

Mathematical Topics in Virtual Medicine

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The speaker and his ZIB research groups “Computational Medicine” as well as “Medical Planning” have been collaborating with medical clinics for many years, establishing an efficient basis for patient-specific *Virtual Medicine*. In the course of this collaboration, the following typical three step procedure has evolved:

1. Mapping of the real clinical situation in the computer, i.e. building of a patient-specific *geometrical model* in necessary detail; this step includes many years of computer science development, essentially in the field of mathematical visualization; one of the outcomes is the worldwide distributed software package Amira.
2. Construction of a *virtual patient*, i.e. a patient-specific mathematical model, which usually involves partial differential equations (PDEs) describing the physiology within the body and the medical technology to be applied to the patient; this step comprises the development of efficient adaptive multigrid methods for the arising PDEs on the 3D geometry of the individual patient, which includes detailed challenging mathematics and algorithm development.
3. Therapy or operation *planning* for the virtual patient and return of the mathematical solution back to the real clinical situation; this step involves optimal control, basically PDE constrained optimization.

Among the many medical topics treated so far the following ones are selected:

1. therapy planning in *deep regional hyperthermia*, a recent cancer therapy which requires local heating of the tumor (easy), but no heating healthy tissue (difficult), a recent survey has been published in the 2012 issue of Acta Numerica,
2. operation planning in *cranio-maxillo facial surgery*, a survey has been published in AMS Notices,
3. *osteotomic surgery*, which is presently still at its start, since the underlying mathematical problems had turned out to be extremely hard, here publications on the mathematical theory appeared in recent years.

The talk will include movies and visualizations of real patients treated by our methods.