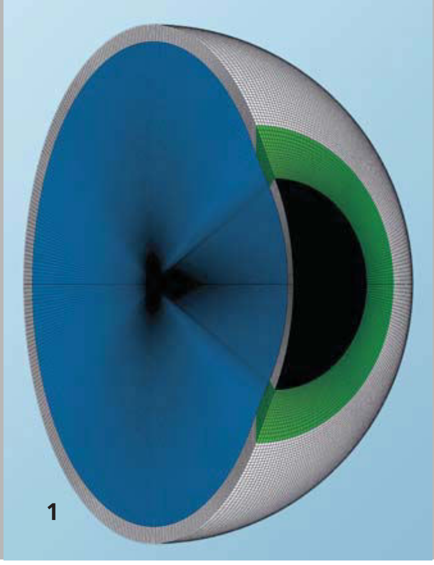

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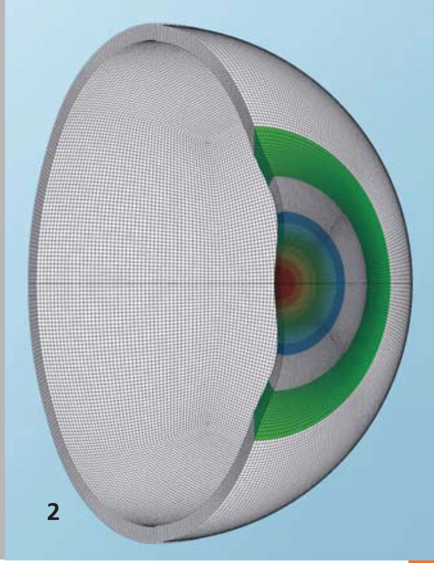

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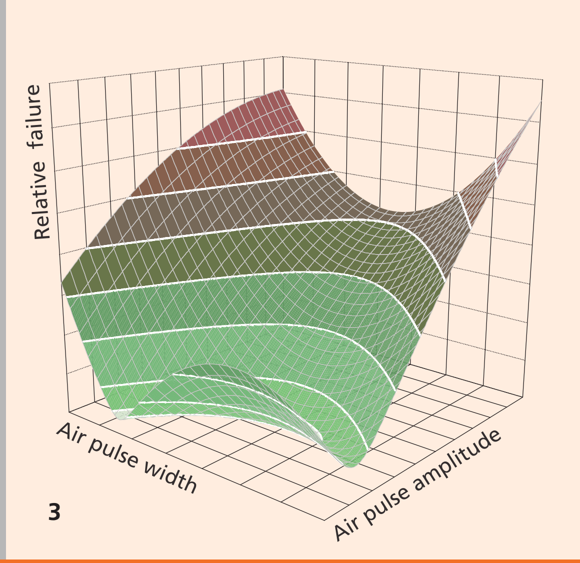


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# SIMULATION-BASED DETERMINATION OF BIOMECHANICS OF THE HUMAN EYE

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The sooner you identify diseases, the sooner you are able to react. Previous possibilities to diagnose eye disease, like glaucoma, are limited, and therapies can just keep the current condition. The Keratokonus, a thinning and deformation of the cornea, is a similar example. In order to early diagnose the diseases, an effective method is necessary.

Changes in the biomechanical properties of eye parts are reasons or side effects of various diseases. To determine these properties non-destructively is the challenge. The company OCULUS Optikgeräte GmbH developed a medical device, the so-called Non-Contact Tonometer, for measuring the intraocular pressure contact-free. It uses an air pulse to deform the cornea and record it visually. Therefore, it offers the possibility to determine biomechanical properties of the eye on the basis of the deformations, if the functional relations are known.

In cooperation with OCULUS Optikgeräte and the ophthalmic clinic of the university medical center Carl Gustav Carus in Dresden, Fraunhofer IKTS is currently working on the advancement of the medical device targeting the identification of regression functions for inversely determining the material properties of the human eye.

Performing plenty of parameter variations with comparatively low effort is a potential of a numerical model. In combination with statistical methods, such as the significance analysis, the effects of different parameters can be systematically analyzed with regard to particular variables.

The determination of the air pulse parameters serves as initial point of the cooperation because these are not measurable due to the highly transient appearance of the impulse. Therefore, experiments with contact lenses were performed and simulated under variation of the air pulse parameters in order to identify the functional coherence.

The relative failure between the results of the regression functions and the experiments according to the air pulse parameters is visualized in the diagram. During the further course of the project, a geometrically detailed numerical model of the human eye was generated, which is gradually adapted to the reality. Currently, it includes anisotropic material characteristics, which are adjusted to the real course of collagen fibrils (= fiber reinforcement). Furthermore, there is an iteration algorithm implemented into the model, which adjusts the geometrical initial state of the eye under intraocular pressure with high precision. Prospectively, hyperelastic material models and a dependency between the material characteristics and the load type (tension/compression) typical for fiber composites are implemented.

Although the model is in development, medical questions were investigated in addition to the device-related ones. As an example, analyses regarding the influence of the vitreous body and its viscosity on the deformation behavior and the intraocular pressure were performed. Furthermore, simplified regression functions for determining the biomechanics were identified. In future, functions with higher accuracy and additional information will follow.

1 *Numerical model of the human eye.*
2 *Deformed model (fluid suppressed).*
3 *Surface plot of the relative failure regarding the air pulse parameters.*

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