COMPLEX VARIABLE SENSITIVITY ANALYSIS OF THE RADIO FREQUENCY ABLATION PROCESS FOR CANCER TREATMENT

Juan Felipe Monsalvo Salazar*
Manuel Julio García Ruiz†

Applied Mechanics Research Group
EAFIT University, Medellín, Colombia

Abstract

The complex taylor series expansion (CTSE) method was suggested by Moler and Lynes [1], and Trapp and Squire [2] were the firsts to obtain a very simple expression to calculate the first derivative of real functions. We apply the CTSE method in the sensitivity analysis in radio frequency ablation (RFA) procedures, in which the temperature distribution has to be accurately predicted in order to apply proper temperature values to tumor tissue and to avoid unwanted damage of healthy one. For this reason the CTSE method was used to calculate local sensitivity of several variables involved in the process and to identify which ones impact the most on the tumor temperature distribution.

In this work we solve a basic 2D model of the RFA process modelled by the bioheat transfer equation, introduced by Pennes [3], and coupled with Joule heating equation. In the numerical example the CTSE method is compared with the finite difference method. The accuracy, robustness and step-size independence are the main advantages of the CTSE method presenting as only weakness the duplication of the degrees of freedom, impacting the computational cost. It was found that this impact is in a relation of one to four compared to a finite element code. However, the major feature is that the sensitivities are readily available for the analyst from step one of the simulation.

Keywords: Sensitivity analysis; Complex taylor series expansion (CTSE); Bioheat transfer equation; Radio frequency ablation (RFA)

References

[1] J. N. Lyness and C. B. Moler, "Numerical Differentiation of Analytic Functions," *SIAM Journal on Numerical Analysis*, vol. 4, no. 2, pp. 202–210, Jun. 1967.

[2] W. Squire and G. Trapp, "Using Complex Variables to Estimate Derivatives of Real Functions," *SIAM Review*, vol. 40, no. 1, pp. 110–112, Jan. 1998.

[3] H. Pennes, "Analysis of tissue and arterial blood temperatures in the resting human forearm," *Journal of applied physiology*, 1998.

*E-mail address: jmonsa13@eafit.edu.co
†E-mail address: mgarcia@eafit.edu.co