CHAPTER 6
CONCLUSION AND FUTURE WORK

This thesis presents a comprehensive study of the most significant choice when implementing the experimental set-up of DOT and solving numerically. DOT designed module is essential and cost effective in today’s biomedical imaging techniques. Detection of soft tissue sarcoma in brain and breast were diagnosed, based on the clinical results of the tumor patient. The DOT system solves the forward problem of cross-talk occurring between the sources and detectors by the selection of optimal distance. The regression model using ANOVA (Analysis of Variance) provides 95% of significance level which maximizes the signal extraction from the soft tissue. Therefore, the quantitative accuracy is improved in predicting the physical properties of the tissue.

The numerical solution of the DOT, includes mesh resolution, reconstruction basis and a number of measurements on the reconstructed optical image quality. The optimal computational parameters for 2D optical imaging were estimated through this analysis. The image domain sensitivity is greater near the boundary compared to the interior, leading to less accurate recovery in the interior imaging domain. The spatial resolution is improved by sparsity reconstruction using Split Bregman method by localization of the inclusion. The SURE regularization removes the ill-posed problem as the MSE approaches the SURE estimate, therefore the de-noising is predominant.
Tumor volume boundary detection investigated by FGWN segmentation, is advantageous due to its ortho-normal property.

6.1 CONTRIBUTIONS TO RESEARCH

[1] DOT Module Design:

The DOT experimental set-up was designed using six pairs of laser diodes OPV310 (850nm) and D7805I (780nm) along with six avalanche photo-detectors OPT101. The NIR light incident on the soft tissue is absorbed and scattered. These scattered rays are detected by the avalanche photodetector. The statistical model using regression method explicitly is ANOVA (Analysis of Variance) which optimizes the forward model. It maximizes the tissue optical flux on the basis of the input parameters such as DC bias voltage applied to the laser diodes and distance between the sources and detectors. The analysis of ANOVA using Box-Behnken method produces optimum values with 99% of desirability range. Deviation of optical coefficients from optimum value is evaluated by error percentage. The error percentage is found to be 0.2 for mua and mus, which is the least one compared with existing systems.

[2] Soft tissue property extraction:

Forward design module is used to provide the photo-detector voltage on the sources of scattering. Based on the photo-detector voltage, optical parameters such as absorption coefficient, scattering coefficient, optical flux and diffuse reflectance were manipulated. The fluence rate was solved in three different boundary element conditions specifically in semi infinite, infinite and layered medium. The reflected ray from the boundary of the geometrical structure contributes to diffuse reflectance.
The large size of bedside equipment is not required for carcinoma cell detection. Instead, a hardware kit with head band predicts the tumor based on absorption and scattering coefficient. Image reconstruction is another module lacking accuracy and time consuming algorithms and therefore, this module can be eliminated since the carcinoma cell detection is analyzed at signal level with optical parameters namely absorption coefficient, scattering coefficient, optical flux and diffuse reflectance. The determination of optical coefficients further leads to error percentage computation. Error percentage of two frequently used NIR wavelengths 780nm and 850nm are found to be in the range of 0.58 to 0.1, which is minimum one compared with the existing system. Clinical diagnosis of tumor patient was tested with our DOT module to predict the presence of tumor with harmless effect.

[3] Numerical solution of forward and inverse model:

Forward model simulation was performed along with the numerical analysis for DOT image reconstruction. The performance of the proposed system was evaluated, based on the cancer patient optical coefficient measurement. The numerical solution of the forward model affords an indispensable solution for non-linear structures using FEM. The diffusion approximation equation solved using FEM, creates the tissue boundary envelop with discrete tissue elements. Meshing the spherical tissue with angular boundary elements in homogeneous medium predicts the accurate optical flux also in robust conditions.

Inverse model reconstructs the phantom image from solution of fluence rate. The measured value flux compared with the standard tissue flux is numerically solved using standard reconstruction and sparsity reconstruction. Levenberg-Marquardt regularization used in standard reconstruction is capable of reconstructing the phantom boundary. Split Bregman regularization used in sparsity reconstruction provides de-noising
using shrink function. The inclusions in geometric structure are efficiently reconstructed along with localization in the internal regime by big anisotropy factor g.

[4] **Regularization and DOT image Segmentation:**

To solve the ill-posed problem in order to improve the spatial resolution and qualitative accuracy of DOT images, various regularization schemes are employed. The standard regularization or Tikhonov regularization is frequently used $l_1$ regularization method. The exponential is a basic sparsity regularization scheme which reconstructs the tumor boundary efficient with high scattering coefficients. Adaptive regularization locates the tissue boundary or inner most part of the soft tissue. The penalty term or regularization term can be varied, based on the projection error. In model based regularization, the modeled data is matched with observed data using linear regularization term improving the spatial resolution. In our DOT module, SURE regularization is introduced. Choosing an optimum regularization factor, the noise is removed as MSE (Mean Square Error) is small and it approaches to the SURE estimate. The SNR (signal to noise ratio), CNR (Contrast to Noise Ratio) and ROC (Receiver Operating Characteristics) proves to construct high de-noising DOT images using SURE regularization. To detect the boundary of the tumor and extract the soft tissue sarcoma volume, FGWN (Fixed Grid Wavelet Network) is adopted. FGWN is efficient as the number of iteration levels is reduced by the ortho-normal property. The Mexican hat wavelet filtering removes the noise and the FGWN estimates the image parameters. The performance of FGWN is compared with Genetic Algorithm (GA) and Graph Cut Algorithm (GCA).
6.2  FUTURE WORK

The future work is to develop a compact DOT instrument in the form laser torch which is economical to detect the soft tissue sarcoma at cellular level depending on the physical properties of the tissue.

The forward model measurements are numerous to obtain a smooth high quality DOT images. The experimental set-up converted into a device with minimum error promotes the optical parameter measurements at higher rate.

The absorption, scattering and optical flux accuracy is a major factor to determine the tumor diagnosis at cellular level. The forward model with linear data after regularization provides high speed of image reconstruction in a homogeneous region. In heterogeneous soft tissue structure the image reconstruction is difficult without the priors.

Inverse model image reconstruction algorithms must be enhanced at a higher speed of 3D phantom image reconstruction. This process can be accomplished by developing an image reconstruction processor.

The 3D imaging system at cellular level based on hemoglobin, oxyhemoglobin, water and lipids with the help of scattering and absorption coefficients predicts the presence of tumor and avoids biopsy present in today’s clinical method analysis.

To enhance the spatial resolution in DOT systems, we can adopt hybrid-optical imaging systems. Forward model FEM accuracy is high but complex in continuous 3D tissue structures. 3D patient imaging system and phantom data need to be explored more extensively and a detailed investigation might lead to the refinement of the method to specify the patient imaging systems.
6.3 SUMMARY

This chapter discloses the future work to broaden the contributions presented in this thesis. The future work could further improve the results of forward model device and inverse model algorithms. Another area of future work is to make the contributions of the thesis available to both patients and health care professionals.