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Editorial

Editorial to the Special Issue on "Ocular Imaging for Eye Care"

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The need for fast, inexpensive, and robust medical technology is now more crucial than ever. Ocular imaging and visual performance assessment are integral parts of ophthalmic examination, and are necessary for many clinical aspects of eye care, such as ocular implant design and treatment. The recent advances in optical technologies and information processing have continuously extended their applicability to eye care. This Special Issue gathers contributions in these fields that emphasize eye care. A total of 12 articles are published in this issue, demonstrating the extraordinary progress in a variety of scenarios, from ocular image processing and artificial intelligence [1–4] to ocular lens design and characterization [5–8], and visual performance [9–12]. Half of the articles deal with ocular lens implants, which has been revealed to be a very active field in surgery [5–7,9,11,12].

Regarding ocular image processing, Gonzalez-Amador et al. [3] proposed a method for improving retinal images affected by cataracts. Their approach adaptively enhances the contrast in retinal images in the color space to reveal diagnostic features that are often missed. Zéboulon et al. [1] developed a deep learning approach for detecting stromal and epithelial edema on optical coherence tomography (OCT) images. Using the innovative transfer learning technique, they train the deep neural network on a limited training set and later validate it on a much larger dataset with reliable results. Bustamante-Arias et al. [2] used different machine learning algorithms for discriminating between healthy and pathologic corneal images, by evaluating digitally processed spectral-domain optical coherence tomography (SD-OCT) corneal images. The different approaches considered show promise in reliably using machine learning for many ocular image classification tasks. Fernández et al. [4] measured both the choroid and retina thickness from OCT images centered at the foveal depression in a group of young healthy subjects with refractions ranging from emmetropia to high myopia. They concluded that the differences in the choroid and retina thickness along the horizontal meridian, as a function of refraction, do not characterize the onset and progression of myopia at early stages, since they only manifest in the group of subjects with high myopia.

In regard to ocular lens design and characterization, Romero et al. [6] proposed extending the depth of focus of an ocular lens based on an optimized quartic phase mask. Their optimization method allows a parameter-free iterative approach to be performed that yields the best trade-off between extending the depth of focus and achieving the best image quality. Martinez-Espert et al. [5] proposed a new intracorneal diffractive lens for presbyopia correction that could allow reasonable distance, intermediate, and near vision. They used an adaptive optics visual simulator to study the influence of spherical aberration and the potential errors in thickness caused during the manufacturing process. Their results showed that the inlay through-the-focus imaging performance could be customized with the spherical aberration value, favoring either distance–intermediate or intermediate–near vision. In another study, Łabuz et al. [7] assessed the image quality, tilt, and decentration of supplementary intraocular lenses (IOLs) in a two-lens configuration. The analyses showed a trend towards a lower impact on the modulation transfer function and fewer optical errors with decreasing nominal power. Their results showed that when misaligned, low-power sulcus-fixated IOLs might retain their good optical quality. However, the proper alignment of a high-power capsular fixation lens is essential for achieving a desirable postoperative outcome.

Finally, regarding modeling and visual performance evaluation, López-Gil [8] revised the Gullstrand intracapsular accommodation mechanism based on the concept that the change in lens power during accommodation can be larger if the lens is modeled by two different refractive indexes than if it is homogenous. This model was compared to a six-surface model eye built based on actual experimental data obtained with precise imaging techniques of the lens change during accommodation. The results show that nearly half of the accommodation of the Gullstrand model eye is produced by this mechanism, while a model eye based on actual data produces small intracapsular dis-accommodation. Simpson [9] contributes to modeling the far peripheral vision region beyond 60° and addresses, in particular, the topic of linearity across the entire range of visual angles. The results obtained by ray-tracing calculations show that the chief ray angles at the exit pupil are linearly related to the input visual angles, and that the linearity is maintained for other axial reference points because the retina curves around to meet the rays as the angle increases. In addition to linearity, Simpson finds that the nodal point location does appear to provide scaling that matches the input angle directly, but that is not because of the paraxial nodal point characteristics of the lens system, but instead is due to other characteristics of the eye, involving the cornea, the lens, and the retinal curvature. Van Ginkel et al. [10] develop an experiment to measure on-axis and off-axis low-order optical aberrations at different levels of accommodation with a commercial Hartmann–Shack aberrometer. They compare the results obtained under two illumination conditions (red and white light) in healthy, young, and emmetropic subjects. The resulting wavefront data were analyzed in terms of the vector components of refraction and the relative peripheral refractive error. Variations with eccentricity, accommodative demand, and illumination conditions are outlined. Vinas-Pena et al. [11] present the chromatic difference in focus and longitudinal chromatic aberration in phakic and pseudophakic eyes implanted with different IOL designs and materials, obtained from computational ray-tracing, on-bench and in vivo measurements using a custom-developed polychromatic adaptive optics system. The results confirm that diffractive multifocal IOLs modulate chromatic aberration; the predicted data obtained by simulations in computer eye models show excellent agreement with the experimental data (on-bench and in vivo). Clavé et al. [12] address the basic question of the equivalence, in the context of intermediate and near vision, of assessing visual acuity using negative lenses or changing the distance of the object. Such equivalence is particularly important because the defocus curve—with the use of negative lenses—has become the gold standard method for assessing the visual performance at different distances and, hence, evaluating the depth of focus provided by modern presbyopia-compensating IOLs. The results show that both methods are equivalent in precision and accuracy, and can be used indistinctly, with the defocus curve method being more practical in clinics because it does not require further control of the chart positioning and illuminance.

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