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Adaptive optics visual simulator with extended dioptric range

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Abstract

Purpose : Adaptive optics visual simulators (AOVS) are already commercially available instruments allowing to predict the impact of different optical aberration patterns on vision (i.e., VAO, Voptica SL, Murcia, Spain). This type of instrument allows measuring and modifying the eye's aberration while performing visual testing. Current systems present some limitations when high ametropes or pathologic patients are tested due to the limited measuring/correcting range. To solve this problem, we have developed a new AOVS instrument with a large range of operation that would virtually cover any eye.

Methods : The instrument incorporates a Hartmann-Shack wavefront sensor (HS) and a liquid crystal on silicon spatial light modulator (LCOS-SLM) for measuring and manipulating aberrations respectively. These are coupled to a variable lens with a defocus range of ± 10D to modify defocus independently of the LCOS-SLM. Proper calibration and characterization of the variable lens was performed and linked by the software to the sensor and the modulator. The temporal response of the variable lens was in the order of 10-30 ms and presented a low chromatic dispersion yielding a high optical quality for the entire range of use. An additional motorized diaphragm with variable diameter ranging from 0.5 to 8.2 mm at the exit pupil plane was also incorporated. Visual stimuli were presented to the subjects by means of a high definition (HD) resolution digital light processing projector. For both optical and visual measurements, the variable lens compensated for the most of a subject's defocus, leaving the rest of the operation to the other components.

Results : The new AOVS was successfully used in three high myope patients: S1 (female, 21 yo, refraction -10D, astigmatism -1D, 90°), S2 (female, 21 yo, refraction -7D, astigmatism -3.5D, 165°) and S3 (female, 20 yo, refraction -12D). In all of the cases, refraction and aberrations were measured with HS after pre-compensation of the defocus. Visual acuity and contrast sensitivity were measured for different optical conditions, including correction of defocus and high order aberrations.

Conclusions : A new AOVS with a large dioptric range of operation has been developed. It is capable of accurately measuring subjects with high myopia and elevated amounts of aberrations. This type of instrument would extend the range of application of the visual simulation to nearly every patient, regardless of their optical conditions.

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