Detection and Segmentation of Stroke Lesions from Diffusion Weighted MRI Data of the Brain

Abstract:

Stroke is a chronic disease which often leads to death. Different medical imaging modalities enable diagnosis for stroke after the onset of symptoms. Time is of the essence during stroke analysis since the window of therapy is very small (< 3 hrs after the onset of symptoms). Recent clinical studies have shown the usefulness and significance of diagnosing stroke on the *Diffusion Weighted Magnetic Resonance Imaging* (DWI) scans of the brain in the early stages. Visual inspection of the DWI scans is difficult since multiple scans are acquired for a patient with varied contrast and the scans depict complementary information about the diffusion process in the brain. To make matters worse, the DWI scans are acquired at a very low resolution with poor signal to noise ratio (SNR) since the time of acquisition is significantly less (< 1 min) and are confounded by artifacts that mimic stroke lesions. Thus, an automated framework which can accurately capture the stroke lesions in the DWI data would assist the clinicians in a better diagnosis. This is focus of the thesis.

Varying the acquisition parameter (*b-value*) generates different DWI scans with varied contrast. DWI with higher b-values provide improved sensitivity, conspicuity of stroke lesions and reduced artifacts at the cost of lower SNR. Along with the DWI scans, the Apparent Diffusion Coefficients (ADC) maps are also derived which give a measure of the true diffusion process in the brain irrespective of the acquisition artifacts that resemble stroke. In this thesis, we argue that integrating information from multiple sources, namely, low and high b-value data along with the ADC maps, can aid better characterization of stroke lesions in the data. Accordingly, we propose a novel approach for detecting and segmenting stroke regions from DWI data.

An automated framework comprising of three stages is proposed for accurately capturing the stroke lesions: (i) Stroke Detection (ii) Contrast Enhancement and (iii) Stroke Segmentation, utilizing information from low and high b-valued DWI data and the ADC maps. The detection stage utilizes the information from lower b-value data and the ADC data to identify the stroke lesions on the higher b-value data and reject the false positives due to low SNR in high b-value data. The detected stroke lesions are segmented using the higher b-value data and ADC information. Integrating information from the higher b-value data along with the ADC data helps better define the stroke lesion in the segmentation stage. An auto-windowing technique is designed to enhance the contrast of the stroke lesions in the DWI data prior to segmentation. The contrast enhancement scheme also assists the radiologists in the manual/visual diagnosis of stroke in DWI scans.

The proposed method was evaluated on datasets acquired from different scanners with different acquisition protocols. The performance evaluation of the proposed approach validates its robustness and effectiveness. Receiver operator characteristic

(ROC) analysis shows high values of sensitivity, specificity and area under the curve. The proposed system achieves a sensitivity of 0.96 at a specificity of 0.95 with the area under the receiver operating characteristic curve (AUC) of 0.987. Qualitative and quantitative analysis of the results presented in the study establish the strength and robustness of the method in capturing the small-sized lesions in the data which are often missed by segmentation methods operating on a single b-value data.