Real-time Optimization of Thermal Ablation Cancer Treatments

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Abstract:
Percutaneous ablation cancer treatments are performed by inserting a probe directly into or close to the tumor. The probe generates heat and destroys the cancerous tissue. Such treatments are becoming increasingly popular due to their potential to be applied to non-resectable tumors, as well as due to the localized nature of the treatment which minimizes the inflicted damage to surrounding healthy tissue and organs.
The problem can be formulated as a parametrized optimal control problem governed by a partial differential equation, the Pennes bio-heat equation. Our goal is to improve the accuracy and effectiveness of ablation treatments by developing reliable and computationally efficient simulations and optimization routines, which can be used not only preoperative in the planning phase, but also in real-time during the treatment. To this end, we employ the reduced basis method as a surrogate model for the solution of the optimal control problem and develop rigorous and efficiently computable a posteriori error bounds for both the optimal control and the associated optimal cost functional value. We present numerical results to confirm the validity of our approach.

Bio note:
Zoi Tokoutsi is a Marie Curie research fellow in the AdapTT European Industrial Doctorate (EID) program. AdapTT is a collaboration project between Philips Research, the RWTH University Hospital, and the AICES graduate school. The focus of the project lies on the development of biophysical models, experimental validation procedures, and the development of planning and guidance tools for radio-frequency based ablation treatments. Zoi is working on reduced basis methods for the construction of real-time efficient and quantifiably accurate surrogate models in ablation treatment planning. She is currently in the final stages of her PhD.

Zoi holds an MSc in Mathematics from the Free University Berlin, and a BSc also in Mathematics from the Thessaloniki Aristoteles University. Her research interests lie in Model Order Reduction, Mathematical Optimization, and Scientific Computing. She also has experience with Geometry Processing and Mathematical Visualization of Complex functions. She is co-author in one journal and two conference publications and one patent.

Within Philips, Zoi is collaborating with senior research scientists. In addition to her research work she is currently the committee chair of the Philips PhD Community. As part of the committee she organizes events that increase the visibility of PhDs within Philips and their networking possibilities.