Medical imaging is the methodology or process, that is used for creating the images of the human body, for the purpose of clinical or medical science, which is routine and essential in the field of medicine. Medical imaging techniques can also be utilized when planning or even when the surgery is performed (Ganguly et al, 2010). Medical image segmentation is the procedure of creating a partition of a medical image into several segments. The aim of segmentation is the simplification and/or modification of the way of representation of an image into a form that gives more meaning, and is easy to analyze (Akselrod-Ballin et al, 2009). Image segmentation is generally used for locating the objects and edges (lines, curves, etc.) in images. In a more precise manner, image segmentation is the process of assignment of a label to each pixel in an image where the pixels with similar label share a few visual features. The computation of medical image segmentations is done at multiple scales in scale space and at times moved from coarse to refined scales. Epilepsy is a usual and different set of chronic neurological disorder that is depicted by seizures. Epileptic seizures are due to abnormal, unrestrained or hypersynchronous neuronal activity in the brain (Hills, 2007). Epilepsy is generally controlled, but not cured completely, with the aid of medication. The evolution of automatic and efficient brain image segmentation technique could be helpful in locating the epileptic seizures, that could be used for the clinical diagnosis.

Image segmentation aims at labeling voxels based on the tissue type which they represent and comprises of WM, GM and CSF. The objective of this work is to provide an automated tool that helps in locating the epileptic tissue on MRI image. There are multiple techniques available, through which epileptic tissue can be found, but there are a few disadvantages of the available methods in the literature. Hence, a robust technique for segmentation and denoising of MRI images can be developed, by employing an efficient segmentation technique that can detect epileptic tissue with accuracy. The motive of the proposed research is the extraction of cerebral tissues for segmenting the human...
3.1. Preprocessing and Segmentation of MRI Brain Images

3.1.1. Medical Image Denoising

The emerging of digital medical imaging methodologies such as PET, MRI, CT and ultrasound imaging has created quite a stir in modern day medicine. All these images are degraded by various types of noises (Roy et al, 2010) such as additive white Gaussian noise (AWGN) (Lal et al, 2011), speckle noise (Goyal et al, 2011), salt and pepper noise (Pei-Yin, 2008), rician noise (Nowak, 1999), Brownian noise, etc. In the recent times, there is no need for the patients to experience invasive and frequently dangerous procedures for diagnosing a large number of illnesses. With the extensive use of digital imaging in medicine currently, the quality of digital medical images poses a serious issue. For achieving the best possible diagnosis it is crucial that medical images need to be sharp with clarity and are devoid of noise and artifacts.

While the technologies for the acquisition of digital medical images keep on improving, thus resulting in images of more and higher resolution and quality, the removal of noise in these digital images still persists as one of the huge challenges in the field of medical imaging. This is due to the fact that they could cover up and blur out the significant intrinsic features in the images, and hence several people have analyzed that denoising techniques have their own issues. Image denoising still stays a challenge for researchers, because, noise elimination produces artifacts and induces blurred images. Noise modeling in medical images is hugely affected by the image capture devices, data transmission media, image quantization and distinct sources of radiation. Various algorithms are employed on the basis of the noise model. Many of the images are presumed to possess additive random noise, which is represented as an AWGN.
Medical images like MRI and ultrasound images have been largely made use for more real pathological changes along with diagnosis. Still, they have a number of drawbacks which include acquisition noise from the instrument, environmental ambient noise, the existence of background tissue, other organs’ and anatomic influences like body fat, and breathing movement. In general, MRI images are contaminated by rician noise. Hence, reduction of noise is very much necessary, as different types of noises that are produced reduces the efficiency of medical image diagnosis. An instance of the actual MRI image and with AWGN is illustrated in Figure 3.1.

![Figure 3.1: (a) Original MRI image (b) AWGN image](image)

3.1.2. MRI Image Segmentation

Segmentation at the initial stage is highly important, and required for analyzing the medical images for computer assisted diagnosis and treatment. As the images are intrinsic by nature, medical image segmentation is a sophisticated and highly challenging task (Shen et al, 2005; Sutar and Janwe, 2011; Maji et al, 2006). MRI is a critical diagnostic imaging technique, which is used for the earlier detection of abnormal variations in tissues and organs (Senthilkumararan and Rajesh, 2009; Forghani et al, 2007). It is also a non-invasive imaging methodology; therefore, it lets a radiologist to make an image of the inherent aspects of living tissue (Revett and Khan, 2005). Generally, the structure of brain
is complicated and its precise segmentation is very important for the discovery of the tumors, edema and necrotic tissues, so that proper therapy can be specified (Maji et al, 2006). The brain matters are chiefly classified into WM, GM and CSF. Normally, the brain structures are described distinctly by the boundaries surrounding the tissue classes; hence, an approach for the segmentation of the tissues on the basis of these categories is a huge step in quantitative morphology of brain (Mostafa et al, 2003).

Besides other diagnostic techniques, MRI systems can be used for generating many images, and each image is indicative of a different important parameter of the intrinsic anatomic structure in the same body section with several differences, according to the local variations of spin–spin relaxation time (T2), spin–lattice relaxation time (T1) and proton density (PD) (Jzau-Sheng et al, 1996). The existence of noise and errors present in the scanners, and the structural differences of the imaging objects are the significant hurdles to the segmentation of MR images. Such hurdles are grouped into four categories: thermal/electronic noise, magnetic field non-uniformities, biological tissue variations and imperfect volume effects (Rajapakse et al, 1997).

In addition to this, manual identification and analysis of the lesions from MR brain images are usually time consuming, highly uneconomical and can generate unsatisfactory high intraobserver and interobserver variability (Wells et al, 1992). The MR images segmented, that are employed in the medical diagnostic process, is dependent on a combination of two frequently conflicting essentials, namely, the elimination of unwanted information available in the actual MR images and the preservation of the critical details in the obtained segmented images (Jabbar and Mehrotra, 2008; Karayiannis, 1997). MR image segmentation techniques are generally assessed on the basis of their capability to distinguish i) Between CSF, WM and GM, and ii) Between normal tissues and abnormalities (Karayiannis and Pin-I, 1999).

The effective denoising and segmentation techniques introduced help in solving the issues mentioned above during cerebral tissues segmentation. Figure 3.2 describes the architecture of the automatic image segmentation technique for MRI image samples.
3.2. PROPOSED METHODOLOGY

The overall proposed research focuses its analysis chiefly on the denoising and segmentation techniques for efficient segmentation of the MRI images with epilepsy disease. For the purpose of performing this process, the research methodology is implemented as indicated in Figure 3.3, and it is grouped into five major phases as below.

- Phase I: For the removal of the non-cerebral tissues from MRI brain images, skull stripping is performed with noisy and denoised images,
- Phase II: Segmentation employing Clustering techniques including K means and FCM are conducted with noisy and denoised images,
- Phase III: Segmentation applying Optimized Clustering techniques like GA and FA that are incorporated into FCM is carried on with noisy and denoised images,
- Phase IV: Random based Optimized Clustering techniques, comprising of Chaotic with Firefly Algorithm (CFA) and Levy Flights with Firefly Algorithm (LFFA) that are integrated into FCM are executed with noisy and denoised images, and
- Phase V: Evaluation of efficiency of Optimization and Random based Optimization methods is conducted with the traditional Benchmark Test Functions.
3.2.1. Collection of Real MRI images

As the primary step, the original MRI images are obtained from Clarity Scan Centre, Coimbatore, from March 2012 - September 2014. Size of the image is transformed into 256 x 256 in jpeg format. The dataset comprises of images of 2 normal and 2 abnormal patients. Every patient has 64 slices, and totally 64x4 images were taken into consideration. A few sample MRI slices are shown in Figure 3.4.

Figure 3.3: Research Methodology
3.2.2. Phase I: Skull Stripping With Noisy and Denoised Images

The goal of preprocessing is the processing of the images that were in unrefined form, and then get better quality images, that can suit the next steps of image processing. In preprocessing, skull stripping and image denoising are the two steps taken into consideration.

3.2.2.1 Skull Stripping

Skull stripping plays an important role in brain image analysis and is a huge challenge for image segmentation. Cerebral and non-cerebral tissues have similar pixel intensities. Hence, this issue in MRI image segmentation results in confusion in segmentation process. Therefore, the elimination of non-cerebral tissues (like skull, scalp, vein or meninges) is a significant step in preprocessing with the aid of skull stripping techniques. The mathematical morphology opening operation is employed for the segmentation of the brain cerebral tissues like WM, GM and CSF from the non-cerebral tissues. Dilation and Closing are needed for segmenting the brain tissues without holes. This step considers the actual MRI brain images for stripping the non-cerebral tissues. The noisy skull stripped images are taken into account for the next level investigations of the research work.

3.2.2.2 Image Denoising

Denoising technique is a process in image processing, which targets at removing its noise, and hence improves the quality of the images. MRI brain images are degraded by AWGN from the image acquisition instrument. Spatial filters are the generally employed filters for the removal of the AWGN from the images.
The proposed denoising algorithm is called as Optimized Total Variation Filter (OTVF). This method improves the real MRI images in two steps, namely, denoising and edge enhancement. Almost all the denoising solutions are focused mainly on noise reduction and neglecting the edge details. A few methods employ different algorithms for these two steps. This work introduces a single process that performs these two operations, simultaneously making use of a combination of image preprocessing approaches. Regularization parameter (lambda), which is a positive value that specifies the fidelity weights, controls the amount of denoising. The fidelity weights are smoothed and optimized, making use of PSO for restoring the regularization parameter limit between 0 to 1. Chapter 4 focuses on the elaborate description of the design and realization of preprocessing techniques with and without denoising phase.

3.2.3. Phase II: Segmentation using Clustering Techniques with Noisy and Denoised Images

Image Segmentation is the procedure of division of an image into regions with similar kind of properties like gray level, color, texture, brightness and contrast. The issue with image segmentation involves subdivision of an image into multiple cluster regions, which are categorized alone by making use of clustering techniques. The image resulting from the first phase is provided as input for the subsequent phases. In this phase, implementation of clustering approaches with K-Means and FCM for the segmentation of the MRI brain cerebral tissues like GM, WM and CSF regions is given consideration and the discussion in detail is given in Chapter 5. Then the results got from clustering segmentation with various tissues are isolated. The comparison made between K-Means algorithm and FCM with and without denoising is evaluated on the basis of over segmentation (OvS), incorrect segmentation (InS) and under segmentation (UnS) is discussed in chapter 8.

3.2.4. Phase III: Segmentation using Optimized Clustering Techniques with Noisy and Denoised Images

The FCM technique gets easily stuck into the local minimum and does not take the spatial contextual information into consideration. Hence, there is an ever increasing need for the optimization of the cluster centers in FCM segmentation. This phase deals with the optimized clustering methodologies like GA and FA which find their
implementation into FCM, for the segmentation of the MRI brain cerebral tissues like GM, WM and CSF regions. Then, the results received from clustering segmentation with various kinds’ of tissues are isolated. For the determination of the global optimal value and initial cluster centers, GA and FA are realized and incorporated into FCM for the segmentation of the cerebral tissues in MRI images, and their detailed description is provided in Chapter 6. For each optimization problem, there should be many local minimum values and only one global minimum value. For the purpose of evaluation, effectiveness of the optimization algorithm, test function is conducted in this phase by employing 14 standard benchmark test functions. The FAFCM technique proposed attained global minimum value in Egg holder test function as discussed in Chapter 8.

3.2.5. Phase IV: Segmentation using Random based Optimized Clustering Techniques with Noisy and Denoised Images

The behavior of attraction co-efficient and randomization co-efficient of firefly can be fine tuned for finding the global search mobility for which the random based metaheuristic optimization methods are given focus in this phase. Random based Optimized Clustering Techniques, like Chaotic and Levy Flights, are deployed into FA for getting the global cluster centers as the initial cluster value of FCM and it is explained in detail in Chapter 7. Eventually, FCM is utilized for the segmentation of the MRI brain cerebral tissues like GM, WM and CSF regions. The Chebyshev Chaotic map and Levy distribution is employed for the optimization of the attraction and randomization behavior of firefly algorithm. Afterwards, the results got from random based clustering segmentation, with various kinds of tissues, are separately segmented. For the purpose of evaluation, effectiveness of the optimization algorithms, test function is conducted in this phase by employing 14 standard benchmark test functions. The newly introduced hybrid Levy Flights Firefly Algorithm with FCM technique achieved global minimum value in 4 test functions like Michalewicz, Rastrigin, Goldstein and price, and Egg holder function; Chaotic Firefly Algorithm with FCM technique achieved global minimum value in 2 test functions like Michalewicz and Egg holder which is studied in Chapter 8.

3.3 EXPERIMENTAL RESULTS

The tests were performed, and the comparison of the results with the original MRI image samples that are collected from Clarity Scan Centre, Coimbatore, from March
2012 - September 2014, are made. Size of the image is converted into 256 x 256 jpeg format. The dataset comprised of images of 2 normal and 2 abnormal patients. Every patient has 64 slices, and totally 64x4 images were taken into consideration. MATLAB, the simulation tool was deployed for the implementation of this proposed work. The four leveled stages were conducted for the experimental results of the proposed system. In the first phase, the performance evaluation of the preprocessing methods such as PSNR, RMSE and SSIM. In the second phase, the performance of the cluster based segmentation algorithm, comprising of K means and FCM, is assessed on the basis of Over Segmentation (OvS), Incorrect Segmentation (InS) and Under Segmentation (UnS). In the third phase, the performance evaluation of the optimized cluster based segmentation algorithm like GA and FA, is assessed on the basis of OvS, InS and UnS. In the fourth phase, the performance evaluation of the random based optimized clustering segmentation, comprising of Chebyshev Chaotic map and Levy distribution with Firefly Algorithm based FCM is performed on noisy and denoised images, with the aid of 14 standard benchmark test functions. The final stage involved the discussion, for analyzing the existing and proposed techniques with noisy and denoised results. The optimization algorithms are tested, with the assistance of 14 standard benchmark test functions.

3.4. SUMMARY

The objective of the proposed research is the design and development of an efficient cluster based segmentation technique for the segmentation of cerebral tissue of the MRI images, and consists of four important steps, namely, preprocessing without filtering and skull stripping, preprocessing with filtering and skull stripping, the clustering based segmentation like K-means and FCM with noisy and denoised images, the optimized clustering based segmentation dependent on GAFCM and FAFCM with noisy and denoised images, the random based optimized segmentation on the basis of the clustering approaches like CFF-FCM and LFFA-FCM with noisy and denoised images. The efficiency of the segmentation is increased by the proposed random based optimization clustering segmentation algorithm. Overall, this chapter dealt with the entire design of the proposed techniques phase wise. In the ensuing Chapter 4, the preprocessing technique with and without filtering step, skull stripping is carried out for segmentation of MRI cerebral tissues is discussed.