CHAPTER 10
SUMMARY AND CONCLUSIONS

10.1 MAJOR FINDINGS

Alzheimer’s disease is the most frequent neurodegenerative dementia and a growing health problem. Currently, there is no cure for Alzheimer’s disease, but its early detection is essential to an effective treatment, slowing down the progression of symptoms. An important motivation relates to the fact that today’s diagnostic procedures are highly dependent on the physician’s and radiological expertise and is very time consuming. Consequently, the development of automated image based classification of individual patients could provide valuable diagnostic support for clinicians.

The research presented in this thesis analyze the performance of CAD techniques to discriminate between AD patients and healthy control subjects, and hence to predict conversion from MCI to AD in South Indian population. This study examined the comparative performance of voxel based methods and different classifier techniques such as unsupervised K-means and supervised RBFNN, GRNN, PNN, BPNN, MSVM moreover combination of Bacterial Foraging Optimization tuned ANN based classifiers to map the progression of GM loss in MCI patients over time and to help detect brain changes between MCI patients who may convert and may not convert to AD. However, the application of a Bacterial Foraging Algorithm for the early diagnosis and tracking the progression of AD has not been reported yet. Inspired by the success of evolutionary algorithms in the diagnosis of AD, possible application of BFO tuned ANN in the diagnosis of AD could be investigated.

1. The prospective nature was treated as a major strength, since all the analysis discussed were based on the data collected from 2009-2013 period. In detail, the patients were recruited after detailed physical, clinical, neuropsychological, cognitive and neurological assessments through the memory clinic.

2. The current study is the first in analyzing original MR Images of AD, MCI and NCI sample which have been derived from population based cohorts in a southern Indian province, Kerala. The study utilized various CAD based volumetric techniques for early detection of AD and tracking the progression of MCI to AD
3. In literature no studies reported such a combination of mathematical morphology, 2D Gabor texture features, different classifiers (K-means, RBFNN, GRNN, PNN, BPNN, MSVM and BFO tuned ANN) and volumetric analysis of segmented regions of Gray Matter, White Matter and Cerebro-spinal fluid for the early diagnosis of AD and tracking the progression of MCI to AD as we used in this thesis.

4. To the best of my knowledge, there is no previously reported CAD system for the early diagnosis of AD and longitudinal prediction of MCI to AD using the Bacterial Foraging algorithm optimized neural network with improved classification accuracy.

5. This proposed study has implemented recent supervised classifier techniques like RBFNN, GRNN, PNN, BPNN and MSVM for the comparative performance analysis.

6. The BFO tuned ANN based classifier have identified the volumetric changes in the brain well, a comparative assessment of the results has revealed the BFOANN has outperformed the other classifier in terms of accuracy and sensitivity.

7. This is the first Indian study in which volumetric results of AD in specific cortical regions were obtained from ROI based volumetry and SPM map were correlated with cognitive measures for longitudinal and cross sectional analysis in the early diagnosis and tracking the progression of AD using real time images.

8. The current study revealed that the PMCI subjects are not exactly same as AD and may be converted to AD groups within 1-3 years.

9. The supervised classifiers, BPNN, MSVM and BFOANN identified one NCI subjects have some structural volume changes in the follow-up evaluations. These subjects may be considered in MCI category.

10. The BFOANN identified some significant volume change in the comparison of baseline and second follow up of one SMCI subjects. Mostly this subject will be included in the PMCI category.

11. This study also identifies neuropsychological and MRI measures in the Indian population that may serve as potential predictors of cognitive impairment or dementia in the elderly population in India.
12. The novelty of this work is the longitudinal analysis of MR images, the annual conversion rate from MCI to AD over a follow-up of 18 months was observed.
13. VBM and classification algorithms revealed the vast majority of the brain atrophy in the Gray Matter structures and corresponding enlargement of the ventricle in AD patients compared to the control subjects.
14. At the NCI to MCI comparison, Hippocampus is not an early marker of AD. Whereas, more pronounced hippocampal volume loss appeared in MCI to AD.
15. The supervised classification algorithms could get higher sensitivity and accuracy of classification than unsupervised clustering techniques. All the classification techniques prove useful in the early identification of subjects at risk for conversion to dementia and to assess the rate of atrophy in stable and progressive MCI subjects. The BFOANN has yielded the best performance in the classification algorithms.
16. In the comparison of NCI to MCI using VBM techniques can identify structural changes in the GM regions, but not significant. But in the case of classification algorithms can easily discriminate MCI from NCI.
17. In the Neuropsychological analysis 6 MCI patients converted to AD during a mean follow-up of 18 months, and remaining the 17 subjects continue the stable state in the baseline and follow-up evaluation. This result is not supported by the proposed CAD technique.

10.2 CONCLUSION

This thesis presented a comparison of the tissue segmentation algorithms of two computer aided diagnosis techniques such as VBM and classification algorithms for the early diagnosis and tracking of AD in MR images. The automated algorithms developed were implemented, tested and analyzed in the MATLAB image toolbox built-in functions allows to read, write and display the real MR images. Real data sets in a South Indian population were used to perform the comparison and to determine the efficacy of the respective segmentation algorithm. These methods revealed significant global and local atrophy in AD and MCI patients at baseline relative to healthy controls and characterization of atrophy in MCI, AD and prediction of disease course.

The VBM technique can provide very important information about regions of atrophy across group wise analysis but not in individually. All the
classification techniques prove useful in the early identification of subjects at risk for conversion to dementia and to assess the rate of atrophy in stable and progressive MCI subjects. The supervised classification algorithms could get higher sensitivity and accuracy of classification than unsupervised clustering techniques. The BFOANN has yielded the best performance in the classification algorithms. The BFOANN can easily discriminate the MCI from NCI based on the volumetric analysis of the GM and CSF. Validation of imaging biomarkers is important as they can help enrich clinical trials of disease modifying agents by identifying individuals at highest risk for progression to AD.

10.3 FUTURE DIRECTIONS

The present work focuses the classification algorithm only on the changes in the volume of GM, WM and CSF. Future research will show the respective images at ROI based analysis will give a better understanding of the regions or depths at which the change is happening and will be clinically more helpful in predicting the cognitive change. The novelty of this study is the demonstration of Neuro-anatomical correlates of structurally and regionally validated tools for assessment of cognitive functions in Alzheimer’s dementia from Indian sample. However, larger samples with comprehensive neuropsychological assessments are needed to specifically link structural and regional volumetric deficits in the brain with specific cognitive deficits in AD.

There are many simulations and testing platforms like MATLAB capable of delivering fast analysis on existing processors. Yet the scope for developing a standalone dedicated embedded system for this application is very much challenging and much awaited. Designing and developing a low cost and high performance embedded processor should beckon future research.