GEOSEMINAR

Image Guided Modeling of Brain Tissue

by

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Abstract

This work proposes a new approach for modeling mechanical behavior of the in-vivo human brain tissue for applications in therapy and neurosurgery. We call this approach Image Guided Constitutive Modeling (IGCM). Its importance arises from the fact that image guided neurosurgery is mainly based on pre-operative (non-deformed) images of brain, in spite of the fact that the brain undergoes considerable deformations when the skull is opened. Such deformations strongly affect many high-risk neurosurgical operations and in some cases lead to fatal results. Applications of IGCM include subdural electrode placement in epilepsy surgery, brain shift compensation during craniotomy, needle guidance during brain biopsy, and simulating specific complicated neurosurgical procedures before performing them on real patients or for the purpose of training surgeons.

IGCM consists of defining the mechanical properties of the brain tissue in-vivo by taking the MRI or CT images of a brain response to ventriculostomy – the relief of the elevated intracranial pressure. Then, based on 3-D image analysis, the displacement fields are recovered from these images. Using inverse analysis and a robust numerical method allowing for reliable computations of large strain deformations, constitutive parameters of the brain tissue are determined. In this work, the IGCM approach is tested in controlled laboratory experiments with silicone brain models mimicking the in-vivo brain geometry, mechanical properties, and boundary conditions. The ventriculostomy was simulated by successively inflating and deflating internal cavities that model cerebral ventricles. The obtained CT images were analyzed to determine 3-D displacement fields, meshed, and incorporated into a finite element code. The subsequent inverse analysis allowed for determination of the hyper-elastic (neo-Hookean) constitutive parameters of the brain model material. The obtained mechanical properties have been verified with direct laboratory tests.

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Cem obtained his M.S. degree in CE from Georgia Tech in Dec 2006. Prior, he worked as a research assistant in Civil Engineering and Applied Mathematics departments at Middle East Technical University (METU). He has been working under the direction of Professor Germanovich.