Comparative Study on 3D Modeling of Breast Cancer Using NIR-FDOT

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Abstract

Fluorescence Diffuse Optical Tomography (FDOT) uses Near Infra-Red (NIR) light to monitor physiological changes in internal organs. NIR light being less energetic in nature can be used for continuous monitoring of tumor infected biological tissue, neonatal brain and many such applications where high energy radiation can cause severe damage. In this paper, a comparative study on the 3D modeling (i.e. both forward and inverse model) of breast cancer using NIR-FDOT is discussed. Fluorescence diffuse optical tomography relies on the presence of fluorophore molecules in tissue that re-radiate fluorescent light after illumination by excitation light of a different wavelength. The reconstructed images demonstrated significant tumor contrast compared to typical endogenous optical contrast in breast. The forward model and the reconstruction are simulated using the Wave Optics Module of COMSOL Multiphysics® software. The forward problem of DOT, which involves obtaining of the radiance values of light at the boundary of the specimen (with known µa and µs values) after irradiating it with NIR radiation, can be described by the Radiative Transfer Equation used with diffusion approximation .This equation is represented in the form of an Helmholtz Equation in COMSOL Multiphysics®. A mesh model of human breast is created and the flux intensity values are modeled using FEM with the coefficients (quantum yield, molar extinction coefficient, etc.) obtained from the in-vitro studies. Where the values of the quantum yield and molar extinction coefficient obtained for an estrogen conjugate fluorescent dye are 0.144 and 6.25e5 M-1cm-1 respectively. Both the excitation (754nm) and emission (787nm) equations are inverted using iterative Levenberg-Marquardt method with Tikhonov minimization of measurement and calculated matrix. At the system level, a complete DOI setup consists of five functional blocks: the light source, imaging platform, photo detector, hardware controller, and signal processor. The signal processor is mainly a computer with various software, including mathematical models, signal processing algorithms and reconstruction methods. Simulations in COMSOL Multiphysics® were carried out to obtain the 3D forward and inverse model of breast cancer for multiple fluorescent inclusions. The fluorescent phenomenon in biological media is successfully simulated using COMSOL Multiphysics®.