CHAPTER 6

CONCLUSION AND SCOPE FOR FUTURE WORK

In this chapter, the conclusions of the thesis are stated and the scope for future research has been discussed.

In section 6.1, the concluding remarks are presented chapter wise and in section 6.2, the possible scope for future work has been stated.

6.1 Main Conclusions of the thesis

The research contributions and research achievements of this thesis are as follows:

Chapter 1 discussed the introduction, motivation and problem description for the presented work including thesis scope/objectives, and contributions. Finally, the chapter concludes with the organization that describes the coverage of chapter in the thesis.

Chapter 2 discussed the theoretical background related to medical image reconstruction. It gives an overview of the physics, geometries of imaging systems, more specifically generation and detection techniques. The basic concepts of ill-posedness, ill-conditioned problems in reconstruction methods and the formulation of various reconstruction problems are also discused. A brief discoussion about the state-of-art of SIR image reconstruction techniques used in various medical imaging modalities like CT/PET/SPECT etc. is also presented. Further, in the last section of the chapter qualitative analysis and behavior of these reconstructions algorithm are provided. Analysis of different simulated test phantoms and standard digital test image are also presented for quantitative analysis.

In **Chapter 3**, various priors have been studied. This chapter focuses on improving statistical iterative reconstruction algorithms by incorporating a suit-

able prior knowledge of the object being scanned. Some statistical maximum likelihood (ML) based approach for CT, PET, and SPECT image reconstruction methods are proposed. The proposed method investigates and presents various choices of regularization priors used in standard SIR reconstruction methods like MLEM, MRP, and OSEM in literature. Experimental analysis has been performed over own created mathematical test phantoms and benchmark Shepp-Logan head phantom plus real thorax test phantom. The results have been compared with existing methods using six quantitate measures that are signal-to-noise ratio (SNR), the root mean square error (RMSE), the peak signal-to-noise ratio (PSNR), the correlation parameter (CP), and mean structure similarity index map (MSSIM).

In **Chapter 4**, we have discussed the major drawbacks associated with statistical iterative reconstruction algorithms include the problem of slow convergence, choice of optimum initial point and ill-posedness. To alleviate these issues, in this chapter, we have proposed three different hybrid-cascaded efficient frameworks for MLEM, MRP and OSEM based SIR reconstruction algorithms. The proposed framework is based on two consecutive modules viz. Primary and secondary. We have performed experiments over three different simulated mathematical test phantoms and one standard thorax image. The results have been evaluated and compared with existing methods in terms of visual analysis as well as quantitative analysis using SNR, PSNR, RMSE, CP, and MSSIM performance measures. Hence, in the last section of the chapter, after comparison with all three proposed methods, we have concluded that OSEM based efficient hybrid-cascaded framework which is an accelerated version of MLEM performs better with the projection data which dedicated to PET and SPECT imaging scanner.

Chapter 5 presented a low dose image reconstruction method for computed tomography (CT). The theoretical background, issues and challenges of low dose CT reconstruction are discussed. To address the issues in this chapter, we have proposed a statistical sinogram restoration models for low dose CT reconstruction. To examine the efficacy and usefulness of proposed models an appropriate qualitatively and quantitatively analysis using simulated test phantom and standard digital image. The obtained results justify the applicability of the proposed method.

Finally, the overall conclusion of the thesis is being summarized as follows:

- To investigated and presented the quantitative analysis of various regularization priors available in reconstruction literature to deal with the problem of ill-posedness and recommendation for selecting an appropriate prior to be used with MLEM and its variants.
- Proposed a new PDE based variational approach for MLEM algorithm using Euler-Lagrange minimization technique for medical image reconstruction.
- Developed and implemented a regularized statistical approach for CT/PET/SPECT image reconstruction. The improvement that we aim is related to both speed of reconstruction and the quality of the obtained image.
    - a new family of statistical algorithms was proposed for PET/SPECT image reconstruction;
    - the algorithms were tested and validated on synthetic data;
    - a comparative study of proposed method with the state-of the-art reconstruction methods: SART, MLEM, MRP, and OSEM.
- Design and Development of a new efficient hybrid-cascaded framework for medical image reconstruction. Following frameworks are presented and experimental results are carried out:
    - a flexible generalized framework using SIR methods for PET/SPECT image reconstruction. (General Model)
    - an efficient framework for MLEM based SIR method. (Model-1)
    - an efficient framework for MRP based SIR method. (Model-2)
    - an efficient framework for OSEM based SIR method. (Model-3)
    - validate the results on simulated phantom and real data image.
    - a comparative study with state-of-the-art PET/SPECT reconstruction methods

After, critically comparing the results of all three proposed methods, we conclude that the OSEM based hybrid-cascaded framework (accelerated version of MLEM) outperforms better with respect to other proposed models on common projection data.

- Development and implementation of an effective approach for statistical sinogram smoothing for low-dose CT reconstruction.
    - an efficient method for statistical sinogram restoration.
    - validate the results on simulated phantom and real data image.
    - a comparative study with state-of-the-art low-dose X-ray CT reconstruction method.

The works presented in the thesis, brings important contributions to computer vision and medical image reconstructions. A detailed study of the literature was performed for all the research areas addressed in this thesis. The proposed methods and algorithms have been rigorously validated and compared with recent state-of-the-art methods. The contributions of this thesis are both theoretical and applicative.

6.2 Scope for Future Works

The research work presented in this thesis can be taken further into different directions. The scope for future works is as follows:

Optimization is an important strategy for the solution of an inverse problem with the minimization of the least square functional. Further, optimization is an essential part of the parameterization algorithm. Several powerful methods for the minimization of functions have been presented in the numerical research world. Forthermore, it would be interesting to examine several families of multidimensional minimization that includes the calculation of first derivatives such as steepest descent, conjugate gradient and Newton methods etc. Furthermore, enhancement is required for improving the efficacy and accuracy of the proposed method by using some multidimensional optimization techniques in this work.

Since most of the PET/SPECT image reconstruction problems available in literature do not address the problem of poisson noise minimization, which is present in the reconstructed image during the acquisition phase. To address the problem of poisson noise minimization, an attempt has been made to cast an effective and efficient framework to address the problem of poisson noise minimi-

zation for PET/SPECT image reconstruction. Looking forward in this manner, it is reasonable to speculate that the proliferation of proposed hybrid framework for imaging systems may stimulate further research into multimodality image reconstruction that could be used in the clinical applications.

Another issue associated with low dose sinogram restoration that it is affected by the signal independent Gaussian noise. For this purpose, an efficient method for statistical sinogram restoration has been proposed.The maintainance of the quality of reconstructed image on low projection data is still a challenging task. Further, enhancement is required in proposed framework to make the design more robust and anatomically driven to handle the noise in measured sinogram data.