Modal Tomography of human eye aberrations

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Purpose:
The purpose of the study is development of methods for homographic reconstruction of the aberrations of cornea and based on the wavefront sensor measurements.

Methods:
Novel modal reconstructor based on Zernike aberrations representation and suitable for human eye optics is developed. The homographic eye model includes cornea and lens of regular shape combined with two thin variable phase screens located at the cornea and lens principal planes. The measurement scenario consists of the multiple wavefront measurements at different angular position of reference beam. The maximum angular deviation is 5-7 degrees. For each angular position of reference beam a wavefront is acquired by the Shack-Hartmann sensor with 40 FPS and dithering speckle suppression. The number of measurement points varies from 3 to 7. The spatial resolution of wavefront sensor was approximately 400 points for 6mm pupil. The modal reconstructor is based on the noniterative LMS technique. The tilt indetermination problem was resolved by the forward path model incorporation into the restoration scheme.

Results:
The restoration scheme is proved to be stable on the model eye with two phase screens. Computer model predicts a high accuracy restoration and separation of aberration. The accuracy of restoration depends on the angular separation of reference sources and its number. The reasonable angular separation for the reference sources was found in order of 5 degrees with number of sources 3 to 7. The single pass experimental validation confirms an excellent accuracy of restoration. Dual path experimental system exhibits somewhat higher restoration error due to incomplete tilt recovery by forward path model. The both experimental configurations are capable restoring phase screens composed by 3-rd and 4th order Zernike terms.