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 neuroscience research, driven in part by technological improvements allowing us to record from more sensors simultaneously. However, as researchers record from more sensors, network analyses can become unwieldy and hard to interpret, because the number of possible network connections scales quadratically with the number of sensors (e.g. electrodes). Further, we expect neural processes to form dynamic networks that vary over time, frequency, and spatial scales (e.g. within and between brain regions), adding complexity to network analyses. While careful statistical modeling and strong hypotheses are important for yielding interpretable results, interactive visualizations are a neglected tool for coping with high-dimensional analyses.

Visualizations allow us to 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 allows the user to change perspectives and modify analyses on demand, facilitating comprehension and hypothesis generation.

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, 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 dataset collected during an overt reading task. We believe this application will be of interest to the COSYNE audience because network analysis is prevalent in systems neuroscience, visualization is essential for understanding networks at all stages of analysis, and current visualization practices do not reflect network richness and complexity. Additionally, SpectraVis is open-source and free to use 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 example, the edges are binary, representing significant changes in local field potential coherence between *Speech* — subjects reading aloud the words of the Gettysburg Address — and *Silence* at a particular frequency (10 Hz) and time (187.5 ms after speech onset)[4]. 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 300 ms 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, 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 (sensor 90) and S1 (sensor 85) represents a 10 Hz increase in speech coherence relative to silence. The increase co-occurs with higher frequency beta (15-25Hz) power suppression on the M1 sensor. Mousing over these displays updates the network view to the time-frequency bin under the cursor.

[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
[4]Details of network construction methodology: http://search.proquest.com/docview/1731940762?accountid=9676

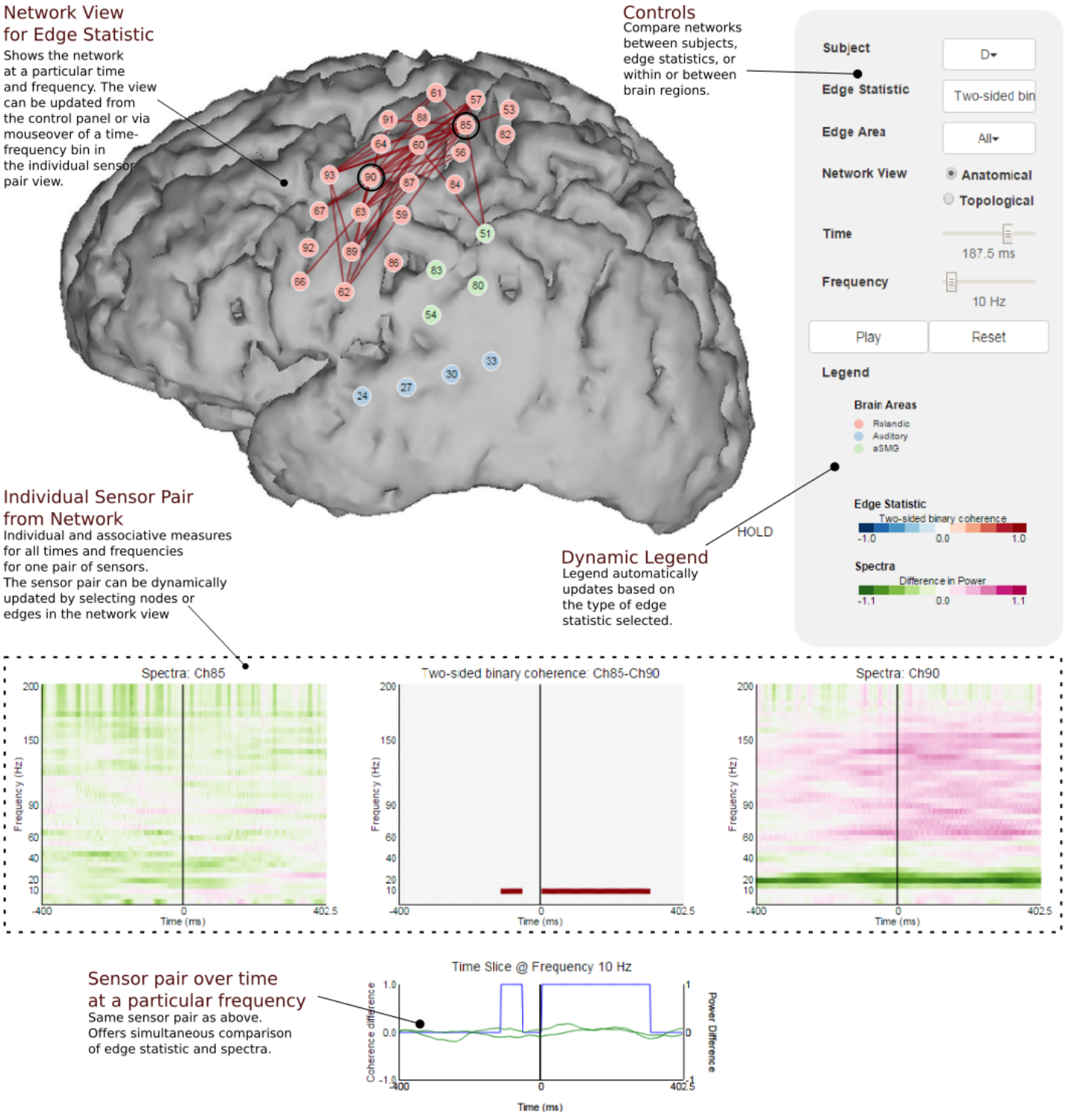

Figure 1: A static screenshot of the SpectraVis interface with the ECOG overt reading data.