Cancer Detection via Electrical Impedance Tomography and Optimal Control of Elliptic PDEs: invitation to interdisciplinary research

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A new mathematical framework utilizing the theory of Partial Differential Equations(PDE), inverse problems and optimal control of systems with distributed parameters for the detection of the cancerous tumor growth in the human body is developed. The Inverse Electrical Impedance Tomography (EIT) problem on recovering electrical conductivity tensor and potential in the body based on the measurement of boundary voltages on the m electrodes for a given electrode current is analyzed. The variational formulation is introduced as a PDE constrained coefficient optimal control problem in Sobolev spaces. The novelty of the control-theoretic model is its adaptation to the clinical situation when additional "voltage-to-current" measurements can increase the size of the input data while keeping the size of the unknown parameters fixed. The existence of the optimal control and Fréchet differentiability in the Sobolev space along with optimality condition, and the convergence of finite-differences method is proved. Numerical analysis of the simulated 3D model example demonstrates that by increasing the number of input boundary electrode currents from m to m^2 through additional "voltage-to-current" measurements the resolution of the electrical conductivity of the body identified via gradient method in Sobolev space framework is significantly improved.