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A theoretical study of medical imaging by optical tomography using a radiative transfer model

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Abstract

A new method for image reconstruction from optical tomography is developed.The radiative transfer equation is used to describe the photon propagation in participating media. The reconstruction method consists on two steps : - Development of a forward model based on the discrete ordinates method associated with a finite volume scheme. - The use of a downhill Simplex algorithm to perform a minimization of the objective function that provides values of the differences between the detected and the predicted data. The studied medium is a tissue-like medium. The scattering is modeled making use of the Henyey- Greenstein function. The accuracy of the proposed method is tested in a rectangular geometry. Some results are given using simulated data. In recent years there has been attempts to develop a diagnostic imaging modality based on near-infrared radiation . This new imaging modality is commonly known as optical tomography (OT). Changes in the optical properties are closely related to physiological and pathological changes of different tissues.The OT imaging process is based on the reconstruction of the distribution of optical properties inside a medium by using results of light-transmission measurements obtained on the surface. This provides information of human organs without having to draw upon surgery ; so this technique could be a good candidate to fulfilling conditions of a low cost, non-ionizing tomography method easily movable and even capable of on-line monitoring. Light-transmission measuring technology on human subjects is nowadays available. Then a crucial research task is to perform adapted algorithms that transform these measurements into medical images. It is established that the quality of reconstructed image depends on the accuracy of the model of photon transmission in human tissue-like media. One way to model propagation of near-infrared light is diffusion equation. It is an approximation of the photon transport equation in very high scattering biologocal tissue. Many of commonly known reconstruction algorithms are based on this approach. However low scattering regions in human body such as the cerebrospinal fluid of the brain, the synovial fluid of human finger joints and the amniotic fluid in the female uterus could be not accurately represented by this model. Also highly absorbing regions such as hematoma and liver tissue risk to be out of media concerned by diffusion

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approximation model.Therefore, for a general biological tissue-like medium, it is desirable to have a reconstruction method based on radiative transfer equation itself. Some works have been already developed concerning radiation inverse problem. A majority of these attempts has dealt with one dimensional geometry configuration. Other works have used very complicated algorithms such as GIIR methods that overcome some limitations but they demand a lot of derivative calculus.Monte Carlo methods have been also used in reconstruction problems based on radiative transfer theory but they risk to have high time-price. In this work we present a finite volume discrete ordinates method for the solution of the radiative transfer equation as a forward model. The reconstruction method is based on minimizing an objective function using a downhill simplex algorithm. This method requires only functions evaluation , not derivatives. Some results are given from simulated data for media with varying scattering coefficients.

Key words: Optical tomography - Radiative Transfer Equation - Discrete Ordinates Method - Simplex Algorithm - Medical Imaging.
