ABSTRACT

Diffuse Optical Tomography is non-invasive, non-ionizing, portable, economical and secured biomedical imaging technique in Near-infra-red light. This imaging modality promotes the functional imaging of soft biological tissues namely the brain and breast. The diffuse optical tomography facilitates to reveal the morphological information of fibrous and muscular tissue lying underneath the blood vessels in brain and breast. The Near-infra-red light ranging (700nm-1000nm) illuminates the brain or breast and the diffuse transmitted light is collected at the tissue surface.

In this thesis, a diffuse optical tomography experimental design with placement of laser sources and detectors along the tissue boundary are modeled as forward model. The scattered rays are measured by using avalanche photo-detector signals, since they dominate the tissue medium. The detector signal is processed to produce the attenuation or the depth of penetration of the laser source signals in the phantom. The absorption and scattering signals for different tissue volume and area was determined. The optical flux or fluence rate of the phantom was analyzed in different boundary conditions using boundary element method. Thereby, the soft tissue optical property was extracted with diffuse reflectance, which defines the reflectance outside the tissue boundary. On evaluation of the soft biological tissue optical properties, based on absorption and scattering coefficient value the normal and cancer patient identification is performed on actual measured data.

This thesis also developed an optimized model of the instrumental setup adopting Response Surface Methodology, in order to reduce all possible errors in the measured reading. Analysis of Variance model developed using Box-Behnken Design is significant. It states that spacing of the sources,
detectors and wavelength are prudential factors for image contour reconstruction. The regression method states that the error percentage values between the predicted and experimental values.

The thesis improved the experimental analysis with numerical solution in the case of forward model diffuse optical tomography system. The solution of forward model was obtained by solving the diffusion equation using Finite Element Method (FEM). Forward Model was evaluated with various angular and spacing arrangements of laser sources and detectors in NIR wavelength.

In this thesis, an improved regularization method was applied to remove the measured non-linear data. Stein’s Unbiased Risk Estimate (SURE) regularization increases the resolution of the reconstructed image. The Mean Square Error (MSE) is approximately nearer to SURE estimate which satisfies the condition to obtain the best estimate of the input non-linear data.

This thesis also extends to build a computationally efficient reconstruction algorithm to improve the speed and accuracy of the process. The performance of image reconstruction using Split Bregman method was compared with existing Gauss Newton algorithm. The reconstructed images were analyzed by using image segmentation algorithms such as Fixed Grid Wavelet Network (FGWN), Graph Cut Algorithm (GCA) and Genetic Algorithm (GA).