CHAPTER 1
INTRODUCTION

Abnormality detection in Magnetic Resonance (MR) brain images is a challenging task. The difficulty in brain image analysis is mainly due to the requirement of detection techniques with high accuracy within quick convergence time. The detection process of any abnormalities in the brain images are a two-step process. Initially, the abnormal MR brain images are classified into different categories (image classification) since treatment planning varies for different types of abnormalities. Further, the abnormal portion is extracted (image segmentation) to perform volumetric analysis which verify the success rate of the treatment given to the patient. Conventionally, the detection process is performed manually which is highly prone to errors because of the intervention of human perception.

Several automated techniques are developed to overcome this drawback. Among the automated techniques, Artificial Neural Networks (ANN) and Fuzzy techniques are found to be highly efficient in terms of the performance measures. But, the major factor is that the merits are not simultaneously available in the same ANN or the fuzzy technique. In this research work, several modified ANN and fuzzy techniques are proposed for image classification and segmentation applications. The focus of this research work is to develop automated techniques with simultaneous merits of high accuracy and convergence rate. Few conventional ANN and fuzzy techniques are also implemented to show the superior nature of the proposed approaches. This chapter specifically focuses on the significances of the various aspects of the automated abnormality detection process.

1.1 SIGNIFICANCE OF MAGNETIC RESONANCE IMAGING (MRI)

Modern medical imaging technology has given physicians a non-invasive means to visualize internal anatomical structures and diagnose a variety of diseases. Among the imaging techniques, Magnetic Resonance Imaging is found to be
much superior to other techniques especially for brain tissues. This type of scan uses magnetism to build up a picture of the internal parts of the body. The main advantage is that the soft tissue differentiation is extremely high for MRI which is essential for brain imaging.

Compared to other techniques, MRI has high spatial resolution and contrast. Other advantages of MRI scans are that they are devoid of X-ray radiation and a single scan can produce many pictures. MRI is also better than Computer Tomography (CT) at showing how deeply the tumor has grown into body tissues. It can be particularly useful for showing whether tissue left behind after treatment is tumor or non-tumorous tissue. These MR images are used to find the different stage of tumor. The MRI scanner can be also used for cross section views of the body.

Thus, these factors have motivated the usage of MR brain images for the abnormality detection process in this research work. These MR images can be collected from scan center or can be downloaded from publicly available database. Both these options are tried in this work for image classification and image segmentation applications.

1.2 SIGNIFICANCE OF IMAGE CLASSIFICATION

Image classification is one of the sub-categories of pattern recognition system in which an input image is categorized into any one of the pre-defined classes. The image classification process is often confused with the image segmentation techniques. The image classification is performed with the whole image rather than with pixels. In other words, image classification can be termed as ‘between images’ operation and image segmentation can be called as ‘within image’ operation.

This image classification technique is able to give the information about the presence of abnormality in the input brain image. Broadly, the image classification is divided into two subclasses: (a) Binary classification and (b) Multi-level classification. In the binary classification system, the number of pre-defined classes is only two and hence the details of the presence or absence of the
abnormality in the brain image can be obtained. The output of such systems is able to differentiate the normal images and the abnormal images. Practically, this information is insufficient since the nature of the abnormality is necessary for treatment planning. The next level of classification is multi-level classification in which the number of pre-defined classes is more than two. These classification techniques have the capability of differentiating the different types of abnormalities which aids in treatment planning. The complexity of such techniques is quite high but these classification systems are more suitable for real-time applications.

1.3 SIGNIFICANCE OF IMAGE SEGMENTATION
The methodology of image segmentation is slightly different from the classification techniques. Image segmentation categorizes the pixels in the input image into different classes unlike classification which categorizes the whole image. This pixel based categorization is based on similarity measures such as the distance measures. The neighborhood effect of the pixels is also involved in the segmentation process. These segmentation techniques are also called as clustering techniques. This technique is mainly used to extract the abnormal portion from the classified input MR brain image. The segmentation process is necessary to perform the quantitative analysis or volumetric analysis on the abnormal portion.

There are some significant differences between the image segmentation and image classification during the practical implementation. The training dataset for image classification consists of ‘images’ but the training dataset for the image segmentation consists of ‘pixels’. Images from same category are sufficient for training the segmentation system but images from different categories are required for image classification. Another significant difference is the methodology of feature extraction for these techniques. The features are extracted from the whole image for image classification but the features are extracted using the neighborhood effect for the image segmentation techniques.
Both image classification and image segmentation techniques are essential for the automated abnormality detection process which is the main objective of this research work.

1.4 SIGNIFICANCE OF ANN AND FUZZY TECHNIQUES

ANN is a mathematical model or computational model that is inspired by the structural and functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons and it processes information using a connectionist approach to computation. In most cases, an ANN is an adaptive system that changes based on external or internal information which flows through the network during the learning phase. They are usually used to model complex relationships between inputs and outputs or to find patterns in data.

An ANN is typically defined by three types of parameters: (a) the interconnection pattern between different layers of neurons, (b) the learning process for updating the weights of the interconnections and (c) the activation function that converts a neuron's weighted input to its output activation. The two major learning algorithms are supervised learning and unsupervised learning. ANN is commonly used for real-time applications such as function approximation, classification, data processing, etc.

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions.

The reasoning in fuzzy logic is similar to human reasoning. It allows for approximate values and inferences as well as incomplete or ambiguous data (fuzzy data) as opposed to only relying on crisp data (binary “yes/no” choices). Fuzzy logic is able to process incomplete data and provide approximate solutions to problems other methods find difficult to solve. Fuzzy logic has been applied to
many fields from control theory to artificial intelligence. The main focus of this research work is to develop novel ANN and fuzzy logic based automation techniques.

1.5 PROBLEM DEFINITION

The abnormality (tumor) detection in MR brain images is the main objective of this research work. Normally, the abnormalities are identified by the human observer (radiologist). The probability of error for such identification is very high due to the presence of psycho-visual effect. Besides being inaccurate, the requirement of convergence time is also high which accounts for the practical difficulty of such abnormality detection systems.

An extensive literature survey has revealed the availability of semi-automated and fully automated techniques for this application. Most of them are computer based approaches and involves the concept of soft computing approaches such as ANN and fuzzy logic techniques. But, the major drawback is that if the techniques are accurate, the time requirement is high and vice-versa. In other words, both the merits of high accuracy and low convergence time are not simultaneously available within the same technique. This has lead to the reduction of the efficiency of automated disease identification system.

In this work, this problem is tackled by proposing several modified ANN and fuzzy techniques for image classification and image segmentation. These modifications are performed with an objective to ensure the presence of both high accuracy and low convergence time within the same approach. Some of the conventional ANN and fuzzy approaches are also implemented in this work to perform the comparative analysis. Several individual modules are available within the automated classification and segmentation systems along with the modified approaches. Thus, this work highlights suitable alternate for conventional ANN and fuzzy based automated systems for medical imaging applications.
1.6 OBJECTIVES OF THE RESEARCH WORK

Based on the various challenges encountered in the brain image analysis, several objectives are framed for this research work. The significant objectives of this work are:

- To automatically classify the abnormal MR brain images into different categories using modified ANN. The modified ANN used in this research are Modified Counter Propagation Network (MCPN), Modified Self Organizing Maps (MSOM1 and MSOM2).

- To automatically segment the abnormal (tumor) portion from the classified MR brain images using modified ANN. The modified ANN used in this research is Modified Back Propagation Neural Network (MBPN).

- To automatically segment the abnormal (tumor) portion from the classified MR brain images using modified fuzzy techniques. Two Modified Fuzzy C-Means (MFCM1 and MFCM2) algorithms are used in this research work.

- To implement few conventional ANN such as Back Propagation Network (BPN), Learning Vector Quantization (LVQ), Counter Propagation Network (CPN) and Self Organizing Map (SOM) for image classification and image segmentation. Conventional Fuzzy C-Means (FCM) is also used in this work. This implementation is performed to aid the comparative analysis of the modified approaches with the conventional approaches.

1.7 PROPOSED METHODOLOGY

The overall framework of this research work is shown in Figure 1.1. The complete system is made up of individual modules and each individual module is associated with its own techniques. The major modules of this work are image database, pre-processing, feature extraction, image classification and image segmentation. Image classification and image segmentation includes techniques with ANN and fuzzy approaches. These techniques form the core of this research work.
Figure 1.1 Framework of the proposed system

The individual modules are explained in the subsequent sections.

1.8 ORGANIZATION OF THE THESIS

The rest of the thesis is organized as follows.
An extensive literature survey on brain image analysis using ANN techniques is given in Chapter 2. This chapter also shows the available literature for the individual modules such as image pre-processing and feature extraction.

Chapter 3 covers the implementation aspects of the image pre-processing and feature extraction. The mathematical details and the experimental results are also displayed in this chapter.

Chapter 4 displays the technical details of ANN based image classification approaches. In this chapter, three modified ANN and two conventional ANN are discussed with the experimental results.

The ANN based image segmentation techniques are analyzed in chapter 5. One modified ANN and two conventional ANN are implemented and tested using the abnormal MR images.

Chapter 6 deals with the fuzzy based image segmentation techniques. Two modified FCM algorithms are tested in this work. The results are also compared with the conventional FCM algorithm.

Chapter 7 concludes the work by highlighting the significant factors of each technique used for classification and segmentation applications. A detailed comparative analysis is also provided in this chapter. The significant contributions, scope for further work are also discussed in this chapter.