ADAPTIVE FINITE ELEMENT METHODS FOR NONCONTACT FLUORESCENCE TOMOGRAPHY

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Fluorescence optical tomography is novel and rapidly growing biomedical imaging modality, which exploits the deep penetration of near infrared light in tissue and molecularly targeting fluorescence agents, to locate diseased tissues in three dimensions. Mathematically, the fluorescence optical tomography problem is an inverse problem which involves the identification of coefficients of a coupled elliptic PDE system describing the propagation of NIR photons in tissue. The inverse optical tomography problem is typically cast as a nonlinear optimization and solved by Newton type methods. The computational expense of repeatedly solving the coupled elliptic system for generating image updates restricts the choice of discretization level employed. Further, since light rapidly attenuates by multiple scattering and absorption in tissue, the tomography problem for determining the concentration of a fluorescence agent in tissue is highly ill-posed, which also affects the choice of discretization level. In joint work with Wolfgang Bangerth at Texas A & M University, we have proposed novel dual adaptive finite element based strategies for high resolution (1mm) yet rapid (under 20 minutes) fluorescence optical tomography for large tissue volumes (approx. 1 Liter).
A promising application of adaptive FEM based fluorescence tomography is the identification of the lymph nodes draining from the primary tumor in breast cancer patients. Breast cancer predominantly spreads through the lymph system. Localization of fluorescently tagged cancerous tissue in the lymph nodes around the breast can guide the surgeon for resection. In addition, 3D imaging of cancerous tissue with suitably designed agents can also act as a tool for tracking the spread of the disease, and monitoring the response to therapy. In this talk, I will detail the development and implementation of adaptive finite element based fluorescence tomography algorithms, integration of the inverse algorithms with the noncontact frequency domain fluorescence imaging hardware, and demonstrate successful 3D image reconstructions of fluorescently tagged lymph nodes in a living large animal (Yorkshire Swine).