ABSTRACT

Diffuse optical tomography (DOT) is a non-invasive imaging modality that reconstructs the optical parameters of a highly scattering medium. However, the inverse problem of DOT is ill-posed and highly nonlinear due to the zigzag propagation of photons that diffuses through the cross section of tissue. The conventional DOT imaging methods iteratively compute the solution of forward diffusion equation solver which makes the problem computationally expensive. Also, these methods fail when the geometry is complex. Recently, the theory of compressive sensing (CS) has received considerable attention because of its efficient use in biomedical imaging applications.

In this, the DOT inverse problem has been formulated as an single measurement vector (SMV) and multiple measurement vector (MMV) DOT reconstruction problem by using compressive sensing framework and joint sparsity. Greedy algorithms such as orthogonal matching pursuit (OMP), compressive sampling matching pursuit (CoSaMP), and stage wise orthogonal matching pursuit (StOMP), regularized orthogonal matching pursuit (ROMP) and simultaneous orthogonal matching pursuit (S-OMP) have been tested for reconstruction of the change in the absorption profile. We have also applied the conventional DOT methods like least square method and truncated singular value decomposition (TSVD) for comparison. A modified compressive multiple signal classification algorithm (CS-MUSIC) has been proposed for diffuse optical tomography reconstruction and compared its performance with other algorithms such as multiple signal classification (MUSIC), CS-MUSIC, and subspace augmented multiple signal classification (SA-MUSIC).

We have also studied the subspace based CS-MUSIC for DOT reconstruction using the simulated geometry. The sparse recovery algorithms have also been studied using the circular geometry. The experimental validation of the greedy algorithms, modified CS-MUSIC, and sparse recovery algorithms have been done for the rectangular and circular wax phantoms. We have also shown the finger joint imaging and fruit quality assessment as an application to DOT. The performance metrics such as mean square error (MSE), normalized mean square error (NMSE), structural similarity index (SSIM), object centroid error (OCE), and peak signal to noise ratio (PSNR) have been used to evaluate the performance of the DOT reconstruction. Extensive simulation results confirm that CS based DOT reconstruction outperforms the conventional DOT imaging methods in terms of computational efficiency. The main advantage of this study is that the forward diffusion equation solver need not be repeatedly solved.

Keywords:

Diffuse optical tomography (DOT), compressive sensing, single measurement vector (SMV), multiple measurement vector (MMV), greedy and sparse recovery algorithms, joint sparsity.