Performance of an AO - sub system for imaging human retina *in vivo*: An update on the UC Davis AO-OCT / AO-SLO instrument.

Robert J. Zawadzki[1], Steven M. Jones[2], Dae Yu Kim[1,3], Lisa Poyneer[2], Arlie G. Capps[1,4], Scot S. Olivier[2], John S. Werner[1]

[1]Vision Science and Advanced Retinal Imaging Laboratory (VSRI) and Department of Ophthalmology & Vision Science, UC Davis, 4860 Y Street, Ste. 2400, Sacramento, CA 95817 (USA)

[2]Lawrence Livermore National Laboratory, 6000 East Avenue, Livermore, CA 94550 (USA)

[3]Department of Biomedical Engineering, UC Davis, One Shields Avenue, Davis, CA 95616 (USA)

[4]Institute for Data Analysis and Visualization (IDAV), Department of Computer Science, UC Davis, One Shields Avenue, Davis, CA 95616 (USA)

rjzawadzki@ucdavis.edu, stvnjns@llnl.gov, dyukim@ucdavis.edu, poyneer1@llnl.gov, agcapps@ucdavis.edu, olivier1@llnl.gov, jswerenr@ucdavis.edu

Purpose

To summarize performance of three different configurations of the AO-sub system implemented for high-resolution human retinal imaging with the UC Davis AO-OCT and AO-OCT/AO-SLO instrument.

Methods

The combination of adaptive optics (AO) with any retinal imaging technique allows for improved lateral and axial resolution. The combination of modalities may result in the creation of powerful imaging modalities that can provide high-volumetric-resolution *in vivo* images of the retina at a cellular level. The AO-OCT/AO-SLO instrument at UC Davis has been under development for several years, and has demonstrated the utility of this technology for microscopic, volumetric, *in vivo* retinal imaging [1,2]. The development stages of our AO sub-system included dual deformable mirrors and two configurations of single deformable mirror wavefront correction. In this paper we report on our testing of the AO subsystem performance with these three configurations. Figure 1 shows actuator geometry for all three DM configurations scaled to the eye’s pupil plane.

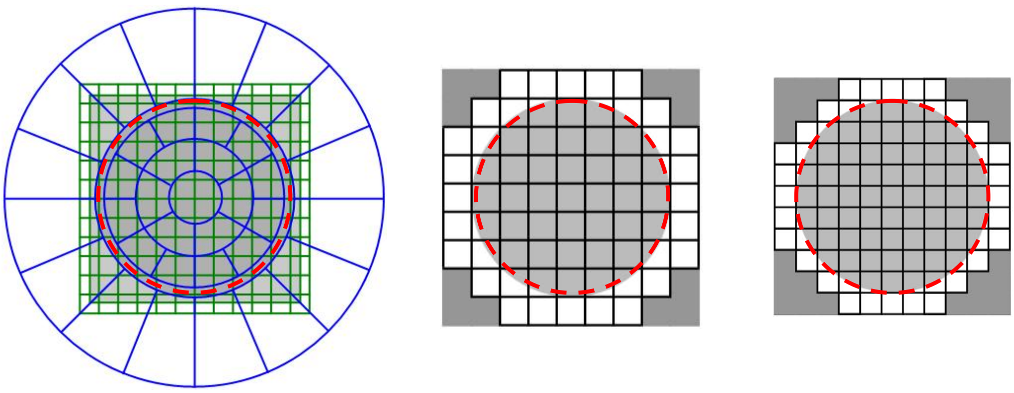

Fig. 1. Actuator geometry for three AO configurations implemented at UC Davis. Left: 2DM configuration with 35+2-element Bimorph Aoptix DM (blue - circular shape) and 140-element MEMS BMC DM (green - square shape); Center: 69-element ALPAO DM; Right: 97-element ALPAO DM. The gray area represents mirror surface of the DMs. The mirror size conjugate to the subject’s eye pupil (diameter 6.75 mm) is marked by the red dashed circle on each DMs.

As previously reported, the initial configuration of the UC Davis AO sub-system used a 35-actuator AOptix bimorph deformable mirror (DM) for low-order, high-stroke correction [3] and a 140-actuator Boston Micromachines MEMS DM for high-order correction. Performance of the AO-subsystem of this instrument was previously evaluated and results were presented by Evans *et.al.* [4]. Later we replaced this configuration with a single novel membrane magnetic deformable mirror with increased stroke and actuator count. Initially we implemented the 69-actuator ALPAO membrane magnetic deformable mirror. Both AOptix and MEMS DM's were removed from the system. A flat mirror was placed at the MEMS DM position and the AlpAO DM was placed at the AOptix position (similar diameters of these DMs permits them to be exchanged without changes in optical components of the system). Recently we upgraded the AlpAO DM to its 97-actuator version and changed the AO-OCT/AO-SLO sample arm optics to accommodate the larger diameter of that mirror (13.5mm)

Results

The evaluation of the AO-subsystem performance for the three waterfront corrector configurations was based largely on quantifying the residual wavefront error (WFE) as well as AO-OCT image quality. Testing of both ALPAO deformable mirrors included measuring their dynamic range when placed in our AO-OCT/AO-SLO system. This involved use of a model eye in conjunction with trial lenses that were placed in front of the eye to mimic refractive errors of various powers. Results of using these AO configurations for correcting aberrations of human subjects will also be presented.

Conclusions

Adaptive Optics using a single deformable mirror with increased stroke and actuator count offers a good compromise if compared with our two DM (woofer-tweeter) configuration. It allows for a more compact optical design and simplifies AO control software. The performance of the novel membrane magnetic deformable mirror should be sufficient to correct aberrations for many subjects to successfully achieve cellular resolution retinal imaging [5,6]. Additionally, future improvement of the UC Davis instrument will be discussed, particularly with emphasis on improving the AO-sub system to enhance OCT image contrast.

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