Abstract

Alzheimer's disease (AD) is the most widespread and fatal neurodegenerative dementia in the recent past. Prominent symptoms of AD include short-term and long-term memory loss, poor judgment, abstract thinking, disorientation of time and place, emotional outbreaks etc. AD substantially affects elderly persons and the progression of disease becomes worse over time. AD starts very slowly and is mostly detected at a later stage where treatment can only improve some temporary symptoms but reversal or termination of the progression of disease seems to be impossible. AD-related primary cognitive declinement is largely known as mild cognitive impairment (MCI) which has a very high tendency to be converted into severe AD as compared to healthy control (HC). Hence, the prevention of AD is mostly dependent on diagnosis at a trivial stage of MCI. Magnetic resonance imaging (MRI) is regarded as a reliable, non-invasive, and most effective tool for the diagnosis of brain diseases over a long time. This thesis work introduces various novel methodologies of analyzing MRI and Rf-MRI (Resting state functional MRI) images to develop the tools for detecting AD at an early stage.

Mild and severe AD is associated with tissue loss in the medial temporal lobe (MTL) and hippocampus. MCI can be more accurately identified by precise detection of object boundaries in brain MRI scans. Existing edge detection techniques fundamentally select each pixel in digital image space and examine whether they can be considered as an edge pixel or not. Proposed algorithm follows some other paths and finds out the connectedness and natural attachment of pixels that exist in edges of image object boundary. It figures out the connected edge line based on fuzzy weights of pixel intensities for brain MRI subjects. A novel fuzzy rule base and fuzzy inference system is implemented where a fuzzy pixel intensity-based topological selection of adjacent edge pixels is developed for higher-order precision. Since brain MRI scans are generally of low contrast, the presented algorithm extracts regional boundaries with more precision which becomes capable to predict or check disease progression. The presented method emphasizes on settling the primary edge pixel and figures out the next adjacent pixel that can be considered as an edge pixel depending on a dynamic fuzzy pixel intensity correlation algorithm. The selected edge pixels are further accumulated in the pixel matrix to identify the impression of edge

contour. Proposed algorithm leads to tracing early impairment in human brain and helps to detect MCI.

AD, associated with tissue loss in MTL and hippocampus, can be identified by correlated enlargement of the lateral ventricle (LV) region. In connection to this, a composite implementation of several algorithms is presented which is an improved extractor of LV in a form of a segregated entity. A robust morphological filtering process is presented that can eliminate noise, focus lateral ventricle and avoid overestimation in object boundary as well. An improved fuzzy c-means (FCM) clustering algorithm is successfully employed on test MRI images to enhance the lateral ventricle region information. Presented clustering algorithm iteratively uses improved FCM to settle for optimum clustering validity index. This process minimizes the chance of ventricular information loss and simultaneously avoids overestimation. By means of appropriate implementation of active contour without edges (ACWE) and region growing (RG) algorithms with proper seed point, the LV is separated as a single and connected entity for cerebral cortical atrophy subjects. The presented method exhibits superior ability to classify LV both qualitatively and quantitatively. It has subsequently been simulated on a large data set of different MRI subjects. The experimental outcomes demonstrate that the executed method efficiently segregates HC, MCI and AD subjects. Therefore, the presented technique may be used as a viable tool to detect early Alzheimer's disease.

Diagnosing brain MRI scans with an advanced FCM clustering algorithm helps to take appropriate intervention for tracing out MCI. A novel clustering algorithm is presented where firstly the sparsity is initiated for brain MR scans of AD subject. Secondly, a unique neighbor pixel constrained FCM clustering algorithm is designed and implemented where a topology-based selection of parsimonious neighbor pixel is automated. The adaptability in choice of neighbor pixel class creates a more justified object edge boundary. The presented adaptive neighbor constrained deviation sparse variant fuzzy c-means clustering (AN_DsFCM) can withhold imposed sparsity and withstand rician noise. This robust algorithm is applied for MRI of AD subjects and normative data is acquired to analyze clustering accuracy. The data processing pipeline of a theoretically plausible proposition is elaborated in detail. The experimental results are compared with state-of-the-art fuzzy clustering methods for test MRI scans. Visual evaluation and statistical measures are studied to meet both image processing and clinical neurophysiology standards.

Early identification of dementia can be achieved by diagnosis of blood oxygen level dependent (BOLD) signal-based functional magnetic resonance imaging (f-MRI) at resting-state. Detection of dementia at the stage of MCI is limited to effective spatial-temporal dependency. The functional connectivity (FC) among various hubs of human brain estimates neuronal health and disease progression. Due to motion-related artifacts at acquisition time, noise intervention, and many other reasons, the sparse constraint becomes predominant in Rf-MRI. A unique Kullback-Leibler (K-L) divergence-based sparse constrained regression model is presented, which creates a framework to identify and analyze connectivity between the hippocampus and other significant regions of interest (ROI) of brain. Experimental results demonstrate a promising improvement in hippocampus centric connectivity measurements. Outcome of simulated results also appears in the form of a whole-brain correlation matrix which shows significant improvement in connectivity constraints.

Since the MCI related tissue loss primarily affects MTL and hippocampus, the consequent functional connectivity degradation can be observed in Rf-MRI analysis. A three-dimensional model for FC analysis between hippocampus and parahippocampus is presented to trace the early signs of MCI. The FC between each hippocampal subfields and parahippocampal subfields in their entirety is examined. A quadratic detrending algorithm is implemented to model both complex scanner drift constraints and longer scan sessions. The noise interventions and motion-related artifacts and are also well handled by the presented framework. Outcomes in terms of correlation matrix demonstrate noticeable efficiency of dealing with functional connectivity constraints between hippocampus and parahippocampus. The entire process including full brain FC analysis leads to trace MCI related connectivity malfunctions.