A Statistical Model for Spatiotemporal Activity in the Brain

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Abstract
This project explores methodology for developing a brain-wide baseline of spatial and temporal correlates. To date, this has never been done. Yet, the utility for such a model is widespread, including applications for improving EEG source and silence localization, improved implants for the prevention of epileptic seizures, and much more.

Methodology
Data Collection
ECoC data was used since it is collected intracranially, and therefore isn’t affected by the resistance of the skull. The data was compiled from ten Stanford experiments using a total of 29 epileptic patients, representing the whole brain.

Data Processing
• Isolated data from times where no experimental stimuli was being given
• Spatial Filter
• Notch filter for 60 Hz harmonics
• Cross Correlation

Spatial Filtering Options
common average reference spatial filter

\[ V_i(t_j) = \frac{\sum_{i\neq j} V_i(t_j)}{I}, \text{ where } I = 1, \ldots, N_{ch}, j = 0, \ldots, I_f \]

Laplacian spatial filter

\[ V^L_i(t_j) = \frac{\sum_{i\neq j} V_i(t_j) - V_j(t_j)}{\sum_{i \neq j} 1}, \text{ where } I = 1, \ldots, N_{ch} \]

spatial filtering was conducted using a corner reference electrode

First, a common average reference was used. The correlation data showed a trend of dipping negative before starting to level off at 0.

Results
Correlations are expected to be positive since all the data was collected on gyri. Correlations are expected to be negative when neurons face opposing directions, which occurs in sulci.

Next a Laplacian filter was tried; however, this produced many negative correlations.

Utilizing corner reference electrode is the most effective spatial filter for analyzing this ECoC data.

Next Steps
• Determine if the correlation follows exponential decay by analyzing the semi-log plot
• Filter the noise out of the data
• Map the correlations across brain regions
• Test the impact of the baseline of spatial correlates on improving silence localization techniques.
• Apply the same procedure to assessing auto-correlation. This provides correlation information across both space and time. This is likely to be the most effective method for improving silence localization.

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Citations

Introduction
What are potential brain silences?
Ischemic, lesioned, and necrotic tissues have little or no activity. These are caused, among other things, by ischemic stroke, TBI, intracranial hematomas, resected tissue, and demyelination.

Why use EEG for silence localization?
EEGs are more cost effective and portable. This would afford patients the ability to monitor tumor growth more frequently and would also allow EMTs and doctors the ability to quickly assess patients in the case of an emergency.

Why is silence localization difficult?
Source localization, along with silence localization is an inverse problem, which is ill-defined. This leads to the identification of a candidate region, reflecting uncertainty. Unlike source localization, silence localization cannot rely on tracking the propagation of current.

What resolution can you expect from EEG?
In the best scenario, one would hope to identify a 5-10 mm silence (MRIs have ~1 mm resolution).