Analyzing Functional Brain Connectivity by means of Commute-Times: in pursuit of attentional modulations based on multi-trial event-related responses

Dimitriadis S.I. (1,2) , Laskaris N.A. (2), Tzelepi A. (3)

1)Electronics Laboratory, Department of Physics, University of Patras, Patras 26500, Greece;
(2) Artificial Intelligence & Information Analysis Laboratory, Department of Informatics, Aristotle University, Thessaloniki, Greece;
(3) Institute of Communication and Computer Systems, National Technical University of Athens, Greece

1.Introduction
We introduce commute times (CTs) as an alternative way to capture the true interplay between the nodes of a functional connectivity graph (FCG). Commute time is a measure of the time taken for a random walk to set-out and return between a pair of nodes on a graph. Its computation is considered here as a robust and accurate integration, over the FCG, of the individual pairwise measurements of functional coupling.

2.CT's: Outline & Algorithm
Considering that an FCG is given with nodes corresponding to the recording sites or regions of interest (ROIs, usually associated with particular brain regions or areas), the computations of CTs involve the corresponding adjacency matrix A and the weight matrix W, in the entry w(u,v) of which the strength of functional dependence between the nodes u and v is tabulated.

a) The diagonal weighted degree matrix T is first derived with elements defined as:

\[ T_{u,v} = \sum_{n=1}^{N} w(u,v) \]

b) The spectral decomposition of the formed matrix is performed

\[ L = \Phi \Lambda \Phi^T \]

where \( \Lambda = \text{diag}(\lambda_1, \lambda_2, \ldots, \lambda_N) \) is the diagonal matrix with the ordered eigenvalues as elements and \( \Phi = (\phi_1^T \phi_2^T \ldots \phi_N^T) \) is the matrix with the ordered eigenvectors as columns.

c) These eigenvectors (excluding the first one) are used to form the matrix G (which is the pseudo-inverse of L and related to Green's functions with elements)

\[ G(u,v) = \sum_{i=2}^{N} \phi_i(u) \phi_i(v) \]

d) Finally the CT matrix is derived with entries

\[ \text{CT}(u,v) = \text{vol}(I_{1/2} - G(u,v) + G(v,u) - 2G(u,v))I_{1/2} \]

\[ \text{vol} = \sum_{u,v} \text{vol}(u,v) \]

3.Wspl vs CTs

4.Experiment

5. Flowchart of the method

6.Constructing TVFCGs: CTs, W, Wspl

7.Results

8.Discussion

References: