STATISTICS POWERS BRAIN RESEARCH

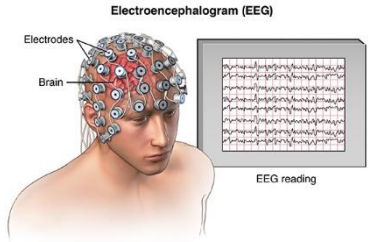
STATISTICAL SIGNIFICANCE

Statistics is transforming how we understand the brain. By modeling complex, time-varying signals from brain activity, such as electroencephalogram (EEG) data, statistical tools help detect subtle shifts that may signal critical events like seizures. In dynamic brain networks, where connections and behaviors evolve rapidly, identifying these structural changes is essential for timely diagnosis and intervention. Statistical methods like change point detection in network models enable researchers and clinicians to uncover hidden patterns, improve neurological monitoring, and guide treatment decisions. With the power of statistics, brain research becomes more precise, responsive, and impactful.

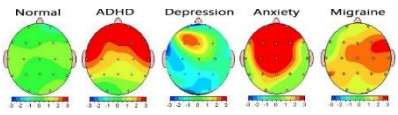
Detecting Change Points in Brain Activity with Time Series Models

What is EEG?

An EEG (Electroencephalogram) is a non-invasive test that measures electrical activity in the brain using small electrodes placed on the scalp.



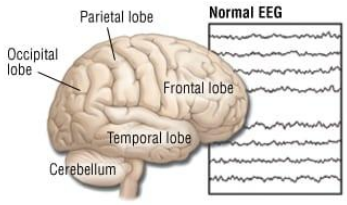
It detects and records brain wave patterns, helping diagnose conditions like epilepsy, sleep disorders, and brain injuries. Analyzing EEG data is also crucial in diagnosing and monitoring mental health and cognitive disorders, such as Alzheimer's disease, schizophrenia, and ADHD. EEG provides real-time insights into

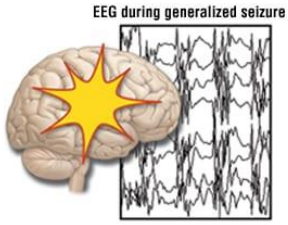


brain function and is widely used in both clinical and research settings.

Seizure Detection with EEG & Statistics:

Seizures often begin with subtle, rapid changes in brain activity that are invisible to the naked eye. EEG recordings capture these shifts, but the data is complex, with thousands of signals fluctuating every second. Advanced statistical models, like network autoregression with change point detection, can pinpoint the exact moments when brain patterns destabilize, flagging potential seizures in real time. This enables faster interventions, personalized treatment adjustments, and even wearable devices that alert patients before a seizure occurs. By transforming noisy data into actionable insights, statistics turns EEG into a powerful tool for epilepsy care.





The Statistical Challenge:

Modern neuroscience produces massive, complex time series data. The data collected from the brain over time are

- Nonstationary: Brain patterns change over time.
- Interconnected: Brain regions influence each other dynamically.

Traditional time series models often assume that relationships between brain regions are stable, but in real life, they shift, especially during critical moments like seizures. This makes analysis especially difficult.

Solution:

We developed a rolling-window detection method for the Network Autoregressive (NAR) model to detect structural change points in dynamic networks, like the human brain.

Key Features of Our Approach:

- Handles high-dimensional time series.
- Adapts to changing relationships between nodes (brain regions).
- Efficient for large-scale, real-time data.

Why It Matters:

Statistics doesn't just analyze data. It unlocks life-saving insights. By detecting when and how brain activity patterns change, we move closer to real-time seizure detection, improving care for patients with epilepsy.

But the impact doesn't stop at medicine. The same statistical tools apply to social media, energy grids, and climate systems—anywhere dynamic, network-based decisions matter.