Marcela Niemczyk, *Statistical modelling of corneal OCT speckle*

ABSTRACT

The goal of this thesis is to propose methods of the statistical analysis of corneal optical coherence tomography (OCT) speckle and validate their usability for detection of changes in corneal properties connected with intraocular pressure (IOP). Two approaches to speckle analysis, parametric and non-parametric, are considered in this work. The parametric approach involves estimation of distributional parameters based on pixel values in OCT images. A set of eight distributions is analyzed in terms of fitting to empirical distribution of pixel values. In the non-parametric approach three statistical distances are proposed to compare empirical distribution of speckle amplitude with benchmark Rayleigh distribution with constant value of its scale parameter. Also, values of contrast ratio are considered in this approach. The described methods of speckle analysis are presented on OCT images from three studies. The first study is performed on phantoms made of epoxy resin, containing different concentrations of scattering particles. The second study includes two experiments *ex-vivo* on porcine eyeballs. In the first experiment eyeballs are subjected to increasing IOP. The second experiment is analogous but with IOP maintained at a constant level. In the third study human corneas are examined *in-vivo* using OCT and IOP is also measured. The relation between speckle statistics and concentration of scattering particles in examined medium is evaluated in the phantom study. In the study on porcine and human corneas, speckle statistics are linked to changes in IOP, which is supposed to affect corneal properties. Additionally, the thesis considers corneal speckle analysis using spatial maps of gamma distribution parameters. The influence of OCT images averaging on speckle parameters is also examined incorporating both the statistics of speckle as well as background noise. Based on these results, a new theoretical model of speckle amplitude is calculated as a product distribution of two gamma random variables. Summarizing, this work presents different approaches to statistical analysis of corneal OCT speckle and shows that they give similar results when changes in IOP are considered. It can be concluded that the development of such methods should head towards simplifying them rather than making them overly complicated.

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