Simultaneous reconstruction of optical parameters and complex coupling coefficients in optical tomography

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Abstract

We present a robust method for the reconstruction of absorption and scattering parameters in optical tomography in the presence of unknown coupling losses associated with both the light delivery and collector fibres. Such losses commonly occur in practical data acquisition systems due to air gaps, hair or moisture between the fibres and the surface of the body, and due to transmission losses in the fibres themselves. If such data-specific perturbations are not taken into account in the reconstruction process, they can lead to severe image artefacts.

We propose a method of simultaneously recovering the unknown coupling coefficients together with the reconstruction of the absorption and scattering images. The algorithm extends the solution space from dimension $2N$ to $2N + 2(Q + M)$, where N is the dimension of the image basis expansion, and Q and M are the number of source and detector sites.

We present reconstructions from simulated frequency domain data contaminated with coupling losses in both modulation amplitude and phase components. The nonlinear reconstruction algorithm employs a Gauss-Newton scheme with line search and an efficient Krylov linear at each step. Our results show that the inclusion of the coupling coefficients in the reconstruction process significantly improves the performance of image recovery.