Università di Pisa

Corso di Dottorato in Scienze e Tecniche dell'Ingegneria Civile
Stefano Pagliara (Presidente)
Curriculum in Ingegneria Strutturale

AVVISO DI SEMINARIO

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Computational Modeling of the Mechanical and Optical Behavior of Human Corneas

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SUMMARY. The cornea is a thin concave-convex lens, which supplies about 70% of the total refractive power of the eye. To provide the refractive power, the external and internal surfaces are very close to spherical segments. In equilibrium under the physiological intraocular pressure (15-18 mmHg), the cornea reaches its maximum refractive power (43 diopters). Refractive errors resulting in myopic, hyperopic or astigmatic vision can be partially or totally corrected with laser refractive surgery (PKR, LASIK, LASEK). The surgery removes a thin layer of the cornea, modifies its external curvature, and changes its refractive power. The shape of the thin layer removed by the laser is planned on the basis of the geometry of the original cornea and of the desired power correction.

We developed a realistic three-dimensional numerical model of the human cornea. The finite element discretized geometry is created by an automatic procedure, which requires a few geometrical data available from standard measurements. The material is modeled as a distributed two-fiber reinforced hyperelastic medium, able to describe the well organized collagen structure immersed in an isotropic matrix. The model has been validated with remarkable correspondence against in-vitro inflation tests. A detailed parametric analysis provided information on the link between mechanics and optical performance. In order to simulate the surgical correction of myopic, hyperopic and astigmatic eyes, the code has been equipped with a reshaping procedure based on standard and personalized ablation profiles. Besides the postoperative shape of the cornea and the final effective refractive power, numerical results provide the pre-postoperative stress distribution, of primary importance in refractive surgery planning of problematic or degenerated corneas.

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