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INVERSE PROBLEMS OF STATE ESTIMATION IN THE HYPERTHERMIA TREATMENT OF CANCER

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ABSTRACT In the medical literature, hyperthermia stands for the temperature increase of body tissues. In fact, there are records on the use of heat for treating diseases even by Hippocrates. For the treatment of cancer, the term hyperthermia is often used when heat is applied to make tumors more vulnerable to other kinds of therapy, such as radiotherapy and chemotherapy. When heat is solely used for the destruction of cancerous tissues, the treatment is denoted as thermoablation. However, within the context of this talk that is focused on bioheat transfer, the term hyperthermia will be used in a broader sense to denote the treatment of cancer from the temperature increase of tumorous cells, either as adjuvant to other therapies or not. With the advancement of nanotechnology, the localized hyperthermia treatment of cancer has gained great interest from the scientific community. By concentrating plasmonic nanoparticles in the cancerous tissues, cell damages can be inflicted mainly to the region of interest, ideally not affecting healthy cells surrounding the tumor. Computational simulations of the physical processes in the hyperthermia therapy are required to be performed under the effects of uncertain geometry and input data. At the same time, recent technological advancements can provide internal temperature measurements of tissues, which do also contain uncertainties. The information provided by the mathematical model for the physical problem and by the measurements can then be adjoined, for the better prediction of the dependent variables, through the solution of state estimation problems within the Bayesian framework of statistics. The class of Sequential Monte Carlo methods, usually denoted as Particle Filters, is nowadays the most general and robust for the solution of state estimation problems dealing with non-linear models and/or non-Gaussian distributions. In this talk, we present the application of different algorithms of the Particle Filter to state estimation problems in bioheat transfer, with focus on the hyperthermia treatment of cancer. The coupled formulations for the propagation of electromagnetic waves and for the bioheat transfer in the tissues are written as a stochastic state evolution model. Temperature measurements are supposed available at few points within the tissues, so that the inverse problem aims at the estimation of the temperature field in the region that contains healthy and tumorous tissues, these last ones loaded with nanoparticles. Results obtained so far with simulated measurements are quite promising, thus revealing that the proposed application of the particle filter may help medical doctors in the future to prescribe treatment protocols, as well as opens the possibility of devising control strategies, for the hyperthermia treatment of cancer.