DOCTORAL DISSERTATION DEFENSE

Solutions for Clinical Problems of Near Infrared (NIR) Light Imaging Reconstruction with Ultrasound Localization

By

Chen Xu

Advisor: Dr. Quing Zhu
Associate Advisors: Dr. Yaakov Bar-Shalom, Dr. Monty Escabi, Dr. Martin Fox, and Dr. Rajeev Bansal.

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Abstract:
Diffuse optical tomography (DOT) using near infrared (NIR) light has a great potential for non-invasive imaging and monitoring tumor angiogenesis development. In recent years, the Optical and Ultrasound Imaging Lab at University of Connecticut has developed a dual-modality technique, which utilizes co-registered ultrasound images to guide the optical image reconstruction. We collected data from over hundreds of patients, and obtained promising initial results. This dissertation focuses on challenges encountered in the clinical experiments and provides possible solutions.

First, we discuss a problem related to imaging shallow targets or breast lesions. Imaging shallow lesions of less than 1.0-1.5 cm in depth with DOT in reflection geometry is a challenge. To solve this problem, we have designed a new probe which incorporates reflection geometry with either reflection boundary condition or absorption boundary condition to improve the illumination of the shallow region. Simulation, phantom experiments and patient data have shown improvement in reconstruction accuracy of targets.

In NIR experiments, the chest-wall layer underneath the breast tissue introduces distortion to near infrared diffused wave measured at distant source-detector pairs. The distorted measurements produce image artifacts. Two methods are proposed to solve this problem. The first method is using a priori chest-wall layer depth information obtained from co-registered real-time ultrasound to assist the removal of distant measurements. The second method is using a two-layer analytical solution to reconstruct optical images.

At the end, we discuss the shadow effect of highly-absorbing larger targets. For deeply located, highly absorbing large tumors, we have found that the reconstructed absorption values and the resulting total hemoglobin concentration are highly dependent on depth. We call this “light shadow effect”. A Monte Carlo method is used to simulate the photon trace inside the medium. The results indicate that the photon group which passes through the bottom part of a large target is much smaller than the photon group which passes through the upper part of a large target. The shadow effect, which is similar to the sound shadow effect frequently seen in pulse-echo ultrasound images, is an intrinsic problem of optical diffuse tomography.