. Smarr, M. Srinivasan, P. Weber, G. Wickham, "The Future of the CAVE", Central European Journal of Engineering, 1(1), 2011, ISSN 1896-1541

2) Diabetic Macular Edema: The edematous layers can be seen very clearly. When changing transparency, the cellular extensions show clearly as well. No independent kysts are found.

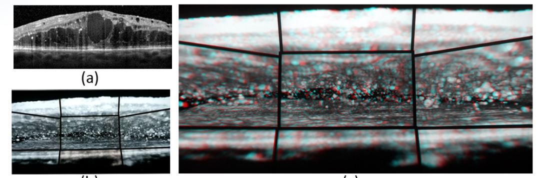

Figure 3: Diabetic Macular Edema: (a) cross-section, (b) 3D reconstruction in the NexCAVE, (c) anaglyph 3D.

3) Central serous chorioretinopathy: the serous retinal detachment and cellular irregularities of the outer retinal layers.

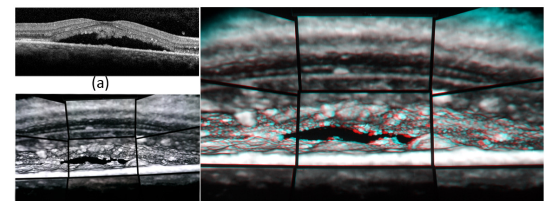

Figure 4: Central serous chorioretinopathy: (a) cross-section, (b) 3D reconstruction in the NexCAVE, (c) anaglyph 3D.

4) Vitreomacular traction syndrome: The retinal surface and vitreal adhesion is visualized in detail. The image can be turned and opened from different views.

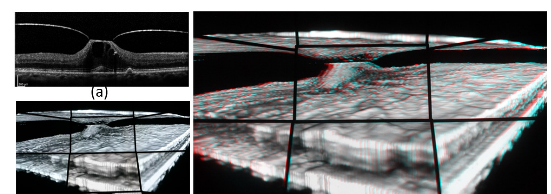

Figure 5: Vitreomacular traction syndrome: (a) cross-section, (b) 3D reconstruction in the NexCAVE, (c) anaglyph 3D.

Conclusions

Extraordinarily high quality 3D-OCT image reconstruction can be achieved with modern VR systems, which is a significant improvement for their clinical analysis. These systems can process OCT image stacks instantly into high-quality 3D pictures, which can be interactively viewed. New 3D TV based VR systems are sufficiently compact and affordable to be installed in a medical unit.