Cornea is a transparent outer tissue covering the central part of the eye, which primary function is to focus the light on the retina. Cornea has several layers and the most distinguishable ones are the epithelium, the layer composed of 5 to 6 sublayers of the cells, and the stroma, the thickest layer composed mainly of collagen fibers and water. Their transparency is guaranteed by special arrangement of mentioned microstructures (cells, collagen fibers, etc.) within the layers, which minimizes the light scattering and provides transmission of light in the forward direction. When this fine arrangement is disrupted (e.g., in keratoconus or Fuch's dystrophy) the light scattering in the cornea increases, less light arrives at the retina and vision quality worsens. Hence, early detection of such rearrangements in the cornea is crucial to prevent potential vision loss. Corneal microstructures can be observed with microscopic imaging, which allows for observation of individual cells or fibers but that cannot be achieved noninvasively. A non-contact, clinically applied technique, which is used to observe both corneal shape and transparency in macro-scale is optical coherence tomography (OCT). OCT technique allows assessing corneal tissue, where its dominant layers (epithelium and stroma) are distinguishable. The OCT images are characterized with a specific black-white random pattern (see the OCT image below) called OCT speckle. Ophthalmologists and OCT device producers mostly treat it as noise, which should be reduced, to clearly observe the cornea in macro-scale. Recent studies prove that this specific speckle pattern is also a source of an indirect information about the corneal microstructure. In other words, the individual collagen fibers and cells cannot be seen in the OCT images, but assessing the statistical parameters of the speckle can provide us with some information about them and their arrangement. The speckle statistical analysis approach was successfully developed and employed in the current research, but only for the stroma, the thickest corneal layer. This research project aims to extend the analysis also for the epithelial speckle. It is planned to introduce a new, holistic approach with analyzing epithelium, stroma and also correlate information from both layers. As a main outcome it is aimed to elaborate on a new diagnostic tool for early detection of corneal diseases. To achieve this goal, four research tasks are considered:

1. Imaging corneal OCT speckle in four groups of subjects, which potentially have disorders of corneal epithelium, including: keratoconus patients, contact lens wearers, diabetic patients and healthy controls.
2. Elaboration on holistic statistical analysis of OCT speckle based on the collected data in task 1 as well as on some retrospective data.
3. Mathematical simulation of OCT signal of two-layered structure (analogical to the corneal epithelium and stroma) of different transparency characteristics based on the subject groups examined in task 1. Holistic statistical analysis of the simulated speckle and validation of the methods elaborated in task 2.
4. Fabrication of two-layered phantoms (analogical to the corneal epithelium and stroma) of different transparency characteristics based on the subject groups examined in task 1. Analysis of OCT speckle from phantoms. Further validation of methods elaborated in task 2.