Abstract for the general public

Deciphering nano-scale tissue motion in healthy and diseased eyes
for next-generation ocular diagnostics

The human eye is a complex organ and dynamic optical structure enabling visual perception. Vision loss has a severe impact on the quality of life since 90% of the information that we receive from the world is visual. **Glaucoma** refers to a group of eye diseases involving damaged ocular nerve tissues, and it belongs to the main causes of blindness worldwide. **Age-related macular degeneration** (AMD) affects central vision, and it is associated with development of abnormal blood vessel behind the retina (wet AMD) or thinning the retinal tissue (dry AMD). Despite the high prevalence of above-mentioned conditions, **current diagnosis and treatment rely only on morphological / functional measurements of the eye, and do not consider biomechanical properties**. Therefore there is a need for novel solutions for diagnostics that incorporates also biomechanical data.

The biomechanics can be assessed indirectly by the analysis of tissue response to well-defined mechanical stimulus. However, **the eye is also subject to small pulsatile deformations**. These natural deformations depend on the pulsating blood perfusion of the eye as well as on the pressure within the eye and the elastic properties of the ocular tissues. Changes of ocular pulsatility are linked to severe eye diseases such as glaucoma. In addition, age-related changes in collagenous fibers may affect biomechanical properties of retinal tissue, e.g. Bruch's membrane. Thus, retinal biomechanics may play a role in the pathophysiology of AMD.

In this project, **we propose to develop high-speed in vivo optical imaging methods and uncover pulsation-induced nano-scale tissue motion within and in-between eye structures**. We expect our approach to be able to chart tissue displacements smaller than a thousandth of a millimeter within a thousandth of a second. By rapidly scanning the light beam over the back of the eye, we will acquire such displacement information over a large volume. The dynamic deformation of roughly 100 million different locations will be tracked over the heart cycle by repeating volume scans a couple of times.

The in vivo studies will be performed using novel prototype devices based on optical coherence tomography (OCT) to reveal the nano-scale response of ocular structures to blood pulsation. We will first use these prototypes to investigate the deformation dynamics in the eyes of healthy subjects. In glaucoma and AMD patients, we will then determine the biomechanical properties and pulsatile motion patterns characteristic to tissues all the way from the front to the back of the eye. In parallel to the imaging studies in human eyes, we will also perform OCT in vivo imaging in experimental models where the pressure within the eye is increased over a few weeks or months or in models with retinal degeneration. Finally, we aim to combine the data from all imaging studies to develop a model representing the observed deformations and elasticity in healthy and diseased eyes. **These results will enable new insights into the relationship of ocular tissue deformation and pathological conditions, which should pave the way for next-generation ocular diagnostics**.