CHAPTER 6

CONCLUSION

This research work is attempted to investigate the changes occurring in white matter of brain due to the process of myelination on the axons. These changes happen throughout the life time starting from prenatal stage to late geriatric condition. Schmithorst et al (2002) states that maturation of brain structures and their connecting pathways is essential for the continuing development of both cognitive and motor functions, as the speed of neural transmission depends on the axon diameter and the thickness of the insulating myelin sheath. Such knowledge of the course of normal brain development and ageing provides the foundation for the recognition of pathologic brain development and decline says Courchesne et al (2000). In particular, white matter lesions are formed in among the brain's message-carrying axons which significantly affect cognitive function in old age.

Schmithorst et al (2002) also states that diffusion tensor MRI modality can be used to investigate and visualize the microscopic diffusion properties of water in living tissue. White matter fiber orientation can be determined by using DTMR imaging sequence, because water diffuses faster parallel to the longitudinal axis of axons than it does perpendicular to it. Therefore, among the in vivo magnetic resonance imaging techniques, DTMRI in particular is an extremely useful tool for looking at white matter.
6.1 CONCLUSION

The brain consists of more than 100 billion neurons, and each of these neurons has one axon. Each axon branch communicates with multiple neurons. Notably, axons that share similar destinations tend to form bundles, and as they travel toward the deep regions of the brain to achieve long-range connections, they form huge axonal bundles called white matter tracts, and this has been indicated by Andreia et al (2010). Alterations of the architecture of cerebral white matter in the developing human brain can affect cortical development and result in functional disabilities. Naama et al (2005) have demonstrated that during childhood and adolescence, white matter anisotropy changes in brain regions are important for attention, motor skills, cognitive ability, and memory. This typical developmental trajectory may be altered in individuals with disorders of development, cognition and behavior. Courchesne et al (2000) has shown that volume of white matter increases from early childhood to adolescence and remains as plateau or rate of increase decreases during fourth decade of life and it reduces for elderly volunteers. BWM is important in analyzing physiological/mental functions, which is widely present in corpus callosum (that contains the largest white matter tract in the brain). The corpus callosum (CC) is the primary connections between cerebral hemispheres, allowing for inter hemispheric integration of sensory, motor, and cognitive processes and this is stated in the literature by Muetzel et al (2008). Observation of such BWM changes is tried in this study using simple procedure and hence this study could be more significant.

In this study, brain maturation as reflected by changes in white matter density with age is investigated. Though the presence of white matter is found in many areas of the brain structure, BWM images are obtained from region parallel to long axis of corpus callosum. This is done because much
fiber tracts are found in corpus *callosum*, which interconnects two hemispheres of brain, and also BWM is the focus of discussion in this study. Johansen-Berg et al (2007) carried out an analysis on specific region for a particular function, by showing the variation in white matter integrity in a specific region in the body of the corpus *callosum* that is associated with variation in performance of a bimanual co-ordination, using diffusion-weighted magnetic resonance imaging.

The present study illustrates the state of normal development of BWM during 8 and 80 years of age and also on pathologic conditions. As well this study also suggests the effect of HIV and cerebral infarction on BWM. Textural features of DTMRI brain scans represent the property of BWM tissues and its structure. These features are obtained through various methods like GLCM, GRLM and eigen-decomposition. Gradual variation (some of the parameters increase while some decreases) in the feature parameters with respect to age can be seen among the subjects with normal (non-pathogenic) condition during the first five decades of life. However the feature parameters show an opposite response during next three decades. Most of the GRLM-based or GLCM-based feature measures shows a maximum response (peak value) around fifth decade of life. This could be interpreted as the generating nature of fiber tracts exists till fifth decade. But, it is very prominent during early decades. Geriatric conditions begin beyond 65 years. Hence the inbetween stage, that is between 40 and 55 years the changes in the feature values are less prominent indicating the steadiness of BWM tissues. Therefore it could be correlated to the mental stability of a person that dictates his/her behavioral aspects. Since white matter structure protects the channel responsible for neuronal communication, its complete formation during 40 and 55 years (as obtained from the results of this study) would definitely help to maintain balanced co-ordination in the human system.
For instance till 50 years, Figure 5.25 (a) suggests that entropy value increases indicating high disorderedness of the white matter texture increases with age on normal conditions, indicating the formation of patterns during early age. This value starts a drastic reduction beyond 65 years of age, indicating there is no more pattern formation or no generation rather only degeneration. On the contrary, Figure 5.25 (c) shows a decrease in the feature value (information measure of correlation), indicating the less loss of information or increase in retentivity of the brain upto the period of 55 years of age, beyond which this power is reduced.

From this it could be inferred that, for any human (without any neurological problem), stable state may be reached between fourth decade and first half of fifth decade of life. This could also be said that maturation of brain white matter is high during this period and then starts decreasing leading to normal ageing process. This result also tallies with the result obtained by Courchesne et al (2000) where they say that volume of BWM grows during initial part of life and reaches a plateau state by fourth decade of life and has significant reduction after 70 years. Hagmann et al (2010) have shown a positive correlation between structural and functional connectivity. Continuous increase in integration and decrease in segregation of structural connectivity of BWM promotes increased global efficiency. These are the result of differential modulation of axonal diameter and myelin thickness.

However, it can be seen that, when the feature extraction technique is applied to the pathogenic cases, HIV with PML shows a very wide variation in feature measurement and goes out of the normal range. But, the value of feature measures obtained from HIV with thrombosis and cerebral infarction the value of feature is well within the normal range. This result tells about the extent of BWM damage. For instance, in HIV with PML cases demyelination would be high, whereas in other two cases BWM damage is
very less and even in some of the case, BWM damage is completely absent. Therefore under any pathological condition if the structure of BWM tissues alters, then the value of textural measures becomes an indication to assess the gross abnormality/findings. Hence understanding gross abnormality could enable the subject for early treatment before going into irreparable state. Since white matter damage increases rapidly after the onset of PML as stated by Halvor et al (2010), early diagnosis could save the patient from irreversible condition.

Brain texture changes with age and hence from the structural variation of brain tissue, age of the subject could be determined. To explore this fact, structure of BWM is sensed via texture analysis technique and age based categorization is performed using BPNN. Though BPNN could do many tasks, this architecture is used here for the purpose of classification. The accuracy of the network would judge the physiological state of brain texture. Training phase of BPNN does not involve any pathological cases. By training the constructed network only with normal subjects, abnormality could be classified without any misclassification.

Thus the feature extraction methods advocated here leads to observation of gross abnormality in the DTMRI of subjects with brain damage due to viral (HIV) infection. Relevant observation is clinically linked to the viral infection with the supporting evidence of other diagnostic/prognostic details. Kirsi et al (2010) have said that one of the biggest challenges in addressing neuropsychological functioning and recovery from small injury is the diagnosis. A variety of imaging modalities are in use for this purpose. MRI is one imaging technique that is more suitable for brain related issues. MR images of tissues contain a lot of microscopic information that may not be assessed visually and texture analysis technique provides the means for obtaining these information. Random patterns rather than regular
textures are more often encountered in medical images. Basically texture is an image feature which corresponds to both brightness value and pixel locations from which texture analysis allows one to calculate mathematical patterns, texture features that can be used to discriminate and characterize the properties of tissues.

In summary, this study enables assessing the ageing process including geriatric state of a human subject via DTMR images of the brain. For this purpose, the image textural data of the subject’s brain are specified in statistical entities, and are used as feature vectors in a BPNN for training and prediction purposes. The BPNN classifies any given feature vector of the images to predict the age of the subject of the image and for detecting neurological state. The test results obtained on a subgroup of adult subjects indicate, in general, a generative/degenerative textural feature trend versus ageing. Such trends can be modeled via nonlinear growth/decay considerations.

6.2 FUTURE SCOPE

This study elaborately discusses the possibility of classifying brain DTMR images based on its texture on normal ageing process and on pathogenic states. If the results are further correlated with IQ tests and evaluation over the subject, then mental status at different stage of age could be discussed. Also, to understand/quantify the complexity of fiber orientation fractal dimension could also be adopted.