Neuroengineering 2023-2024

April 4th 2025

Part II

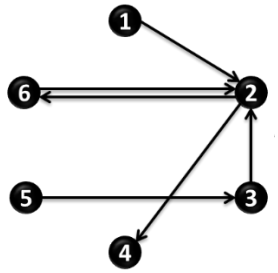
Solutions

Q1. The study takes place immediately before and after brain surgery, so invasive (intracranial) measures can be acquired. Since the regions involved are all subcortical, stereo EEG is the right choice. Other measures are either not sufficiently accurate (e.g. scalp EEG) or target different regions (e.g. ECoG).

Q2. Among the connectivity estimators studied in the course, the best choice would be Partial Directed Coherence. In fact, it is clearly stated that the goal is to build directed functional brain networks, so we need a causality-based method, which limits the choice to PDC or the Granger test. However, we need a spectral estimator since it is known that resting state activity occurs in theta and alpha bands. This limits the choice to PDC. Pros: it is directional and spectral as required; it is multivariate, so it can mitigate the common source problem and return more accurate networks. Cons: the model used is more complex, with many parameters, which requires long recordings to maintain the ratio between the number of samples and the number of parameters. However, in this scenario it is assumed that we have long recordings, so this limitation is acceptable.

Q3.1:

Pre condition:

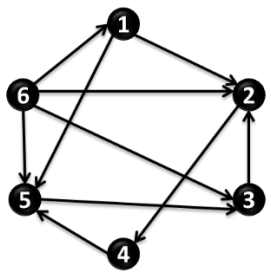


D_{PRE}=

-	∞	∞	∞	∞	∞
1	-	1	∞	2	1
∞	∞	-	∞	1	∞
2	1	2	-	3	2
∞	∞	∞	∞	-	∞
2	1	2	∞	3	-

$$E_{gPRE} = \frac{1}{6.5}\left(6 + \frac{5}{2} + \frac{2}{3}\right) = 0.32$$

Post condition:



D_{POST}=

-	∞	∞	∞	∞	1
1	-	1	3	2	1
2	3	-	2	1	1
2	1	2	-	3	2
1	2	3	1	-	1
∞	∞	∞	∞	∞	-

$$E_{gPOST} = \frac{1}{6.5}\left(10 + \frac{7}{2} + \frac{4}{3}\right) = 0.49$$

Q3.2: Global Efficiency is a measure of how effective the communication in the network is. Comparing the two conditions, we can see that the POST condition has a higher value of E_g with respect to the PRE condition. Therefore, after the surgery, the effectiveness of communication in the network has increased.