Image Based Computing for the Planning of Radio-Frequency Ablation

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Radio-frequency (RF) ablation is a minimally invasive therapy for primary tumors and metastases in the human body. It is applied to treat lesions in the kidneys, the liver, the lungs, and also in bones. A probe containing electrodes is placed into the malignant tissue. Upon connecting the probe to a generator, an electric current flows through the tissue. Consequently, the Ohm-resistance of the tissue causes the development of heat, which destroys the malignant cells.

The success of the treatment heavily depends on the local structure of the vascular system, and a variety of patient-specific properties of the tissue. Unfortunately, tissue properties of individual patients are not exactly known. Values used in simulations are mostly taken from ex-vivo experiments with animal organs. In the interest of the success of the therapy a thorough planning must be made, which yields an optimal position and orientation of the probe, and which takes these important patient-specific properties into account.

The talk focusses on various aspects of a numerical support for the planning of an RF-ablation. A system of partial differential equations (PDEs) is described, which models the underlying bio-physical processes. Due to the complicated boundaries and internal structures of the organs under consideration, it is particularly challenging to solve those PDEs with moderate numerical effort. We use a technique, which bridges the gap between image processing and simulation with PDEs: Using level-set functions to define the geometry and utilizing concepts from image processing and scientific visualization, the approach inherits the efficiency of image processing algorithms.

To take into account the uncertainty and errors associated with material parameters, we consider those to have distributions over certain ranges of possible values. Thus, the deterministic PDE model is generalized to a stochastic PDE model. An optimal probe placement can be obtained from the minimization of objective functions, which involve expectations of the stochastically distributed temperature profile.

Wednesday, February 13, 2008
5:30 pm, Reimar Lüst Hall, Conrad Naber Lecture Hall
Tea at 5:00 pm - All are welcome!