Advances in Retinal Imaging

INTRODUCTION

Since its formation, the Optical Society of America has fostered a symbiotic relationship between the vision science and optics communities. A recent application that has especially benefited from this interplay is that of retinal imaging. Vision scientists have long been interested in imaging the retina *in vivo* in order to diagnose retinal disease and to study basic visual processes but have been limited by the tools available to image the retina. Recent advances in optical instrumentation such as adaptive optics (AO), scanning laser ophthalmoscopy (SLO), and optical coherence tomography (OCT), as well as advances in the ability to molecularly label different cell types in the retina, have made it possible for vision scientists to make major advances in the understanding of the normal and the diseased retina. The goal of this feature issue is to highlight the advances made possible by the dynamic interplay between the vision science and optics communities, focusing on the instrumentation for, and applications of, retinal imaging. The papers presented herein have been organized into four categories: instrumentation and techniques for retinal imaging (eight papers), image processing (five papers), functional imaging of the retina (two papers), and clinical applications of retinal imaging (eight papers).

We were fortunate to have Nicholas Wade contribute an invited review, "Image, eye, and retina." The paper is truly a joy to read and serves to give the reader a historical perspective on issues regarding retinal imaging. It presents a nice contrast to the contributed papers (which focus on the current state of the field) and will no doubt be especially interesting to graduate students and postdoctoral fellows who wish to learn more about the common origins of optics and vision research. Also of broad interest is a paper from Francois Delori and colleagues on the ANSI safety standards, with an emphasis on ophthalmic devices. This paper breaks down the standards and presents practical examples of how they apply to various retinal imaging conditions. This should prove valuable for groups using or thinking about using retinal imaging techniques.

The first group of papers begins with an investigation of holographic modal wavefront sensing for the measurement of static ocular aberrations by Corbett and colleagues. Zhang and Roorda characterize the performance of various photodetectors for use in an adaptive optics scanning laser ophthalmoscope (AOSLO). Hunter *et al.* use different image quality metrics to assess changes in SLO image quality as a function of scattered light, imaging pinhole diameter, and age, while Wanek *et al.* model the effect of scatter on retinal image quality in AO imaging. Chen *et al.* describe a new AOSLO utilizing two deformable mirrors for wavefront correction. Burns *et al.* describe a large-field-of-view AOSLO with retinal stablization. Both instruments have features that will ultimately find their way into future clinical instruments. Bigelow *et al.* analyze the improvement in resolution afforded by combining AO with spectral domain OCT. The final paper of the group, by Bueno *et al.*, describes the use of a polarimetric technique for improving the quality of images from a confocal SLO.

The second group of papers focuses on processing of retinal images, beginning with Chenegros *et al.*, who present a theoretical analysis of myopic deconvolution for retinal imaging. Li *et al.* and Xue *et al.* describe algorithms for identifying cone photoreceptors in *en-face* AO images of the retina. Zawadzki *et al.* illustrate the need for advanced image processing techniques in order to maximize the utility of an AO-OCT system. The paper by Adjeroh *et al.* approaches the problem of blood vessel segmentation in retinal fundus images.

In the third group, Dudgeon *et al.* combine multifocal electroretinography with OCT imaging for simultaneous structural and functional retinal imaging, while MacKeben *et al.* employ software improvements to an SLO for making microperimetric measurements of retinal function.

The final group of papers focuses on clinical applications of retinal imaging. Mancuso *et al.* describe the development of a cone-specific rAAV and measure the time course of green flourescent protein expression using a commercial retinal imaging system. Vilupuru *et al.* utilize an AOSLO to image the lamina cribrosa in a monkey model of glaucoma, while Hood examines the relationship between nerve fiber thickness measurements and behavioral sensitivity in human patients with glaucoma. Miura *et al.* evaluate a polarimetry method to enhance retinal blood vessels masked by epiretinal membranes. Baraas *et al.* use AO imaging to uncover disruption in the cone photoreceptor mosaic in individuals with inherited tritan color vision defects. Jelinek *et al.* implement a segmentation algorithm for use in identifying proliferative diabetic retinopathy. Cideciyan *et al.* describe a new reduced-illuminance autofluorescence imaging technique to evaluate changes in retinal autofluorescence in ABCA4 macular disease. In the concluding paper of the feature issue, Eisner *et al.* utilize imaging polarimetry to examine neovascular membranes associated with age-related macular degeneration.

A number of the papers represent work presented at the Engineering the Eye II meeting in Galway, Ireland. This meeting was generously organized by Chris Dainty and David Williams and brought together scientists engaged in the discovery of retinal function, clinical researchers engaged in the understanding and treatment of retinal disease, and engineers with expertise in advanced optical techniques in retinal imaging. The meeting provided the ideal platform for making real progress in our understanding of how emerging imaging technology might serve to accelerate our understanding of the normal and the diseased retina.

All papers in this issue have undergone a rigorous peer-review process, and we are indebted to the referees for their efforts in ensuring that the Optical Society of America's standards for quality and integrity were met. We are especially gratefully to Steve Burns (Editor-in-Chief) and the publication staff at the Optical Society of America for their hard work and dedication to this feature issue: Alice Markham, Debra Herron, Joe Richardson, and the many others who contributed behind the scenes. Finally, we hope you find the papers in this feature as enlightening and stimulating as we did.

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