Classifying EEG Functional Connectivity Patterns Using A Multi-Domain Convolutional Neural Network

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Abstract: We exploit altered patterns in brain functional connectivity as features for automatic discriminative analysis of neuropsychiatric patients. Deep learning methods have been introduced to functional network classification only very recently for fMRI, and the proposed architectures essentially focused on a single type of connectivity measure. We propose a deep convolutional neural network (CNN) framework for classification of electroencephalogram (EEG)-derived brain connectome in schizophrenia (SZ). To capture complementary aspects of disrupted connectivity in SZ, we explore combination of various connectivity features consisting of time and frequency-domain metrics of effective connectivity based on vector autoregressive model and partial directed coherence, and complex network measures of network topology. We design a novel multi-domain connectome CNN (MDC-CNN) based on a parallel ensemble of 1D and 2D CNNs to integrate the features from various domains and dimensions using different fusion strategies. We also consider an extension to dynamic brain connectivity using the recurrent neural networks. Hierarchical latent representations learned by the multiple convolutional layers from EEG connectivity reveals apparent group differences between SZ and healthy controls (HC). Evaluated on resting-state EEG data, the proposed MDC-CNN by integrating information from diverse brain connectivity descriptors is able to accurately discriminate SZ from HC, outperforming support vector machines.