MNET 2.0:
Big Graphical Mining of Multimodal Brain Networks

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http://neuroimage.yonsei.ac.kr

Introduction

In recent years, network analyses of neuroimaging have played key roles in understanding large-scale structural and functional human brain connectome. Besides, data mining of brain networks has become a global issue in the new discovery science for the brain. Despite the importance of lots of public databases, as a big data for brain networks, we still lack simple and automatic pipeline for analyzing brain networks using multimodal imaging data in the perspective of the structural-functional integration and data mining. Taking all of these into consideration, here we propose a MATLAB-based toolbox combining multimodal network analysis, construction structural and functional connectivity matrices, extraction graph-theoretical featrues of network and structure-function relationships, group level statistical analysis, data mining using machine learning.

Methods

MNET offers various analysis methods based on the graph theory; node definition, edge definition, and topology for each modality (fMRI, EEG, and DTI).

Node definition

First step to explore brain network is to define unique and homogeneous nodes from the continuous medium of the cortex. For this purpose, MNET provides several advanced methods to define network nodes from existing atlas map using spatial ICA (Kim et al., Human Brain Mapping 2013) or Anatomical-constrained Hierarchical Modularity Optimization (Park et al., PLoS ONE 2013).

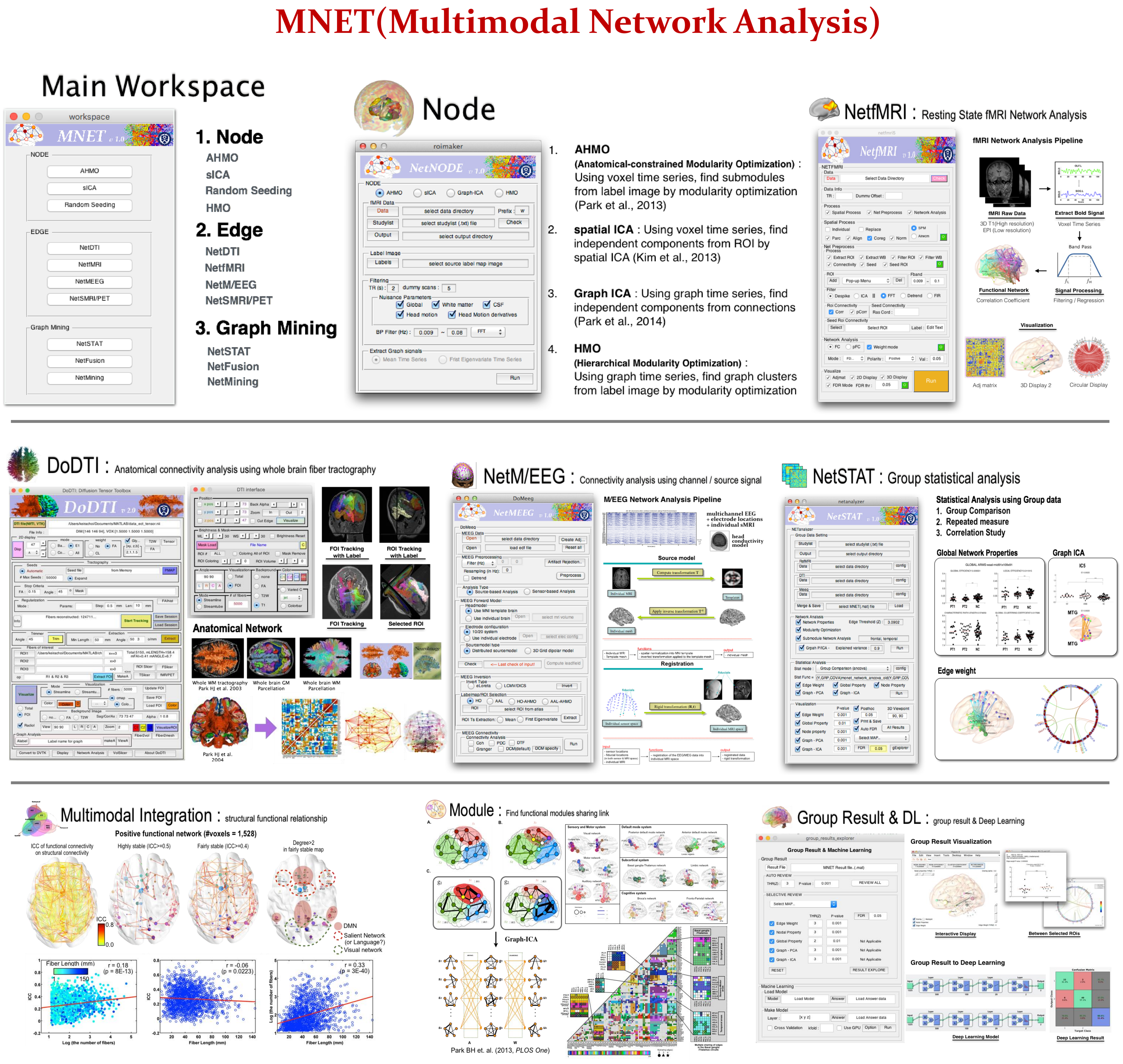
rsfMRI / DTI / EEG Connectivity

Edges can be defined functionally using correlation of fMRI or coherence of EEG time series among nodes. On top of that, existing standard preprocessing pipeline for resting state fMRI (e.g. regression of nuisance variables for physiological signal and motion effect, temporal band-pass filtering) was also designed in MNET. Correlation is calculated in three way. Pre-defined anatomical labels, Seed , SeedROI. DTI based network is constructed using fiber tractography in DoDTI (http://neuroimage.yonsei.ac.kr/dodti) and counting number, length and mean FA of fibers that pass through the nodes, based on pre-defined anatomical labels, which are registered to the individual space to obtain weighted adjacency matrix.

Sub-networks and Topology

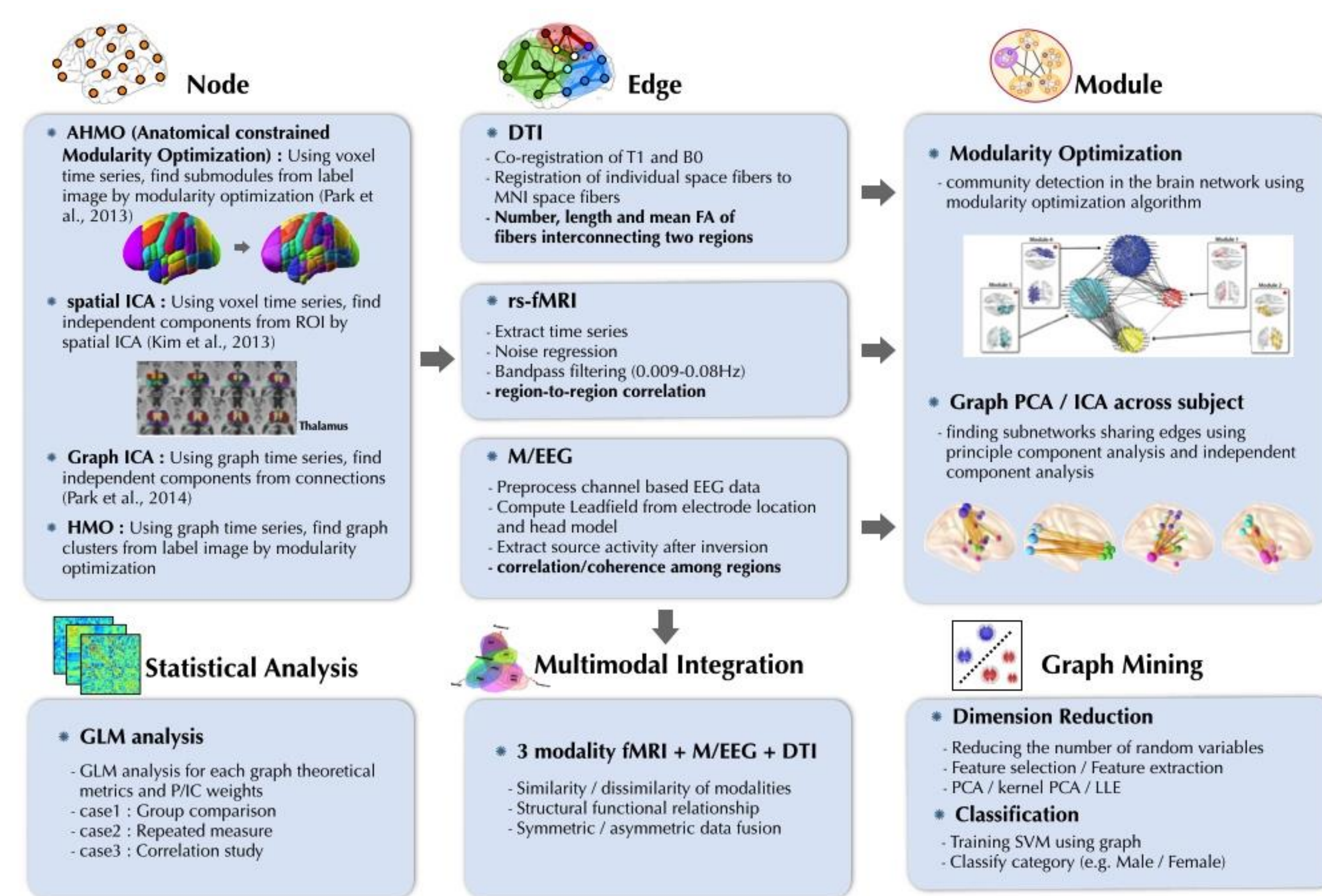
We offered various analysis methods including univariate and multivariate approaches to reveal edge and topological network (e.g. topological properties, graph ICA, modularity optimization). For example, graph ICA can be used to decompose networks into edge-sharing independent subnetworks (Park et al., PLoS ONE 2014). Finally, MNET provides methods for combine and analyze three network modalities.

MNET(Multimodal Network Analysis)



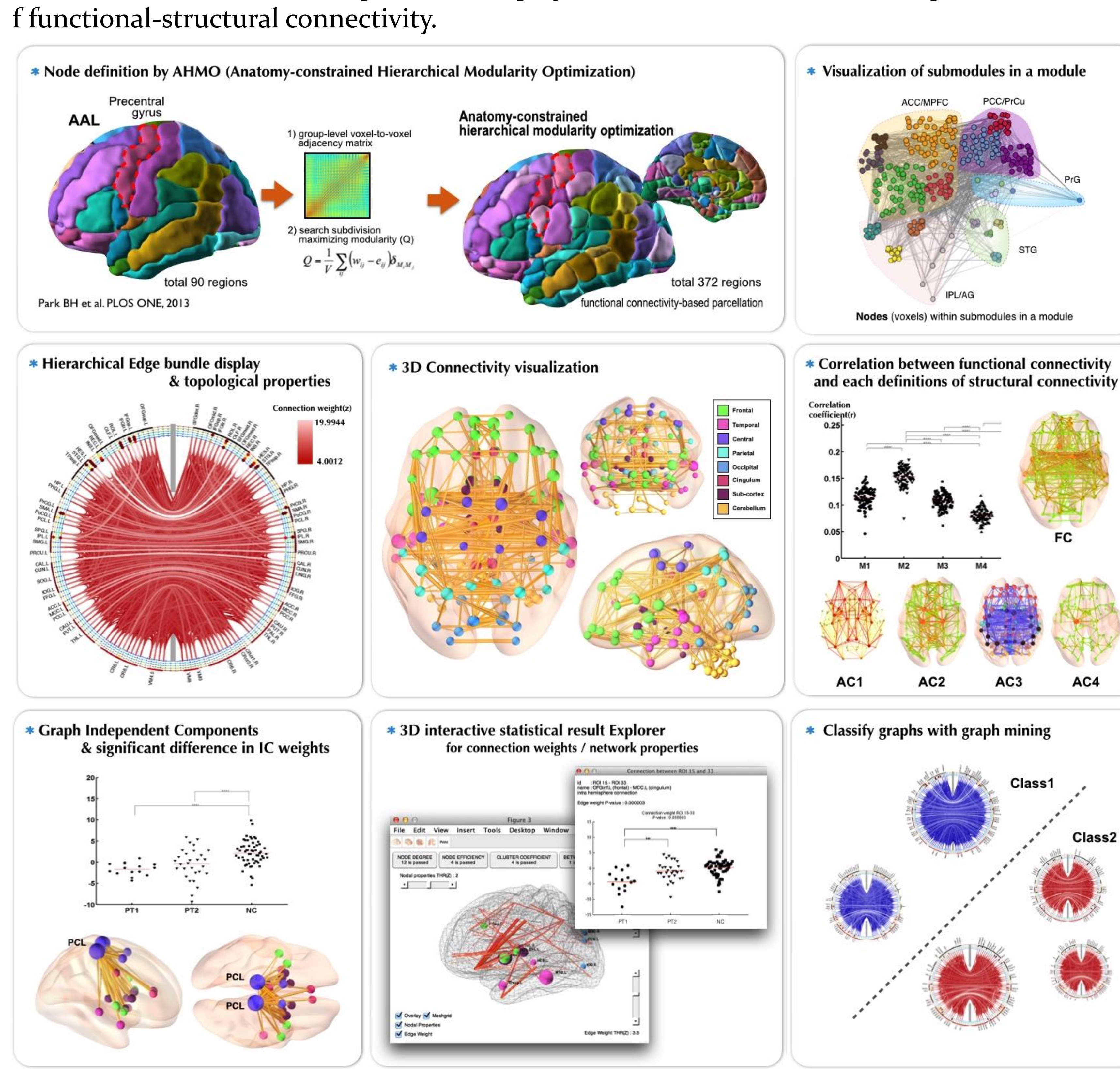
MNET incorporates the network property calculation codes from the Brain Connectivity Toolbox developed by the Sporns group (http://www.brain-connectivity-toolbox.net), and it uses several UI control and other functions from the SPM software (the Wellcome Trust Centre for Neuroimaging, UCL: http://www.fil.ion.ucl.ac.uk/spm/).

Procedures in MNET



Visualization

MNET can produce the results of functional and structural connectivity for each subject. Moreover, using series of graph metrics and adjacency matrices, it could conduct group level study (e.g. general linear modeling including ANCOVA with additional demographic covariates). MNET provided various interactive and informative visualization techniques; 3D-visualization containing edge weights, node degree, and time series plot of each node, colored adjacency matrices, and hierarchical edge bundle display. It could be used for combining visualization of functional-structural connectivity.



Conclusion

In this study, we presented a toolbox MNET, which has fully automated pipeline analysis system of functional and structural connectivity from rs-fMRI, M/EEG and DTI. This toolbox can cover from preparing process for graph-theoretical measurement to statistical analysis. MNET shows the relationship between structural and functional connectivity through comparing their metrics and displaying them together. Also, the toolbox has high usability with both intuitive Graphic User Interface and command-based running. We expect MNET could also be an important tool for clinical application in the diagnosis and prognosis