Improving Statistical Rigor in Intracranial EEG with RAVE, A New Software Tool

Patrick J Karas MD; John F Magnotti PhD; Zhengjia Wang; Daniel Yoshor MD; Michael S. Beauchamp PhD
Department of Neurosurgery, Baylor Colleg of Medicine; Department of Statistics, Rice University

CNS 2018 ANNUAL MEETING
HOUSTON, TEXAS
OCTOBER 6–10, 2018

Baylor College of Medicine

Introduction

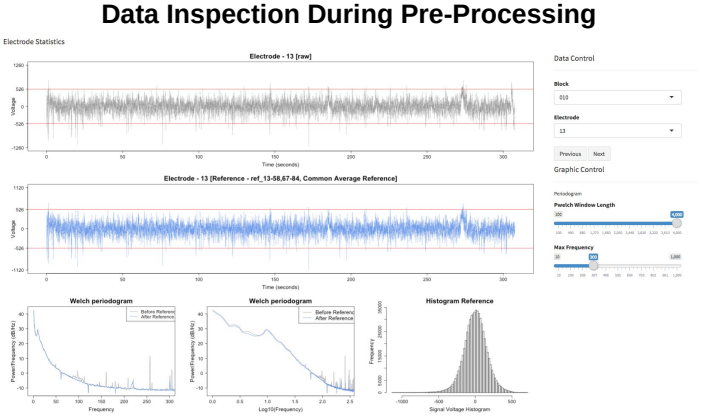
Direct recording of neural activity from the human brain with intracranial electroencephalography (iEEG) is one of the fastest-growing techniques in human neuroscience. While the ability to record from the human brain with high spatial and temporal resolution has resulted in high-impact advances in understanding fundamental mechanisms of brain function in health and disease, it generates staggering amounts of data.

Presently laboratories must code their own analyses using toolkits not designed for iEEG, leading to amalgams of code driven by expediency and unique to each laboratory. In order to advance iEEG research, we have developed a new software package for the analysis of iEEG data named RAVE (R Analysis and Visualization of Electrocorticography).

Methods

The design philosophy of RAVE aims to keep users "close to the data" so that users may make discoveries without being misled by artifacts. RAVE incorporates a well-designed graphical user interface that allows users to easily select portions of very large datasets for analysis. RAVE also incorporates rigorous statistical methodology. Our development team includes expertise in statistics and computer science. RAVE is implemented in R, a language with a rich framework of existing packages developed by leading statistical and machine learning researchers, and includes ports to Matlab and Python.

Data Inspection During Pre-Processing



Each pre-processing step encourages the user to inspect how their data has been transformed. Here the effect of common average referencing is displayed on an electrode time-series.

Pre-Processing

RAVE includes a preprocessing pipeline consisting of notch filtering, wavelet transformation, re-referencing, and epoching. After each step, the data is displayed to allow users to look for indroduction of errors into the data.

Time-Frequency Analysis

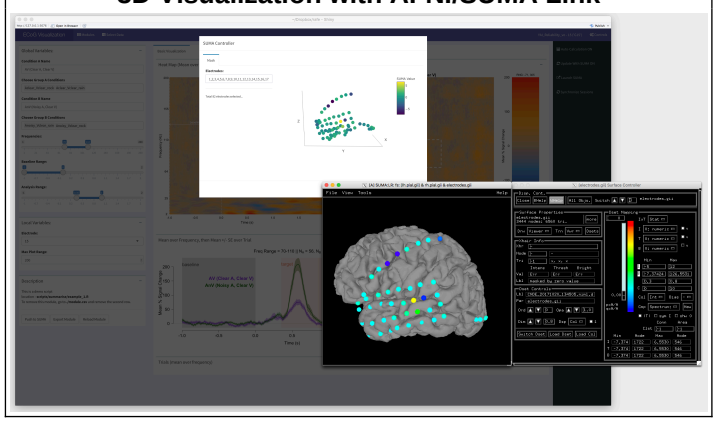
An interactive time-frequency analysis GUI allows quick comparisons between experimental conditions.

Time-Frequency Analysis

Visualization

RAVE is built to work with AFNI/SUMA, NIH's fMRI software. With the click of a button, statistical analyses performed in one of RAVE's toolboxes can be repeated across all intracranial electrodes and displayed over the patient's brain in SUMA's 3D viewer.

3D Visualization with AFNI/SUMA Link



Collaborative Analysis

RAVE is open source software, and is designed to be expandable. Users can write their own analyses packages that can be shared accross the RAVE platorm.

RAVE is built using the R Shiny toolkit mandating a client-server design. RAVE is able to run on a central server accessible from any device with a web browser. This permits a paradigm shift in peer reviewability and data/analysis sharing. Labs performing analysis with RAVE can provide hyperlinks for published figures, directing readers to live RAVE modules in which readers can easily replicate analyses (and assess robustness) in real time while reading papers.

Conclusions

RAVE is a statistically rigorous software platform for analyzing iEEG. As the software continues to evolve, it is bringing clinicians without rigorous programming backgrounds closer to iEEG data, making complex statistical tools accessible and bringing neuroscience discoveries closer to the clinician.

Learning Objectives

- Understand current barriers to iEEG analysis and data sharing.
- Present a new graphical user interface based software package allowing researchers without significant programming backgrounds to analyze iEEG datasets.
- Try the software at **https://openwetware.org/wiki/Beauchamp:RAVE**.

References

- Chang, W., Cheng, J., Allaire, J., Xie, Y., & McPherson, J. (2017). shiny: Web Application Framework for R. R package shiny version 1.0.5. Comprehensive R Archive Network (CRAN).
- Cox, R. W. (1996). AFNI: software for analysis and visualization of functional magnetic resonance neuroimages. Computers and Biomedical Research, 29(29), 162–173.
- R Core Team (2017). Vienna, Austria: R Foundation for Statistical Computing.

A beta version of RAVE is accessible online at **https://openwetware.org/wiki/Beauchamp:RAVE**. RAVE supports ECOG and sEEG.