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Wavelet Graphs on Mutual Information Functional Connectivity for MS Patients in Resting State fMRI

Tuesday, June 10, 2014: 12:45 PM - 2:45 PM
Congress Center Hamburg
Room: Hall H

Submission Number:
1823
On Display:
Monday, June 9 & Tuesday, June 10
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Abstract

Cortical activity in the human brain introduces a complex spatiotemporal evolution, which is modulated by hidden functional connectivity (FC) [1]. The wavelet transform is a beneficial framework for multi-scale representation of the time series data such as functional magnetic resonance imaging (fMRI). In the analysis of resting state FC (rs-FC), fMRI data can be modeled as a graph of nodes and edges representing brain regions or image voxels, respectively, and in order to capture their interrelationship due to existing functional activities. In traditional graph, theoretical analyses of FC in rs-fMRI are based on measuring the correlation between time series of predefined nodes or random voxels in the human brain. However, correlation by itself does not capture higher-order interactions [2]. Moreover, in most available research works, the FC graphs have been partially defined by their binary adjacency matrix, whereas the FC graphs can be fully characterized by undirected weighted adjacency matrix [3]. Selecting the graph theoretical features is substantial for subject pool classification purposes, since the classic graph metrics are not able to discriminate the control subjects from the patients with multiple sclerosis (MS) [2, 4]; A chronic demyelinating disease of the CNS that affects brain both structurally and functionally. It has been shown that wide-spread abnormal network connectivity is present even at the earliest stages of this disease [5]. In this study, we developed a novel analysis technique for the evaluation of rs-FC in fMRI data based the weighted graphs called mutual information weighted graphs (MIWG) and spectral graph wavelet transform (SGWT) to differentiate MS from healthy controls. Two analysis types were used, one for group wise comparisons, and one for machine learning classification. Classification performance using leave-one-out cross-validation (1000 iterations) yielded a sensitivity of 78.40% and specificity of 90.40% to distinguish between MS patients and controls.