Introduction

Emerging imaging developments in experimental vision sciences and ophthalmology

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With delicate anterior and posterior structures, the eye works as a robust optical imager to capture visual information, which is essential for sensing the beauty of the world and effective communication. The anterior segment of the eye, particularly the cornea and the crystalline lens, functions as an optical lens to project the target image into the fundus.[1] Located at the posterior of the eye, the retina is a complex neural network responsible for capturing light photons, converting light energy to bioelectronic activities, and initiating the visual information processing.[2] Because different diseases can target different parts of the eye, clinical examination of both anterior and posterior segments is important for eye disease detection and treatment assessment. As one part of the central nerve system (CNS), retinal neurovascular system is also frequently affected by neurodegenerative diseases such as Alzheimer's disease (AD) and Parkinson's disease (PD).[3] In order to provide intuitive information for identifying ocular pathologies or neurodegenerations through the eye, different imaging approaches have been established for ophthalmic examination. Developments of quantitative imaging are also important for advancing the study of the nature of visual system.

Optical imaging methods, such as slit lamp biomicroscopy[4–6] and fundus photography,[7,8] have played an indispensable role for the eye examination. In traditional fundus cameras, a white light source is typically used for color fundus imaging. It is known that the short wavelength, such as blue or green, light is predominantly sensitive to the retinal morphology, while long wavelength, such as red and near infrared (NIR), light provides enhanced penetration through the retina to reveal choroidal structure. Therefore, multiple-spectral imaging can be used to selectively evaluate the retinal and choroidal layers.[9–12] With the confocal configuration to reject out-of-focus light, scanning laser ophthalmoscopy (SLO) provides a feasible strategy to enhance the resolution and contrast of chorioretinal imaging.[13,14] Adaptive optics (AO) can be incorporated to compensate for optical aberrations of the eye to further enhance the fundus image resolution and contrast.[15–17] Super-resolution ophthalmoscopy has been recently explored through virtually structured detection[18,19] and optically reassigned SLO.[20] By coherent gating of the light from different depths, optical coherence tomography (OCT) enables three-dimensional (3D) imaging of ocular structures at micrometer level resolution.[21,22] While most of the ophthalmic imaging modalities are based on the recording of backward scattered light from the ocular tissues, photoacoustic imaging has been demonstrated to map absorption properties of the anterior[23] and posterior[24,25] segments of animal eyes. Moreover, ultrasound biomicroscopy have been also developed for evaluating the anterior[26,27] and posterior[28–30] segments.

In addition to morphological imaging assessment, there are active efforts to expand the imaging capabilities for functional assessment of physiological condition of the eye. For example, as a special OCT modality, OCT angiography (OCTA) can provide high-contrast imaging of the vasculatures with active blood flow at capillary-level resolution.[31,32] In coordination with visible stimulation, functional OCT has been demonstrated for objective optoretinography of stimulus evoked intrinsic optical signal changes in animal[33,34] and human[35–37] retinas. Functional OCT has been also validated for depth-resolved rhodopsin molecular contrast imaging in retinal photoreceptors.[38] OCT[39,40] and ultrasound[41,42] elastography have been explored for imaging biomechanical property of ocular tissues.

Moreover, quantitative feature analysis and disease classification are being explored on fundus photos, OCT, and OCTA using computer-aided methods.[43–46] Recently, extensive efforts have been made on implementing artificial

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intelligence (AI) tools to improve analytical reliabilities, with machine learning and deep learning algorithms.[47–50]

Four mini-reviews in this thematic issue focus on newly emerging developments of imaging technology and data analysis in experimental vision sciences and ophthalmology. Yao *et al.* summarize the interpretations of anatomic correlates of outer retinal bands in OCT and discusses potential differences of clinical OCT and AO-OCT.[51] Berkowitz *et al.* spotlight one OCT biomarker, i.e. subretinal space change due to light–dark transition imaging, for monitoring mitochondrial respiration of rod photoreceptors.[52] Hollak *et al.* emphasize the AI-aided OCT biomarkers in monitoring the progression of age-related macular degeneration.[53] Le *et al.* summarize the latest progresses in quantitative OCT angiography assisted by machine learning methods.[54]

Eight original research articles in this thematic issue cover ultrasound-related and optical imaging-based experimental study and/or data analysis. Liu *et al.* report an ultrasound elastography study of corneal stromal deformation.[55] Gaffney *et al.* demonstrate AO–SLO to investigate cone photoreceptor reflectance variation in the northern tree shrew and 13-lined ground squirrel.[56] Ansari *et al.* illustrate polarized infrared retinal imaging of pathognomonic macular ripples in patients with foveal hypoplasia.[57] Jiao *et al.* highlight a comparative study of OCT angiography algorithms for rodent retinal imaging.[58] Tan *et al.* describe the potential effectiveness of using OCT for eye disease screening compared to clinical examination.[59] Zhou *et al.* validated 3D OCT segmentation and visualization of choroidal anatomy including topographical features of individual vessels.[60] Liu *et al.* performed normative perfusion measurements in the temporal retina using wide-field OCT angiography.[61] Wang *et al.* developed a multiple subdivision-based algorithm for quantitative assessment of retinal vascular tortuosity in fundus photography.[62]

In summary, this thematic issue provides a small snapshot of the various emerging imaging modalities in experimental vision and eye research as well as to encourage future submissions to *Experimental Biology and Medicine* that incorporate ophthalmic imaging approaches and experimental results into their articles.

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