PREFACE

In clinical practice and research, disease diagnosis is classified into two categories, i.e., subjective assessment, where radiologists manually assess the radiological data and objective assessment, which includes mathematical models. Primarily, the accuracy of both assessments depends on the quality of data obtained from medical imaging scanners.

Magnetic Resonance Imaging (MRI) is an important modality of medical imaging as far as it is concerned with the structure of soft tissues, their details and disease characterization. The advantages of this imaging technique are its non-ionization behavior and better image quality with high tissue contrast resolution. However, the noise, artifacts and poor tissue contrast degrade the quality of MRI data and are the primary concern for subjective and objective assessment of the diseases. Additionally, the objective assessment requires the accurate automatic segmentation method, which is still a challenging issue in the field of medical image analysis.

Many attempts have been made to achieve better image quality for improved accuracy of diagnosis. The key issues are: (i) automatic tuning of mathematical parameters responsible for producing resultant data and (ii) the consistence performance across the differently weighted MRI data. Further, lesion detection based on unsupervised segmentation requires the prior information of the number of clusters present in the MRI data, which restricts the algorithm to make user or parameter independent.

The present work is carried out to address the critical issues as stated above that helps in better diagnosis. In this view, the research work has considered the evolutionary computation based optimization for the de-noising, contrast enhancement and segmentation of MRI data. The remarkable properties of these algorithms are their adaptive nature and high performance.

The thesis can be divided into two parts. After the broad overview and background, the thesis focuses on image enhancement whereas at later stage it investigates the cluster quality index followed by unsupervised segmentation of MRI data. Chapter 1 is the introduction of the thesis, which states the current issues, objectives, and the contribution of the thesis. Chapter 2 discusses the theoretical background of noise estimation, de-nosing techniques, contrast enhancement and automatic segmentation of MRI data. This chapter also provides the brief overview of Dynamic Stochastic Resonance (DSR), unsupervised segmentation, evolutionary computation based optimization techniques, and the role of optimization in medical image analysis.

Chapter 3 proposes an adaptive noise estimation algorithm, which is based on the maximization of the multiple quality measures. The adaptive noise estimation enables the de-noising algorithm to achieve noise filtering along with enhancement in the image features. This proposed noise estimation algorithm in combination with recursive filtering has shown notable performance. At the same time, the proposed noise estimation algorithm works satisfactory in combination with the non-recursive filters. The impact of noise estimation followed by Kalman filter based de-noising on segmentation of MRI data has also been studied.

Chapter 4 proposes a contrast enhancement technique based on optimized Dynamic Stochastic Resonance (DSR) algorithm. The existing algorithms are susceptible to noise in the processes of contrast enhancement, whereas, DSR suppress the noise along with the enhancement of the image contrast. Further, the optimization in DSR facilitates to make algorithms adaptive and independent of manual selection of its dynamic parameters and can produce optimum enhanced MRI data. This study utilizes quartic bistable model and neuron models of DSR. Chapter 5 proposes the intensity inhomogeneity correction of diffusion-weighted MRI data. Chapter 6 introduces a multi-stable model of DSR to achieve superior performance in terms of contrast enhancement. The present study considered different pathological cases such as microadenoma, infarcts, sclerosis and dysplasia to show the effectiveness of enhancement algorithms.

Further, Chapter 7 proposes the robust and automatic segmentation of MRI data, which relies on the multi-objective approach in the Fuzzy c-mean algorithm. The fitness functions i.e., cluster compactness and fuzzy hyper-volume calculated over the local spatial and grayscale information of the image. The multi-objective antlion optimization minimizes these fitness functions and produces the non-dominating set of solutions called Pareto fronts, and the best segmented MRI data is obtained with the help of maximum partition entropy. In addition to this, the present work also proposes a new cluster index to find the optimal number of clusters present in the image. The proposed multi-objective fuzzy c-means algorithm uses this cluster index for automatic detection of tissue of interest. In Chapter 8, the overall contribution of the thesis along with its future directions have been enlisted which might be of interest for further research in this area.