CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Any research work journey commences with literature review or survey. The literature review is the wide-ranging survey and evaluation of reputed peer reviewed scholarly journal papers found in the literature connected to our research topic under study. This will provide a structural and theoretical base for our research work and will help to determine the nature of research outcome. Firstly, a detailed survey of various types of MRI artifacts that appear in brain MRI, their causes and possible remedies taken by the technician/radiologist is studied in detail. Secondly, a broad survey of MRI image segmentation methods is reviewed. Finally, a review of journal papers on artificial neural networks for feature extraction, classification and detection of abnormalities in brain MRI image is done and summarized for our topic of the thesis.

2.2 Review of MRI Artifacts

A wide variety of artifacts can occur during MRI scan, some of them disturbing the diagnostic quality and others may confuse the pathology. An artifact is a feature that appears in an image which is clearly not present in the object which is to be imaged. Artifacts are caused by a variety of factors that may be MRI scanner hardware related or patient related. The types of MRI artifacts are zipper artifact, herring bone artifact, RF noise artifact, Gibbs artifact, Aliasing artifact, Intensity inhomogeneity or bias field, central point artifact, motion artifact, chemical shift artifact and magnetic susceptibility artifact.

It is important for the radiologist/pathologist to become familiar with the appearance of artifacts, since the presence of artifacts can obscure the important findings or confuse the pathology resulting in false negatives and false positives during detection of brain abnormalities like tumor or lesion. Some of the artifacts and their negative influence on MRI images can be minimized or removed by the radiologists by adjusting the acquisition parameters [3][5]. Some other artifacts which obscure pathology and are out of radiologists immediate control are removed or minimized in technical ways by developing image preprocessing techniques.

In [3], Somasundaram K and Kalavathi P, has listed various MRI artifacts and their common causes. The authors conclude that, all the brain image processing techniques
need to incorporate these artifacts to correctly recognize and diagnose the brain related diseases.

In [4], Katarzyna Krupa, et al., summarized the artifacts in MRI and foreign bodies [medical implants, dental filling, cosmetics, tattoos, hair bands, surgical clips, labels on clothes, etc.] inside the patient body may confuse the pathology or may reduce the quality of investigations. The author says that the radiologists are often not told about the medical history of patient’s and whether it is post-operative images or not. The author has presented images with different types of artifacts. The author proposed some methods of reducing artifacts but not discussed in detail the procedures to avoid or limit artifacts.

In [5], L J Erasmus, et al., in their review article has highlighted many different MRI artifacts and possible rectifying methods adopted by the radiologists. However, the author has not suggested any technique to remove artifacts by image processing techniques.

In [6], Alfred Stadler, et al., briefs a wide variety of artifacts and says that the service engineer is required to reduce of the artifacts and the radiologist has the sole responsibility to reduce them to the possible extent by adjusting acquisition parameters of MRI scanner.

In [7], Sabine Heiland, has explained a variety of artifacts that appear in MRI. The author state that the artifacts may degrade image quality and simulate or mask the pathologic abnormalities. He attracts the attention of personnel running MRI scanner to aware of the potential sources and also the physical origin of artifacts.

In [20], Mohana H S, et al., has discussed zipper artifact, presented and implemented a modified Gaussian technique to remove zipper artifact and they claim that the results are satisfactory.

2.3 Review of MRI Image Segmentation Techniques

Automatic segmentation of MRI images of brain is of great importance in medical research. A variety of segmentation schemes exist in the literature. However, the manual segmentation by pathology experts is still considered to be the ground truth or gold standard for any automated segmentation algorithm [39].

In [39], Hayit Greenspan et al., implemented an automated segmentation algorithm to segment brain MRI images acquired under varying noise conditions using Expectation maximization (EM) and Gaussian mixture model (GMM). The authors claim that the algorithm was applied on different slices of T1 weighted images which were noisy and the algorithm gives superior results both visually and quantitatively.
In [41], M Usman Akram, et al. and in [42], Deepti Murthy T S, et al., the authors applied global thresholding and morphological operations to remove false segmented pixels in the image and claims that the algorithm precisely segments and identifies the tumor from brain MRI images.

In [2], K Somasundaram, et al., the authors presented a fully automatic segmentation algorithm for extraction of tumor from axial plane T2 weighted MR images. They applied thresholding, morphological operations, largest connected component analysis and filter mask to extract the tumor. They conclude that the proposed method gave better results compared with other segmentation methods.

In [45][46], the authors implemented a fully automatic segmentation algorithm using thresholding and mathematical morphological operators for detection of abnormalities in brain MR images and applied on different types of brain MR images for both visual and quantitative evaluations. They conclude that this method yielded promising and reliable results in a time frame of few seconds to attain accuracy of tumor detection, to identify the exact region and locations of tumor in the brain.

In [48][49], the authors presented a Fuzzy C-means algorithm and also modified fuzzy C-means algorithm and High speed parallel fuzzy C-means algorithm for segmentation of brain MRI images. They state that the FCM technique takes more time for processing, which can be improved [18] [49] by modifying the objective function of the standard FCM. The parallelism in FCM is fast and requires less execution time.

In [50], Ivana Despotovic, et al., the author presented a review article on various segmentation techniques for brain MRI images, their capabilities, advantages and limitations. The author says that there is no single method that can be suitably applied for all images. Other segmentation methods are discussed and implemented in [54] [55] [57] [61] [62] [65] [67] [68]. From the review it is found that there is no generally accepted technique for brain MRI image segmentation.

2.4 Review of Feature Extraction and Classification Techniques

In [85], Pauline John introduced a method for classification of brain tumors where MRI images are classified as non-cancerous (benign) and cancerous (malignant). Methodology has three steps, namely, wavelet decomposition, texture feature extraction and finally classification. The DWT employs Daubechies wavelet filter (DB4) for decomposing the MRI image into different levels of approximate and detailed coefficients. The GLCM (gray level co-occurrence matrix) is formed, from which the
texture features such as energy, contrast, correlation, homogeneity and entropy are obtained. The results of GLCM are then fed to a probabilistic neural network (PNN) for further classification and detection of tumour. The author tested on real MRI images and found that the accuracy is close to perfect for classification using PNN network.

In [86] Shweta et.al., presented a paper on artificial neural network namely BPN and PNN network to detect and classify the tumour in MRI images of brain. The GLCM is utilized to accomplish the feature selection. Two modes namely Training/Learning mode and Testing/Recognition mode are applied. Back propagation network (BPN) and probabilistic neural network (PNN) are used to order the kind of tumor in MRI images.

In [87], Mohammad Mahmudul Alam Mia, et. al., employed back propagation neural network successfully in many areas with excellent generalization results. Levenberg-Marquardt back-propagation algorithm is utilized for training the network and reconstructs the image. It is found that Marquardt algorithm is significantly more proficient. Author has determined the issue of number of neurons in every hidden layer and the quantity of hidden layers needed for high accuracy.

In [90], Hari Babu Nandpuru, et. al., proposed a classification system using SVM with different kernel functions to recognize and classify the brain MRI images as normal and abnormal. In this feature extraction is done by gray scale, symmetrical and texture features. The authors conclude that the method gives more accurate results.

In [91], P. Mohanaiah, et. al., explained a texture feature extraction using GLCM. In this paper, author exhibited a utilization of GLCM [90] to deliberate second request factual surface components for movement estimation of images. Four specific features like Angular Second Moment, Correlation, Inverse Difference Moment, and Entropy are registered utilizing Xilinx FPGA. The author says that the method requires less calculation time and consequently proficiently utilized for constant Pattern recognition applications like Military & Medical Applications.

In [98], M. Madheswaran and D. Anto Sahaya Dhas developed and presented an enhanced classification system for brain tumor classification from MRI images using association of kernels with support vector machine. Image segmentation is done using fuzzy-c means algorithm and image features are extracted using GLCM. The authors claims that the accuracy is found to be high for SVM classifier with GRBF kernel.
2.5 Review Summary and Discussion

From the literature review, it is understood that the magnetic resonance imaging technique is susceptible to artifacts. The radiologist/technician can adjust the acquisition parameters of the MRI machine to eliminate or minimize the artifacts. However, the artifacts can also be removed by using image processing techniques. In [13]-[20] the authors discussed methods to remove Gibb’s ringing artifact, intensity inhomogeneity (IIH) or bias field and zipper artifact. During the review process, it is found that, there is no technique published in the literature to remove herringbone artifact in brain MRI images. Hence, it is proposed to remove herringbone artifact by developing novel techniques in the frequency domain. After artifact removal, the brain image has to be segmented to detect the presence of tumor if any and classify the brain images as normal/abnormal. Since there is no universal algorithm to segment the brain MRI image, it is proposed to validate three segmentation techniques (Morphology, EM and FCM) and use the segmentation technique which gives better results in terms of segmentation accuracy, similarity index, computational time and image quality in terms of improved SNR and minimized energy loss. After reviewing several papers on classification of brain abnormalities [86, 87, 89, 97, 99, 103-105] using k-NN, BPN, SVM, PCA and Bayes classifier, it is proposed to use SVM for the classification of brain MRI images as normal or abnormal. The SVM is found to provide better accuracy than any other classifier.

2.6 Objectives of Research

The objective of this research work is to study the various types of artifacts that occur during the acquisition of brain images using MRI technique and develop methods and algorithms specifically to remove the herringbone artifact in MRI images of brain and perform analysis for detection and classification of abnormalities. The main objectives of the proposed research work are as follows.

- To develop novel techniques to remove herringbone artifact and technically evaluating the image quality by determining SNR and energy loss metrics.
- To perform segmentation and tumor detection using global thresholding and morphological operations.
- Feature extraction by applying Gray level co-occurrence matrix in different direction (0°, 45°, 90° and 135°) of image to extract the Texture features.
- To use the feature values to implement the Support vector machine to classify the images as either normal or abnormal.
2.7 Methodology

Methodology involves the various steps designed to implement the research problem which is defined after review of literature. It comprises brain MRI image data collection process, analysis of data for its suitability and creating a large database, development of novel techniques to remove herringbone artifact, evaluation of image quality using SNR and energy loss measures. Segmentation, feature extraction and classification techniques are implemented using a computer system with MATLAB software toolkit. The various stages of the proposed research work are highlighted in the flowchart shown in figure 2.1.

![Flowchart](image_url)

**Figure 2.1** Block diagram of the various stages of the proposed methodology
2.8 MR Image data collection and database creation

Any research work is initiated with a motivation, literature survey and problem statement followed by data collection process. Availability of data, quality of data and reliability of data are the issues to be dealt in at the time of data collection. In this work, the MRI image data of human brain is required for carrying research and is collected from the following sources.

Table 2.1 Details of image data source collected

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of image data source</th>
<th>Approximate number of image data sets</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Department of Radiology SS Institute of Medical Sciences and Research Centre Davangere</td>
<td>700</td>
</tr>
<tr>
<td>2</td>
<td>Radiologist Krishna Advanced MRI &amp; CT Vellore</td>
<td>350</td>
</tr>
<tr>
<td>3</td>
<td>IBSR (Internet Brain Segmentation Repository)</td>
<td>150</td>
</tr>
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The collected brain image data consists of T1 weighted, T2 weighted and Proton density images taken in axial, sagittal and coronal planes. All images of patients are taken from a 1.5 Tesla MRI scanner. The image data comprises both normal and abnormal patient brain. This raw data is in the form of DICOM images which is a standard way for handling, storing, printing and transmitting information in medical imaging. First the DICOM images are converted to JPEG format for processing by the computer. The JPEG images are separated into T1 weighted, T2 weighted and Proton density images taken along axial, sagittal or coronal plane. Some of the images contain artifact, some of them are normal and others abnormal. A large database of MRI images in JPEG format is created for processing on the computer. Some of the sample images collected from radiologists taken in axial, sagittal and coronal planes of normal brain and abnormal brain are shown in figures from 2.2 to 2.6.
Figure 2.2: Axial plane MRI images (Normal brain)
Figure 2.3: Axial plane MRI tumor images
Figure 2.4: Coronal plane MRI normal images
Figure 2.5: Coronal plane MRI images (Tumor brain)
Figure 2.6: Sagittal plane MRI images (Normal brain)