SpectraVis: A web application for analyzing dynamic, task-related functional networks

Eric L. Denovellis Emily P. Stephen

Summary: Functional network analysis is a growing area of research, but as technology improves and recordings include more sensors, the dimensionality of the networks can make analysis unwieldy and hard to interpret. Dimensionality is particularly problematic with increasing network size, because the number of possible connections in a network scales quadratically with the number of sensors (e.g. electrodes), and the networks can vary over time and frequency. Additionally, researchers may be interested in several spatial scales such as analyzing connectivity within and between brain regions. While careful statistical modeling and strong hypotheses are important for reducing dimensionality, interactive visualizations are an often neglected tool for coping with high-dimensional analyses.

Visualizations allow us to quickly make multiple simultaneous comparisons, easing the cognitive burden on working memory by efficiently encoding properties of the data into features salient to the visual system. Adding interactivity can allow the user to change perspectives and modify analyses on demand, further facilitating comprehension and hypothesis generation.

Here we present an interactive web-based visualization application, SpectraVis, that: (1) displays task-related functional networks over time and frequency, (2) compares individual and associative measures on sensor pairs (e.g. spectra and coherences), (3) compares different measures of association (e.g. correlation vs. coherence, binary vs. weighted networks), and (4) views networks at two spatial scales (sensor- and region-of-interest-level). The different modules of SpectraVis are dynamically linked, highlighting relationships between the metrics in response to user interaction. We demonstrate its capabilities on an electrocorticography (ECOG) dataset collected during an overt reading task. We believe this application will be of interest to the COSYNE audience because visualization is an essential tool for understanding these datasets at all stages of analysis and current practices for visualization of brain networks do not reflect their richness and complexity. Additionally, SpectraVis is open-sourced and open to use and development by the community.

Detail: A working example of SpectraVis[1] can be found online[2] and the code is accessible on Github[3]. Figure 1 shows a typical view of SpectraVis. The network view shows the anatomical location of the sensors (circles with sensor number) and edges (lines) weighted by the edge statistic. In this case the edges are binary, representing significant changes in local field potential coherence between *Speech* — subjects reading the words of the Gettysburg Address — and *Silence* at a particular frequency (10 Hz) and time (187.5 ms after speech onset). The network has dense connectivity within and between primary motor and primary somatosensory cortices (M1 and S1). The controls can be used to play a movie of the network over time, showing increased connectivity starting within M1 300ms before speech onset and spreading to S1 100 ms before speech onset. Below the network view is a sensor view (dotted box) which depicts the relationship (spectra and coherences) between a selected pair of sensors (circled in black, network view, sensors 85 and 90) at all times and frequencies. Here, the edge between M1 and S1 — representing a 10 Hz increase in coherence relative to baseline — cooccurs with higher frequency beta (15-25Hz) power suppression on the M1 sensor (sensor 90).

[1]Data provided by Dr. Gerwin Schalk and Dr. Peter Brunner at the Wadsworth Institute in Albany, New York.
[2]http://ericdeno.com/research/SpectraVis
[3]https://github.com/edeno/SpectraVis

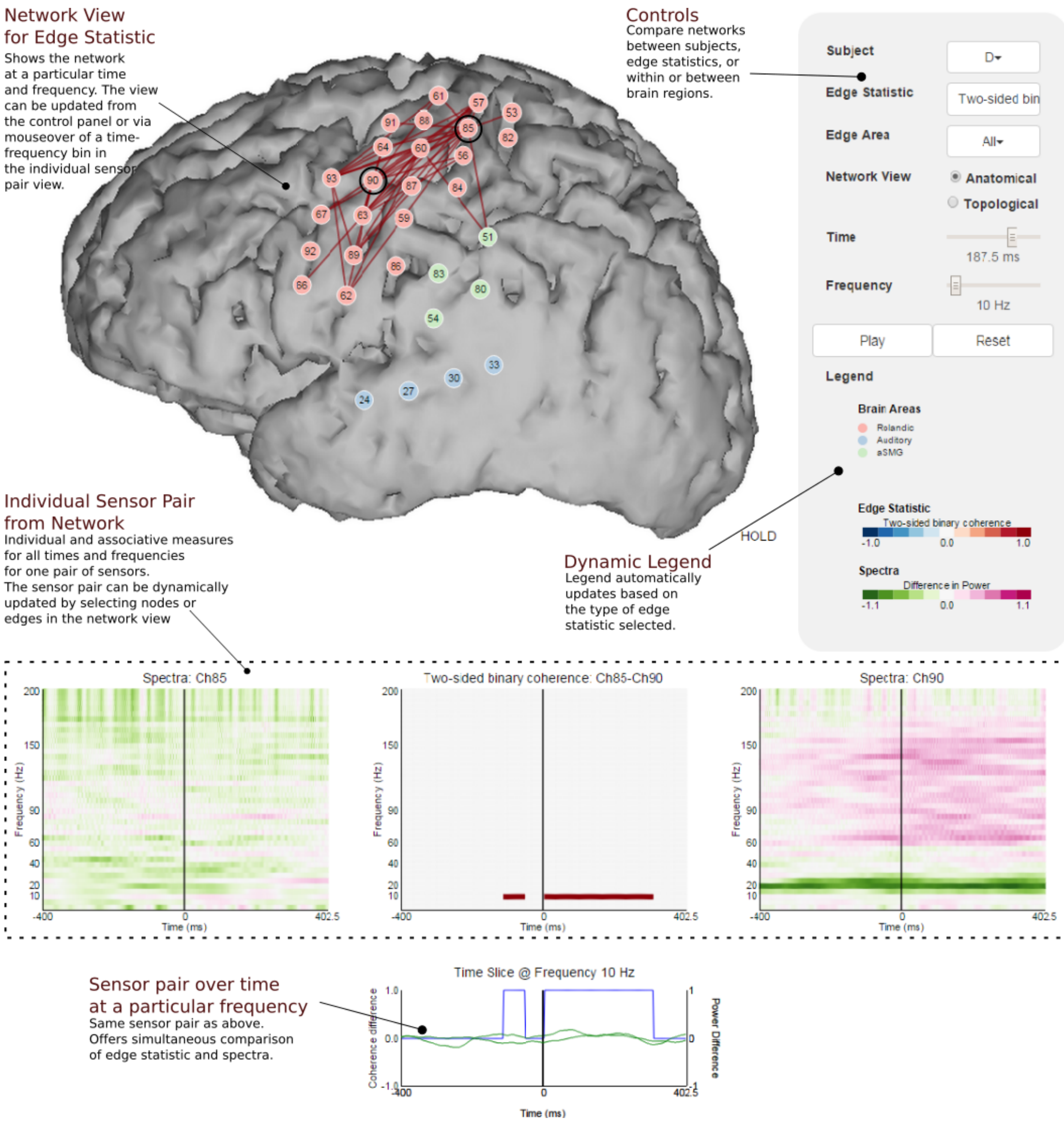

Figure 1: A static screenshot of the SpectraVis interface with the ECOG overt reading data. The network inference methodology is described at http://search.proquest.com/docview/1731940762?accountid=9676