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Curvature Sensor Implementation for Ocular Wave–Front Determination

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Abstract

Abstract: : **Purpose:**Curvature sensing has been successfully used for wave–front phase retrieval for optical testing and astronomy, where it has proved to be suitable for adaptive optics systems. Our purpose is to adapt this technique for eye's monochromatic optical aberrations determination. **Methods:** The principle of the curvature sensor is to record two symmetrically defocused images from the pupil plane. By means of the ITE (Intensity Transport Equation) it can be proved that the contrast between those two images is related to the wave–front curvature at the pupil plane. Then wave aberrations can be retrieved using an iterative Fourier Transform algorithm. We have designed the experimental set–up based on a classical double pass system, with infrared illumination (780 nm) and a CCD camera with improved infrared sensibility, adapted for recording the extra–focal images. The performance of the system was studied by means of computer simulations, analyzing which are the optimal detection planes, and the resolution and accuracy that could be achieved. We have also performed a set of measurements with an artificial eye and different phase plates with known aberrations for sensor calibration. Finally, we have tested the system with some young healthy eyes. **Results:**Simulating the performance of the sensor for real ocular wave–fronts (from 0.1 to 3.6 microns RMS) obtained with a Shack–Hartmann based instrument, we found a very good agreement between our results and the induced aberrations, with an error around the 1% in each Zernike coefficient up to 6^{th} order. So theoretically we can retrieve with great accuracy aberrations in the range of interest for ocular optical quality study. For our experimental set–up, the artificial eye measurements results are equivalent to the nominal value, and for the measured eyes we found a good correlation with Shack–Hartmann results, being

the difference inter–subject dependent. **Conclusions:** We have developed an ocular wave–front sensor based on curvature sensing. Results for computer simulations and for the experimental system show that this technique can be used for human eye's aberration determination. In future work, we will perform a complete comparative study between our system and another currently available wave–front sensor (Shack–Hartmann sensor, Laser Ray Tracing technique,...), in order to determine whether the results are equivalent or not.

Keywords: refractive surgery: optical quality • refractive surgery: other technologies

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