Abstract

Thesis title:

„Investigation of the functional dynamics of changes in the geometry of the anterior segment of the eye"

The purpose of this doctoral thesis is to present an innovative way of analyzing the dynamic changes in the geometrical parameters of the anterior eye segment that occur under the influence of natural physiological processes. The detailed goal is to develop non-standard methods of processing OCT tomograms designed to : 1) reconstruction of the realistic geometry of the eye anterior segment on the basis of OCT tomograms, as well as determination of the parameters describing it, with particular attention to estimation of the position of the corneal limbal points, 2) investigation of dynamic changes in the geometric properties of the registered structures and the blood pulsation signal, 3) use spatial frequencies for the purpose of analysis of deformation of the anterior corneal surface observed during the capturing the OCT sequences.

Measurements were based on the simultaneous recording of the video sequences of eye anterior segment by SS-OCT Casia 2 and a blood pulsation signal using a 027i reflectance pulse oximeter. First, procedures for the preliminary analysis of OCT images are presented, including segmentation and smoothing of the surface of the eye anterior segment, as well as algorithms for optical distortion correction and tomogram stabilization. Several novel methods of estimating the position of the limbal points of the cornea both on its anterior and posterior surfaces were also presented and validated in details. In order to analyze the dynamic changes in the values of 14 geometric parameters of the anterior segment of the eye (including 5 newly proposed ones), the dominant and individual frequencies as well as the similarity matrix were determined. The influence of cardiovascular activity on these dynamic processes was also estimated. Novel methods of describing the deformation of the anterior corneal surface have also been proposed. On the basis of spatial spectrograms, the ranges of spatial frequencies, for which dynamic changes of the shape of the first corneal surface occur, were calculated. The relationship between the distance of the corneal point and the peak-to-peak amplitude of its position changes was also determined. Cross-correlations between the corneal profile in successive frames were used to estimate the second derivative curve of the shape of the anterior corneal profile.

The analysis procedures and results presented in this dissertation may contribute to a better understanding of the geometric and biomechanical properties of the structures of the eye anterior segment, as well as their changes under the influence of natural physiological processes, and may in the future be used in clinical practice to develop some new non-invasive diagnostic methods of anterior segment eye diseases, as well as to control their progression.

Keywords: optical coherence tomography, anterior segment of the eye, dynamics of the anterior segment of the eye, corneal deformation, eye pulsation