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Ocular aberrations manipulation with adaptive optics and its application

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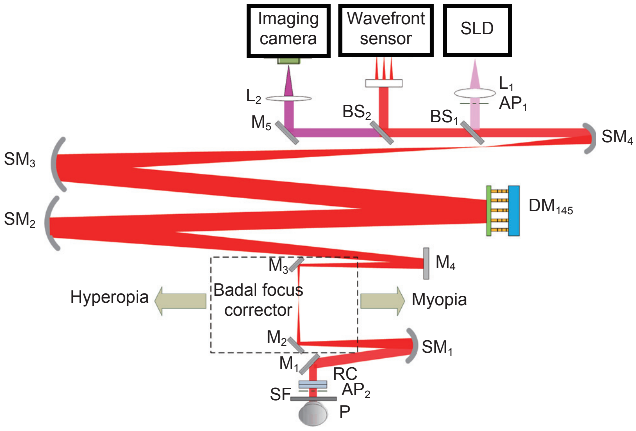

Schematic diagram of the adaptive optics double pass PSF measurement system

Overview: Adaptive optics (AO) techniques allow to measure and manipulate the wavefront aberrations in real time. In 1997, reseachers in Institute of Optics and Electronics (IOE) took the lead in developing of adaptive optics technology in China. This article firstly introduces the principle of ocular adaptive optical system briefly, and then reports the main research progress of IOE for the last five years. In 2012, we measured the effects of perceptual learning on visual sensitivity with and without HOAs-correction both for normal adults, and older child and adult anisometropic amblyopes. We found larger and more robust contrast sensitivity improvements when the HOAs were corrected than when they were left uncorrected. In 2014, we investigated the effects of ocular aberrations on the binocular vision functions. Results showed that ocular aberrations had an inequable effect on the different binocular vision functions. In 2016, an adaptive optics double pass (DP) system was designed and developed for ocular scatter estimation. The experimental results showed that this system could improve the accuracy of ocular scatter estimation. Then we investigated the effect of HOAs and intraocular scatter on contrast sensitivity. Quantitative analysis suggested a potential compensatory mechanism between HOAs and intraocular scatter on contrast sensitivity. In 2016, an AO pattern reversal visual evoked potential (PR-VEP) measurement system was established. PR-VEP measurements were performed with HOAs either retained or corrected. The results confirmed the contributions of the HOAs to the alterations in PR-VEP, and suggested that HOAs should be corrected to realize accurate PR-VEP testing. In 2017, we proposed a deep learning method to restore the degraded retinal images. The method directly learned an end-to-end mapping between the blurred and restored retinal images. The mapping was represented as a deep convolutional neural network. This network was validated on synthetically generated retinal images as well as real AO retinal images. The assessment of the restored retinal images demonstrated that the image quality had been significantly improved.

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