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Zernike reconstruction of ocular aberrations with measurement noise

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The ocular aberrations (wavefront) can be used to describe the vision defects, and wavefront sensing devices (aberrometers) are used to measure the ocular aberrations (OAs). The Zernike polynomials (ZPs) are currently used in wavefront reconstruction algorithms of aberrometers. As the aberrometer measurements consist with noise, the measurements observed using aberrometers are not always accurate. It is therefore necessary to take multiple measurements from the patient in each sitting. However, taking multiple measurements also causes to induce the variations on measurements, and this variability of measurements is significant, and leads errors in clinical practice. Therefore, the variability should be taken into account during wavefront reconstruction. Consequently, unlike prior work, the accuracy of Zernike representation for the ocular aberrations with noise (due to the system noise and the variability of measurements) is studied. In the study, the noisy data is fitted using ZPs. Data sets are created using extracted data from arbitrary OAs, that is, synthetic data sets are used. Normally distributed very small random numbers are added into the data sets in order to create measurement noise. The magnitude of added noisy has been changed to range the signal-to-noise ratio (SNR) from 50.6956 dB to 31.6110 dB. The corresponding Zernike coefficients for each noised wavefront are computed, and visual acuity is used to examine the deviation of the reconstructed wavefront from the data set. The study concludes that the Zernike polynomials are not good enough to represent the wavefront with noisy level less than 38.6547 dB (signal-to-noise ration), and note that the aberrometer SNR is always between 20-30 dB. Moreover, this result is applicable for aberrometers including Shack-Hartmann aberrometer which uses Zernike polynomials as reconstruction algorithm.

Keywords: Zernike polynomials, Ocular aberration, Measurement noise

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