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"INFORMATION TECHNOLOGIES IN MEDICINE AND BIOLOGY"

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"Simulation of a Molecular Imaging System based on Optoacoustic (Photoacoustic) Tomography"

ABSTRACT

Optical imaging techniques have been the primary tool for biological discovery mainly due to the rich molecular and functional information that they provide and also their non-ionizing nature. Optical imaging has been applied to extract information related to biological processes in cellular and sub-cellular level, as well as, to proteomics and gene expression. Due to multiple light scattering of visible and near-infrared light in tissue, traditional optical imaging suffers from low resolution as tissue depth increases. The recent development of optoacoustic (or photoacoustic) tomography has showcased the potential to overcome such limitations and allow high resolution deep-tissue imaging of optical contrast. Optoacoustic imaging is based on the principle of ultrasound signal generation when ultrafast light pulses are absorbed by tissue molecules. The amplitude of the generated ultrasound waves depends on both local light flux and optical absorption properties of the tissue. By recording emitted optoacoustic signals from tissue obtained by multiple projections, optoacoustic images of tissues can be produced through tomographic reconstruction. Combining optoacoustic imaging with the principle of spectroscopy, Multispectral Optoacoustic Tomography (MSOT) has been recently shown able to produce unique molecular and functional information by resolving for example the bio-distribution of optical absorbing agents (e.g. fluorescent dyes/probes, nanoparticles) in three dimensions (volumetrically) within deep tissue and in high resolution. The proposed optoacoustic imaging systems vary in terms of performance and detectability characteristics and can be influenced by a number of factors including the properties of the imaged tissue, the light source's and the ultrasound detector's specifications and also the selected reconstruction algorithm for the image formation. Simulation of an optoacoustic imaging modality can provide an accurate estimation of the contribution of these parameters in the final reconstructed optoacoustic image, acting also as a tool to optimize the whole imaging chain. The purpose of this study is the design and the implementation of a simulation pipeline for optoacoustic imaging systems, as well as the combination and the adaptation of simulation methods and their aspects through a validation with an experimental optoacoustic imaging system.

SUBJECT AREA: Biomedical Imaging, Simulation Methods

KEYWORDS: Optoacoustics, Photoacoustics, Tomography, Light propagation simulation, Acoustic wave propagation simulation.