Assessment of Diffuse Optical Tomography Image Reconstruction Methods Using a Photon Transport Model

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Introduction: Imaging of tissue with near-infrared DOT is emerging as a practicable method to map hemoglobin concentrations within tissue for breast cancer detection. The accurate recovery of images by using numerical modeling requires an effective image reconstruction method. We illustrate a comparison between two widely used reconstruction methods (Born approximation [1,2] and NIRFAST [3,4]) using finite element modeling in COMSOL for 3D forward data generation.

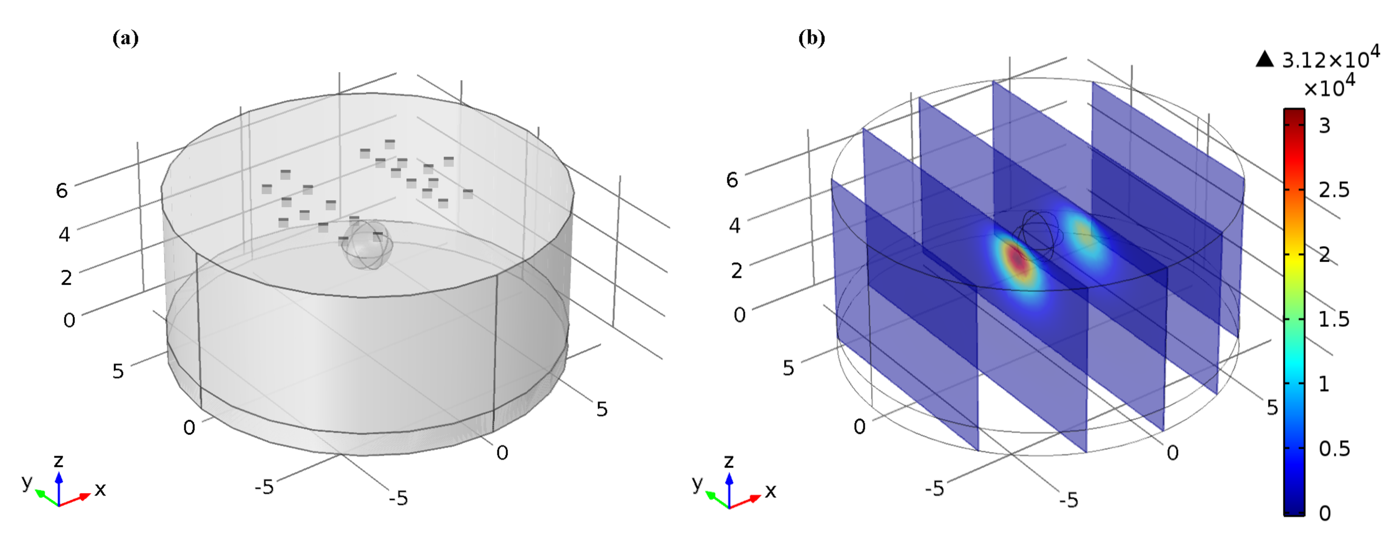


Figure 1. (a) Geometry. (b) Simulated fluance of one source.

Computational Methods: A 3D model was defined in COMSOL using *Helmholtz Equation* in the frequency domain [5] with proper boundary conditions, subdomains, and mesh size as shown in Fig. 1. COMSOL's Helmholtz Equation is expressed as :

$$\nabla.(-c\nabla u) + a\, u = f$$

where "u" is the photon density, "c" is the diffusion coefficient (isotropic), "a" is the absorption coefficient, and "f" is the source term. A cylinder was employed in COMSOL to simulate the semi-infinite breast model (Fig. 1.a). Nine light sources and fourteen optical detectors were utilized to estimate the fluence. The extracted fluence from our COMSOL model was employed to map the absorption coefficient using image reconstruction methods.

Results: A comparison between two DOT image reconstruction methods is presented in the following two graphs and table:

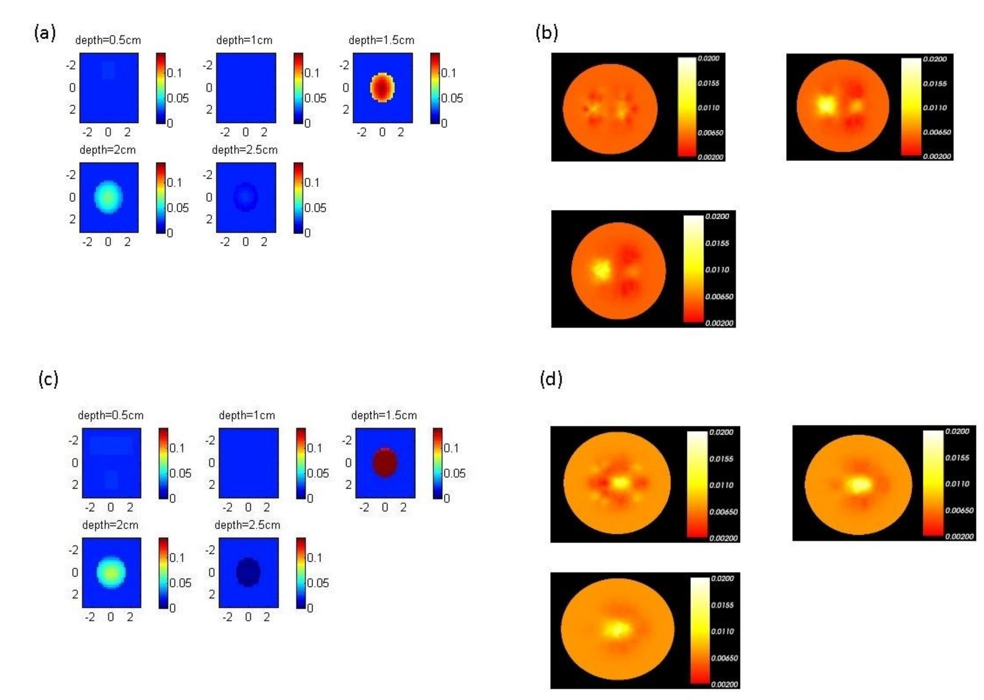
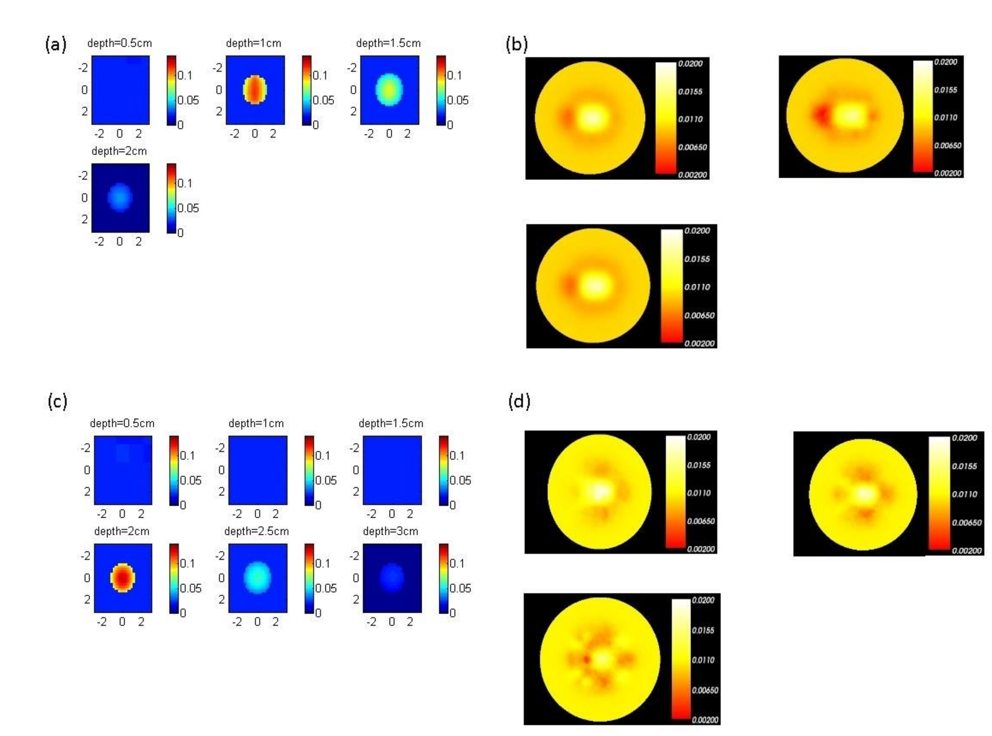


Figure 3 Born Approx., (a & c), and NIRFAST, (b) and (d). Target diameters 1.5cm (1st row) & 2.5 cm (2nd row)

Figure 4 Born Approx., (a & c), and NIRFAST, (b) and (d). Target depths 2cm (1st row) & 2.5 cm (2nd row)



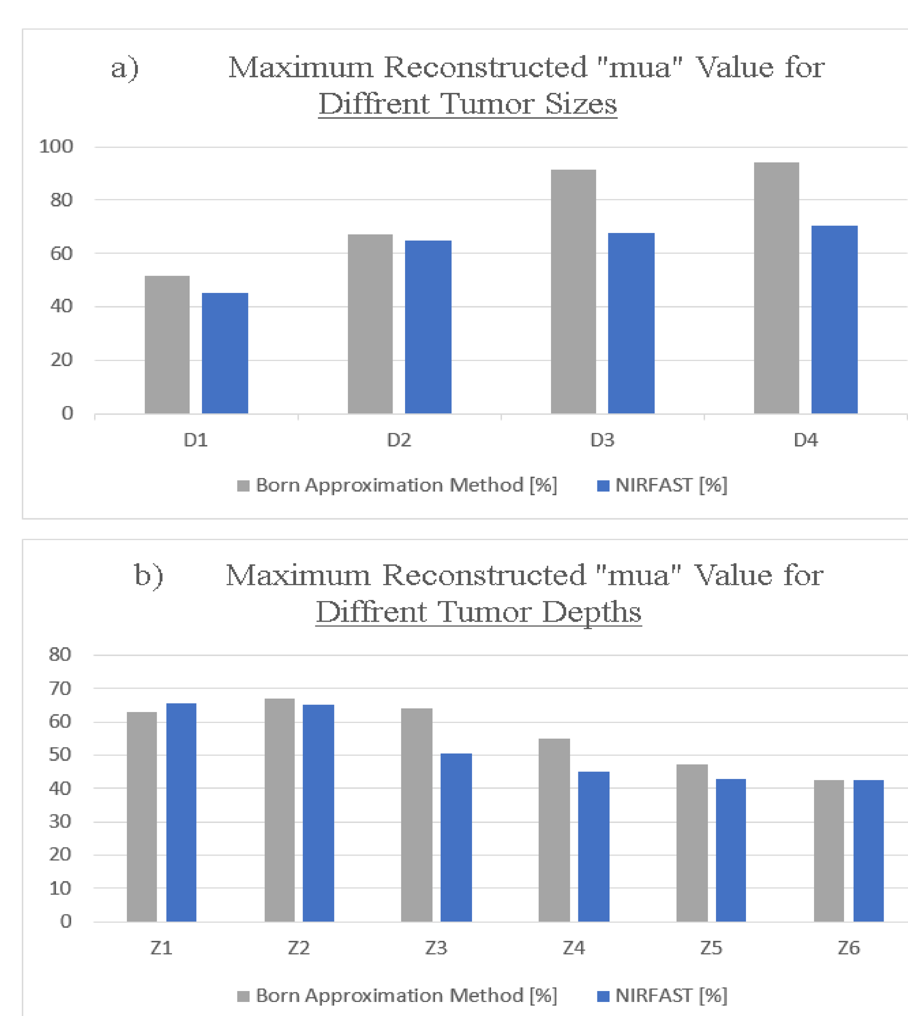


Table 1.
% of the max reconstructed "mua" value to true value, 0.2 cm-1.For (a) different target sizes.
(b) different target depths.

Conclusions: For large targets, both methods provide similar results. However, for smaller targets Born Appr. provides better contrast.

References:

1. Q. Zhu, C. Xu, PY. Guo, A. Aquirre, B. Yuan, F. Huang, D. Castilo, J. Gamelin, S. Tannenbaum, M. Kane, P. Hedge, and S. Kurtzman, Optimal probing of optical contrast of breast lesions of different size located at different depths by US localization, *Technology in Cancer Research & Treatment* 5(4), 365-380 (August 2006)
2. M. Huang and Q. Zhu, A Dual-mesh optical tomography reconstruction method with depth correction using a priori ultrasound information, *Applied Optics* 43(8), 1654-1662 (2004)
3. M. Jermyn, H. Ghadyani, M.A. Mastanduno, W. Turner, S.C. Davis, H. Dehghani, and B.W. Pogue, Fast segmentation and high-quality three-dimensional volume mesh creation from medical images for diffuse optical tomography, *Journal of Biomedical Optics*. 18 (8), 086007 (August 12, 2013)
4. H. Dehghani, M.E. Eames, P.K. Yalavarthy, S.C. Davis, S. Srinivasan, C.M. Carpenter, B.W. Pogue, and K.D. Paulsen, Near infrared optical tomography using NIRFAST: Algorithm for numerical model and image reconstruction, Communications in Numerical Methods in Engineering, Vol. 25, 711-732 (2009)
5. L. V. Wang and H.-i Wu, Biomedical Optics: Principles and Imaging (Wiley, 2007).

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