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Three-dimensional cellular resolution *in-vivo* retinal imaging

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Abstract: Current developments in cellular resolution *in-vivo* retinal imaging systems at the UC Davis will be presented. Instrumentation developments include the combination of adaptive optics with optical coherence tomography and scanning laser ophthalmoscopy.

OCIS codes: (110.4500) Optical coherence tomography; (010.1080) Adaptive optics; (220.1000) Aberration compensation; (170.0110) imaging system; (170.4470) ophthalmology; (120.3890) Medical optics instrumentation

1. Introduction

Recent advances in biophotonics including light sources, detectors, optical components, signal detection and processing schemes have revolutionized methods for imaging the living human eye. It is possible nowadays to see retinal structures with unprecedented contrast and resolution, thereby transforming the diagnosis and treatment of retinal diseases. Current developments on three-dimensional cellular resolution *in-vivo* retinal imaging systems at the UC Davis Vision Science and Advanced Retinal Imaging Laboratory (VSRI) will be described. This includes the combination of adaptive optics with optical coherence tomography and scanning laser ophthalmoscopy. Several examples of clinical applications for retinal imaging will be presented. Possible directions for future system development will be discussed as well.

2. Summary

Since 2004 our laboratory has been involved in the development of cellular resolution *in vivo* retinal imaging systems combining adaptive optics (AO) with Fourier-domain optical coherence tomography (OCT) [1-4]. Recently we added scanning laser ophthalmoscopy (SLO) to our imaging modalities. This instrumentation has been designed and constructed with a single AO subsystem for simultaneous AO-OCT AO-SLO image acquisition [5].

Our combined AO-OCT AO-SLO system uses two separate wavelengths for OCT and SLO. The light source for OCT is a Superluminescent diode (SLD) @ 836 nm with 112 nm spectral bandwidth (Superlum LTD), allowing 3.5 μ m axial resolution at the retina. The light source for the SLO subsystem is also an SLD @ 680 nm with 10 nm spectral bandwidth. We use dichroic mirrors to separate SLO and OCT beams within our system where necessary. Our AO-SLO subsystem shares most of the components with AO-OCT except for horizontal scanners. The OCT light also serves as the beacon for wavefront sensing in the AO sub-system. A Hartmann-Shack wavefront sensor measures aberrations over a 6.7 mm pupil diameter. A deformable mirror from AlpAO is conjugated to the same pupil diameter to allow up to 3 μ m lateral resolution for both subsystems when AO correction is optimized. A bite-bar and a forehead-rest assembly have been mounted on a motorized X-Y-Z translation stage to reduce head motion and position the subject's eye pupil during imaging. Eye fixation is directed to an external target to minimize head and eye motion and to allow precise imaging at different retinal locations. For each imaging session multiple retinal eccentricities are imaged depending on the structure of interest or retinal condition. For each retinal eccentricity at least two line scans and two three-dimensional scans are acquired with the AO-OCT sub-system. The AO-SLO sub system in each case acquires corresponding *en-face* video. Then both images can be displayed, corrected for eye motion, and analyzed both as single and co-registered frames.

3. References

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