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Compensating for Variable Acoustic and Optical Properties towards Quantitative Photoacoustic Tomography

Photoacoustic tomography (PAT) is a noninvasive, high-resolution imaging modality, capable of providing functional and molecular information of various pathologies such as cancer. In PAT imaging one optical limitation is the attenuation effect depth has on fluence and therefore the generation of PA signals from deeper regions of tissue. This makes it impossible to equally compare signals from various depths. In addition, most ultrasound and photoacoustic image reconstruction algorithms assume a homogeneous speed of sound distribution. This leads to a mismatch between the true location and size of the object and what the reconstructed image shows. This mismatch also plays a role in how effective and accurate fluence compensation can be. Since light diffusion is not affected by acoustic properties and the PAT image is, this leads to inaccuracies when fluence compensation is applied. In this study we investigate using a model-based method, that employs Monte Carlo light (MCXCL) and acoustic wave propagation (K-wave) simulations, to demonstrate the benefits of fluence compensation, in addition to the affect speed of sound correction has on fluence compensation. To generate our results we numerically modeled a full-ring illumination and ring-based acoustic detection system that our group has been developing. This model was then used to run an experiment that looked at a numerical phantom which was designed to test the affects of depth, concentration, and varying speed of sound on PAT image reconstruction. Our results indicate improvements in PAT optical fluence compensation and more importantly the feasibility of achieving qPAT images.

Authors: PATTYN, Alexander; Mr MUMM, Zackary (Wayne State University); Dr MEHRMOHAMMADI, Mohammad (Wayne State University)

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