

A Performance Comparison between Continuous-Wave and Time-Domain Diffuse Optical Tomography for Deep Inclusions by Using Small Source-Detector Separations

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Continuous-wave (CW) is the most widely used and commercially available technique for performing biomedical diffuse optics tomography. Nevertheless, CW has been proved to suffer from non-uniqueness [1] problems and large source-detector distances have to be used in order to detect inclusions that are deep from the surface. In order to overcome the former drawback frequency-domain approach has been developed although it also suffers from the latter deficiency. Recently, time domain (TD) diffuse optics has attracted huge interest from the scientific community due to its inherit capacity to associate photons arrival time with the maximum depth that they have reached ; the late arrival photons are the photons that have travelled most and presumably have gone deeper in the tissue. Moreover, not long ago it was proved that in TD there is no need of large source-detector distances for the reconstruction of deep layers of human tissue ; in fact small source-detector separations (s.d.s.) improve the contrast and the absolute number of detected photons [2]. However, no comparison analysis has been done in terms of reconstruction quality when using small s.d.s.

In this work finite element method is used to do a computational comparison between CW and TD approaches where special emphasis is put on the quality of reconstructions 1) with an inclusion at deep levels and 2) when using small s.d.s. TD reconstructions were done using Mellin-Laplace (TD-ML) transform which is fast to calculate and stable to noise [3]. For the experiments, synthetic computationally generated data was used which was convolved with a single-photon avalanche diode detector instrumental response function. Reconstructions for an inclusion are shown in Figure 1 where TD-ML with multiple source-detectors clearly performs better than CW in spatial localization and quantification terms. Moreover, TD-ML with just a couple of source-detector, located above the inclusion and with a small separation between them gives relevant localization information and even better depth estimation than CW.

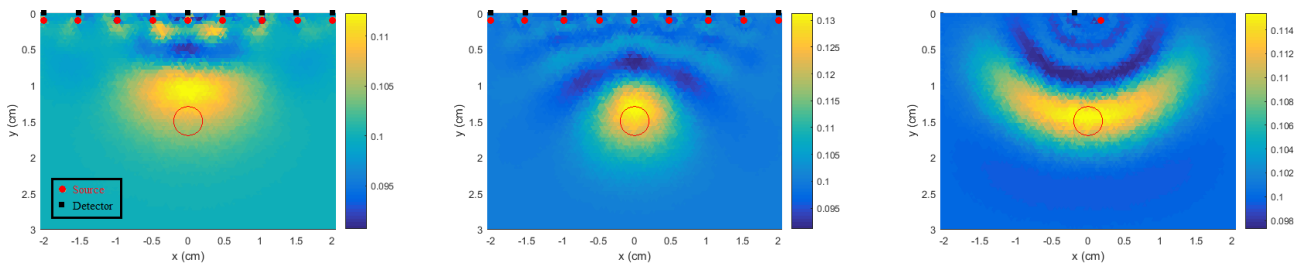


Fig. 1: (Left) Reconstruction using CW with multiple source-detectors. (Middle) Reconstruction using TD-ML transform (10 moments and $\rho = 6$) with multiple source detectors. (Right) Reconstruction using TD-ML transform with just a couple and small s.d.s. (0.4 cm). The background of the medium is $\mu'_s = 10 \text{ cm}^{-1}$, $\mu_a = 0.1 \text{ cm}^{-1}$, $n=1.4$ with an inclusion at 1.5 cm depth, $\mu'_s = 10 \text{ cm}^{-1}$, $\mu_a = 0.2 \text{ cm}^{-1}$ and 0.25 cm radius.

REFERENCES

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