Friedrich-Alexander-Universität Erlangen-Nürnberg

Seminar über Fragen der Mechanik

zu folgendem Vortrag wird herzlich eingeladen

Montag, 04.04.2011, 13:00 Uhr, Egerlandstr. 5, Raum 0.044

Computational Model of Tissue in the Human Upper Airway

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Obstructive Sleep Apnoea (OSA) is a pathological disease that afflicts a large portion of the population. The condition involves a partial or complete blockage of the upper airway, resulting in a restless sleep and, ultimately, an multitude of severe and potentially life-threatening medical ailments for suffers. There are many mechanisms and factors involved, and computational modelling provides a unique insight into the causes of flow blockage.

In order to research the OSA Syndrome, an anatomically accurate model of the human upper airway (HUA) has been constructed. Geometry from the female subject of the Visible Human Project was extracted using commercial software. This data was used to reconstruct a three-dimensional model of the tongue, soft-palate and oropharynx. In addition to macroscopic structures, the underlying histology of each muscle group was extracted.

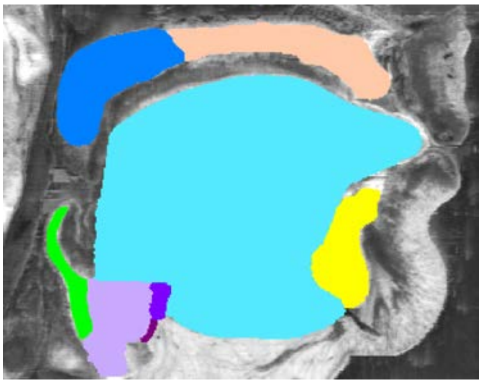

Figure 1: Anatomy extraction

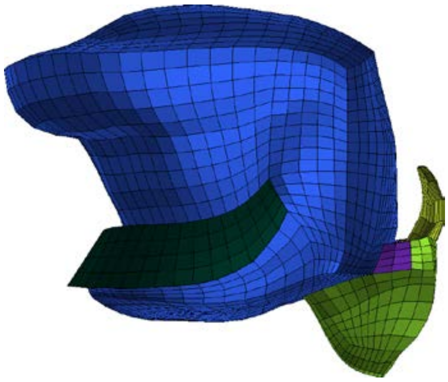

Figure 2: Geometry reconstruction

A computational model of the geometry has been developed to observe the deformation of the soft-tissue due to internally generated and external forces. A fully nonlinear quasi-static finite element model (FEM) was developed using deal.II, an open-source FEM library. The incompressible nature of biological materials has been accounted for. A frictionless contact algorithm has been included to model sliding contact between the tongue, hard-palate, epiglottis and uvula. The nonzero stress state in the initial configuration is accounted for. Representative models for each tissue type have been developed. A comprehensive Hill-type model for muscle tissue that accounts for both the passive and active behaviour of muscles has been incorporated into the model. Extrinsic muscle groups are included as external entities in order to reduce geometric complexity.

Due to the histological and physiological complexity of the anatomy, describing the motion of the tongue is challenging. A neural input model has been developed to compensate for the scarcity of experimental data regarding the neural signals that control muscles in the HUA. The neural input model uses an open-source genetic algorithm (GA) library to control the level of activation of specific muscle groups based on preset criterion. Using the GA, control over the time-dependent position of the tongue is achieved.

Current investigations demonstrate the role of sleeping position and airway pressure on the deformation of the various soft-tissues in the HUA. A comparison is made between experimentally attained EMG data and that derived from the numerical investigation.

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