Editorial

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Characterizing Cognitive Activity in EEG Data Using Computational Neuroengineering Approaches

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Editorial

The human brain, one of the most complex and adaptive systems available to society, consists of tens of billions of processing elements (nodes) called neurons and over 100 trillion interconnections (links/edges). The essential challenge in unravelling the activity of the brain's billions of neurons and how they combine to form functional networks has been one of the major research challenges to the research community. This success of this exploration lies in the extraction of accurate, replicable information that characterizes the behaviour of a normal brain during its various functional states. Creation of time dependent correlations among the neuronal clusters during various mental activities is defined as the functional connectivity and the network created thereof is referred to as a functional network. The brain regions form functional clusters, defined as set of brain regions which interact more strongly than others, when such connectivity is created. The relationships between structural and functional brain networks are explored to demonstrate the implied impact of structural adjacency on the dynamics of neuronal interactions during various cognitive states.

Systematic investigation of measures and metrics to make reliable inferences becomes essential in the neurological analysis. As a result, sophisticated data search capabilities, statistical methods, complex network analysis and graph mining algorithms are needed to unfold and discover hidden patterns and correlations in functional brain networks. Investigations on functional connectivity have revealed several facts in healthy and unhealthy people. Overall functional connectivity decreases as humans grow from childhood (8-12) to adulthood (21-26). The functional connectivity analysis using MEG synchronization in patients with Alzheimer's disease has shown reduction in mean Phase Lag Index in the lower alpha and beta bands. Weighted networks derived from EEG data were used to understand that the clustering coefficient has decreased in patients with Schizophrenia. Understanding the behavior of these functional networks can also be achieved by viewing the brain through network perspective, since the network perspective gives both localized and distributed aspects of brain function which are analogous to segregation and integration principles respectively. Usage of graph theoretical analysis to understand the functional brain networks is developing rapidly. Graph theoretical analysis has been used to study the organization of functional brain networks and to differentiate between ADHD and non-ADHD using delta band of EEG data. Functional brain network analysis gains significance in that it introduces new approaches and methodologies to explore and understand the brain functional networks and study how the parameters of complex brain networks relate to cognitive functions. Further exploration would result in better quantification of cognition and hence improved understanding of cognitive abilities and mental functions, new non-invasive approaches (meditation and biofeedback) to augmenting cognitive function and hence help address mental health issues and better decision making under stress and potential to assist human performance modification.