Model identification in diathermy based on skin temperature

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Abstract: The knowledge of the distribution of temperatures inside the human body allows to assess the effect of a physical therapy on the internal tissues. There are different mathematical models to know this distribution, generally called bioheat equation [1]. They have parameters that represent the different physical processes involved. Usually, simulations are carried out, based on typical values obtained from databases or theoretical calculations [2]. These values show great variability, so that the results obtained are not reliable enough. In order to find better values , temperature measurements can be made on the skin. Thermographic cameras, which are well suited for these measurements, are available. Moreover, their image analysis software allows recording curves of temperature evolution over time. This is the data to be analyzed. The first step is to find the solution of the mathematical model based on given values of the parameters. In some simple cases, as 1D problems, it is possible to find analytical solutions [3]. Electromagnetic theory is necessary to model the heating of tissues by Joule effect [4]. More complicated cases are solved using numerical methods. It is common to use hybrid methods, where two methods are combined. First, the geometric coordinate are discretized and the problem is converted into a system of ODEs [5] [7]. From this solution, the temperature at the surface is selected, which must be compared with the actual data. To be able to perform this comparison and tune parameters, it is necessary to define a loss function and its sensitivity with respect to the parameters. Adjoint method is the most suitable for these computations[8]. Different methods of performing this optimization have been applied to bioheat equation. Some of them are based on the gradient concept[6]. Other methods are based on the randomness, such as Monte Carlo methods [9] or evolutionary algorithms [10] , which have greater robustness in ill-conditioned problems[11]. Several methods are considered: Hamiltonian Monte Carlo [12], Evolucionary Centers Algorithm [13] and BFGS[14]. Artificial datasets have been created, simulating the system and adding Gaussian noise. The original values of the parameters and their estimates have a very good agreement.

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