Modeling the Dynamics of Functional Brain Networks With BrainSTEAM

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Functional brain networks represent dynamic connectivity patterns among brain regions that change across cognitive states and in response to disease or injury. Graph-based models are a relatively new but rapidly developing approach for analyzing functional brain networks that provide unique benefits compared with other popular deep learning models such as CNNs and RNNs due to their explicit modeling of connectivity structures. However, previous frameworks have suffered from underuse of temporal data, data scarcity and sparsity, structural information loss, and overfitting. These issues prevent model usage in real world settings. To address these challenges, this study proposes a novel framework BrainSTEAM which integrates a Spatio-Temporal Chunking module with EdgeConv, Autoencoder, and Mixup approaches. The Spatio-Temporal chunking module is used to dynamically slice the time series of each subject to sub-sequence chunks to capture dynamic interactions between brain regions over time and increase training data size and variety; EdgeConv helps capture local connectivity structures in the brain; Autoencoder reduces data noise by identifying the most salient nodes in the brain during pooling and Mixup enhances model training through linear data augmentation using interpolation rather than concatenation. The framework is evaluated using two publicly available neuroimaging datasets on Autism prediction and gender classification tasks. Extensive experiments demonstrate that BrainSTEAM outperforms state-of-the-art models on both datasets, powers generalization to new data and provides insights into the mechanisms underlying our consciousness and various neurological and psychiatric disorders.

Awards Won:

National Security Agency Research Directorate : Third Place Award “Cybersecurity”