Complex brain networks: graph theoretical analysis of structural and functional systems

Structural and functional brain networks can be explored using graph theory through the following four steps:

1) Define the network nodes. These could be defined as electroencephalography or multielectrode-array electrodes, or as anatomically defined regions of histological, MRI or diffusion tensor imaging data.
2) Estimate a continuous measure of association between nodes. This could be the spectral coherence or Granger causality measures between two magnetoencephalography sensors, or the connection probability between two regions of an individual diffusion tensor imaging data set, or the inter-regional correlations in cortical thickness or volume MRI measurements estimated in groups of subjects.
3) Generate an association matrix by compiling all pairwise associations between nodes and (usually) apply a threshold to each element of this matrix to produce a binary adjacency matrix or undirected graph.
4) Calculate the network parameters of interest in this graphical model of a brain network and compare them to the equivalent parameters of a population of random networks.

Some methods to investigate brain functional systems have been developed, including mathematical models of effective connectivity between regions. effective connectivity models, such as structural equation modeling, dynamic causal modeling or Granger causality, involve estimating the causal influence that each element of a system exerts on the behavior of other elements.