INFORMATION-DRIVEN BRAIN NETWORK MODULE DETECTION: INSIGHTS FROM AGING AND ALZHEIMER'S

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Abstract: In the study of brain networks, modules play a crucial role as they represent subsets of highly interconnected nodes, typically comprising anatomically neighboring or functionally related cortical regions. Accurate module detection aids in revealing meaningful substructures that bridge the gap between brain structure and function. Conventionally, the Louvain algorithm has been employed for module detection in brain network analysis. However, it has many limitations, including a tendency to merge weakly connected modules, sensitivity to initial parameters, a lack of a module evaluation mechanism, and the clustering of all nodes into modules without discrimination. This research proposes the use of information-based Affinity Propagation clustering (AP) as a more natural way for brain network analysis. AP offers advantages such as speed, universal applicability, promising results, and the absence of initial parameters. Additionally, an Adaptive AP (AAP) approach is introduced to overcome the limitations of traditional AP. The primary objective of this study is to apply AP and AAP using different similarity matrices to identify modules within human structural brain network data. This approach has not been previously explored in brain networks. Comprehensive experiments were conducted on structural brain networks of older adults and Alzheimer's subjects, employing various similarity matrices (the diffusion kernel, the shortest path-based distance, and the Pearson correlation coefficient) along with AP and AAP. Using Euclidean distance for each subject and the average brain network, demonstrate the effectiveness of our technique. The results indicate that our approach outperforms the Louvain algorithm, providing a promising avenue for further advancements in brain network analysis. We show that the communities are more modular in older people, and Alzheimer's leads to a progressive and increasing reconfiguration of modules and a redistribution across hemispheres.

Keywords: Affinity propagation, Aging, Hub, Similarity matrix, Structural brain network