Chapter 7
Conclusion, Limitations and Future Directions

7.1 Fulfilment of Project Objectives

The primary objective of this research was to develop methods and algorithms to identify or classify types of neurodegenerative diseases; which is fulfilled by investigating and improving feature extraction methods on the neurodegenerated brain image. These features are then used as the inputs to the artificial neural networks and successfully classified the type of Dementia. Partial achievements are

1. Identified database ADNI with sufficient number of MR images of AD, MCI and normal. As ADNI is not open access, obtained access to this database by submitting research rationale to ADNI.
2. Downloaded and successfully installed SPM and VBM toolkit in MATLAB, for preprocessing of 3D MR images of brain.
3. Made use of VBM (voxel based morphometry) for normalization of 3D brain images and finding brain tissue volumes.
4. Did first classification attempt using brain tissue volumes and affine coefficients (VBM normalization), as features, subsequent ANN was 90% successful.
5. Secondly did VOI analysis for feature extraction from hippocampus (part inside brain) and ANN classified with 86% accuracy.
6. Extraction of texture features from brain image and design ANN classifier resulted into 98% accuracy.
7. Method of applying frequency filter to brain image and obtaining spatial features and ANN classification resulted the best, gave 100% accuracy.
8. Also attempted to get DWT coefficients of 3D MRI as features for ANN input, but could not give accuracy above 77%.
9. Downloaded 2D axial MR images belonging to six classes from Whole brain atlas database. Applied DWT method to get 97.2% accuracy.
10. Used frequency filtering method (described in 7 above) to these 2D MR images and could get 100% classification accuracy up to 3 classes.
11. Keeping belief in multiresolution analysis an attempt was made to extract Slantlet transform features from 2D MRI and achieved success with 100% accuracy even for 4 class classification.

12. Used Discrete Cosine Transform based features and a robust classifier with 100% accuracy, even up to five classes was obtained.

7.2. Conclusion and Discussion (Value to the Research Community)

In the research conducted for this thesis, the task was to extract patterns from Neurodegenerated brains and build accurate and transparent classifiers. The research advances the current diagnosis methods of neurodegenerative diseases in the sense of following facts -

1. Making use of CDR (clinical dementia ratio) as level of Dementia, a MLP classifier for various Dementia levels has been developed to the accuracy more than 95%, is better compared to other researchers referred. This also contains fusion of demographic, socioeconomic and MR imaging parameters from the OASIS database. This seems to be the first classifier of its kind.

2. Application of voxel based morphometry (VBM) for MR image pre-processing in Matlab-SPM environment was a challenging task. But as MR Images are corrupted by smoothly varying intensity inhomogeneity caused by magnetic field imperfections and subject-field interactions, it was necessary to achieve smooth intensity correction.

3. MRI segmentation into GM, WM, CSF and calculation of tissue volume features yielded quite good classification rate as compared to referred researchers in the area.

4. To use MIPAV software for VOI analysis of Hippocampus is an innovative aspect of this research as it has not been tried or reported by anyone else in the area.

5. Most of the spatial/textural feature analyses referred are done only on 2D images and hence there were almost no resources describing, how to get spatial features from 3D MR images. Still a successful extension is made from methods for 2D to 3D resulting in better classification.

6. MIPAV is an excellent and newest platform for deriving FFT of 3D MR images, which was not yet tried for as per review of literature. This
research took advantage of the fact and the result is generation of the most innovative and robust classifier with 100% accuracy.

7. Explored wavelet based feature extraction techniques for 2D MR images giving rise to the development of an automated brain MRI diagnostic system, which can classify whether the 2D MR image belongs to a normal brain or to a person suffering from Alzheimer’s disease or Mild Alzheimer’s disease or Huntington’s disease with 100% accuracy based on Slantlet transform as well as Discrete Cosine Transform.

7.3. Research Limitation

In case of 3D MRI from ADNI, research could not proceed to more Dementia classes because of lack of disease specific images above three types. Also could not add more number of samples, because every sample in 3D MRI sized around 40MB, thus significantly increasing processing burden. The task is rather simplified with use of 2D MRI from whole brain atlas database.

7.4. Future Direction

Dementia classification can be taken towards more detail categories subject to the availability of Neuroimaging databases with sufficient number of cases of each and every disease type. Further work can be done to establish statistical significance through the use of numerous training sets as and when the databases get available with sufficient number samples.

Also according to the opinion from Neurologist, results of this research if combined with other clinical data, like onset of the disease or history it may lead to more robust diagnosis system.