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Adaptive optics visual simulator with dynamic control of chromatic aberrations

Nikolai Suchkov; Enrique Josua Fernandez; Jose Luis Martinez; Pablo Artal
Author Affiliations & Notes

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Abstract

Purpose : Adaptive optics visual simulators (AOVS) allow the correction or manipulation of the eye's aberrations while testing vision through different optical conditions. However chromatic aberrations are usually neglected or taken as constant. The control of chromatic aberration has been accomplished in the past using dedicated lenses, typically doublets or triplets. Here we investigate the use of liquid crystal phase modulator technology to dynamically modify chromatic aberration in an AOVS.

Methods : The instrument incorporates a Hartmann-Shack (HS) wavefront sensor, a liquid crystal on silicon spatial light modulator (LCoS-SLM), and a tunable lens (TL) with negligible chromatic dispersion. The LCoS-SLM was used for the manipulation of longitudinal chromatic aberration (LCA) using adequate phase profiles. Diffraction associated to the phase profiles on LCoS-SLM distributed the light along multiple foci corresponding to distinct wavelengths, thus producing the required induction of LCA. The overall defocus introduced by the phase mask is compensated by the TL. Several programmed chromatic conditions were evaluated in an artificial eye. Subjective measurements of best focus for manipulated chromatic conditions were performed in four normal subjects under cycloplegia.

Results : Four different cases were studied: natural (N), compensated (C), doubled (D) and reversed (R) chromatic aberrations, at three wavelengths (450, 550, 630 nm). Chromatic shifts introduced by the LCoS-SLM was measured by analyzing point-spread functions at the focal plane in the artificial eye. The results were: 0.05D for case N, -1.15D for case C, 1.2D for case D, -2.4D for case R. Subjects found the best focus for the same conditions, and the results agreed with the predictions. The average chromatic defocus between 450nm and 630nm were - 0.1 ± 0.1D for case C; - 2.3 ± 0.07D for case D; and -1.3 ± 0.12D for case R.

Conclusions : A new adaptive optics simulator with dynamic control of LCA has been implemented. This new instrument is a useful tool to design new corrector devices and to study the combined impact of chromatic and monochromatic aberrations in vision.

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