A web-based visualization tool for large-scale functional human brain networks

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Highlights:

1. Our tool provides a web-based user interactive 3D visualization of the EEG signals on the human brain and compute network metrics to quantify dynamics and interactions across various regions of the brain.

2. We have used one common Graph theoretical measure i.e, clustering coefficient to distinguish between resting and non-resting brain states from the EEG data.

3. This tool holds the posibility of easy the accessibility and early diagnose of brain disorders and diseases, including depression, schizophrenia, and epilepsy.

Introduction

Modern neurotechnologies provide us with unprecedented windows into brain structure and function, and network neuroscience is well poised to make sense of and exploit the resulting data. Electroencephalography (EEG) is a non-invasive electrophysiological monitoring method that can provide a characteristic representation of the human brain's physiological and pathological states. The networks built from correlations between regional activations describe dynamic brain states and hold the ability to diagnose brain disorders and diseases, including depression, schizophrenia, and epilepsy. Yet, there remains a gap between this knowledge and clinical practice.

Generally, EEG data is visualized on various software which places undesirable constraints on the Operating System and limits accessibility.

Methodology

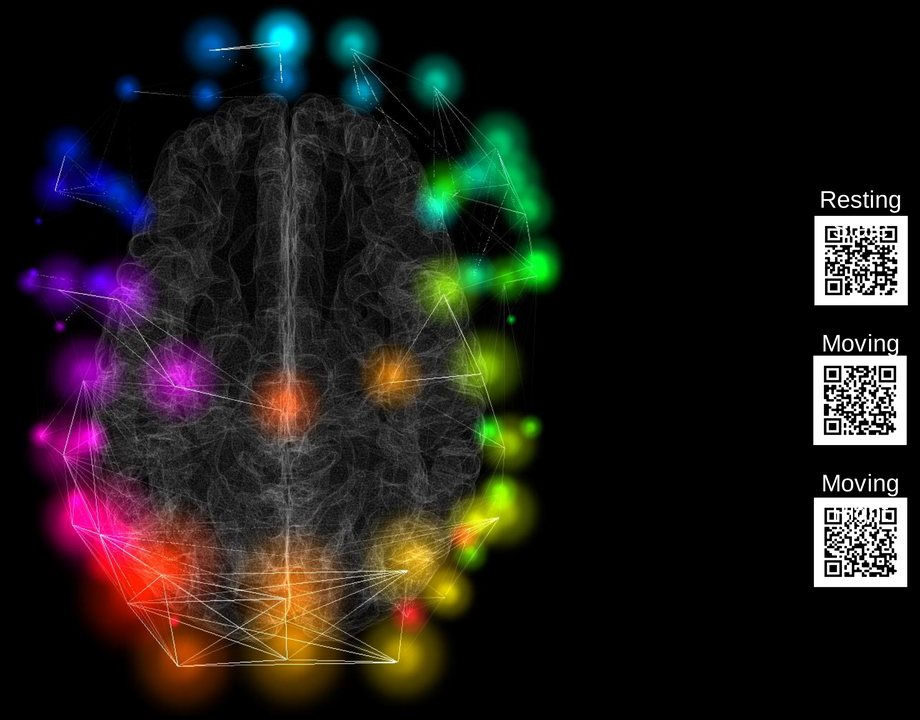
We developed a web-based, open-source application using Python and JavaScript to provide a user-interactive visualization of brain activity displayed as a time-varying 3D network.

Here, nodes correspond to the recording sites of EEG cap electrodes on the head, while the links represent connection strengths (functional correlations) between brain areas at the recording sites.

Our tool can pre-process raw EEG data and compute various graph-theoretic such as degree, clustering coefficient, path lengths, etc.

It can generate functional and effective connectivity from a range of methodologies, including partial correlation and Granger causality.

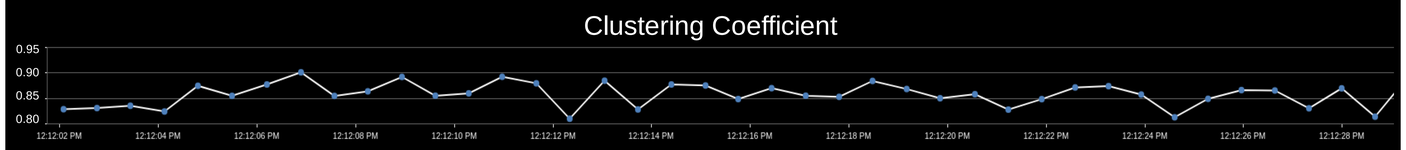
Users can adjust all computational parameters, and display network properties as varying node sizes and links as a function of time. This allows users to access and interpret brain-wide activity easily.



Resting

Moving

Moving



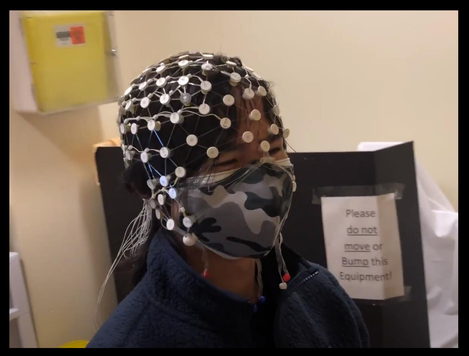


Fig. 1

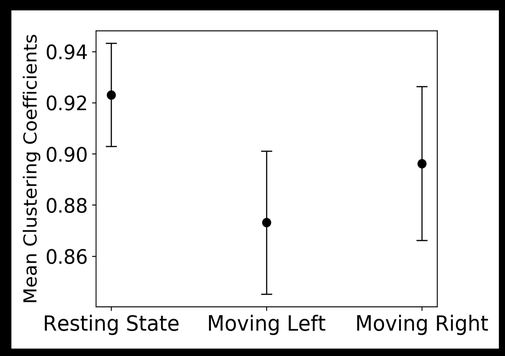


Fig. 2

Results

Our technology was tested with real EEG recordings taken at the Alberta Children's Hospital see(Fig. 1). Three brain states were tested: resting state and tapping the index finger of the left and right hands. The rapid analysis was then performed to give mean clustering coefficients of the networks.

The results are shown in Fig. 2, with max clustering in the resting state and both moving states showing lower clustering. The low clustering coefficient for non-resting brain state implies that during performing a task certain brain regions are more active than the others resulting is smaller clustering coefficient. In constrast, in resting brain state, because of latent brain activities, whole brain shows finite activity resulting in a large clustering coefficent.

Impact

Network neuroscience is being employed for both medical purposes such as early diagnosis of neuro-pathologies in patients as well as accelerating neuroscience research in general - and with great success.

Developing a web application enables increased portability of the setup and allows anyone with EEG data to access the computing capability on any web browser and on any device. Our tool can be used to accelerate discoveries (such as biomarkers of disorder and disease), and to apply them.

Future work

Our tool does not facilitate real-time visualization of EEG data directly recorded from the person yet. Our aim is to link our tool to the EEG recording device to capture brain activities in real-time to characterize individual's physiological and pathological states.

Importantly, the tool holds future potential towards curating highly individualized diagnostics for brain disorders and disease that practitioners may use in real-time with their patients.

References:

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