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Dynamic generation of scattering for high resolution adaptive optics in the eye

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Abstract content :

Adaptive optics (AO) is benefiting a number of different fields. In the particular case of ophthalmic applications, the correction of the aberrations of the eye permits to image the retina with unprecedented level of detail, unveiling the subtle structures of individual cells. On the other hand, the controlled manipulation of the wavefront accomplished by AO visual analyzers allows a better understanding of the impact of eye's aberrations in vision. However, aberrations are not the only limiting factor for both vision and retinal imaging. Normal young eyes also exhibit moderate amounts of scattering which can degrade the optical quality of retinal images. Scattering is known to dramatically increase with age. Adaptive optics may have the potential of eventually removing some scattering, through high spatial frequency correctors. Liquid crystal devices can incorporate resolutions of up to 2 million of independent pixels for scattering compensation, being ideal candidates for such applications. Time reversal experiments demonstrating the practical compensation of scattering have been already reported under controlled situations in microscopy. In this direction, a reliable experimental eye model would be advantageous for the progress of the technique, before its real time demonstration in the living eye. The eye model is necessary for demonstrating the double-pass implementation of scattering compensation, and the subsequent refining of algorithms for real time operation. We have developed a relative simple eye model to mimics the optics of the eye, and includes a transmissive liquid crystal spatial light modulator for scattering control (LC 2002, Holoeye Photonics AG, Germany). The latter can be programmed to different configurations in real time producing different levels of scattering. The scattering can be generated by mostly phase modulation, or with different combinations of amplitude and phase. Double pass images obtained from the model resemble those obtained in real eyes with high levels of scattering. The experimental eye model is an important tool for the development of the next generation ophthalmic adaptive optics systems capable for both wavefront and scattering manipulation in the living eye.

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