EEG P-6

Presented By : Network Ninjas

Dynamical Processes in Complex Networks | S'24

ABSTRACT

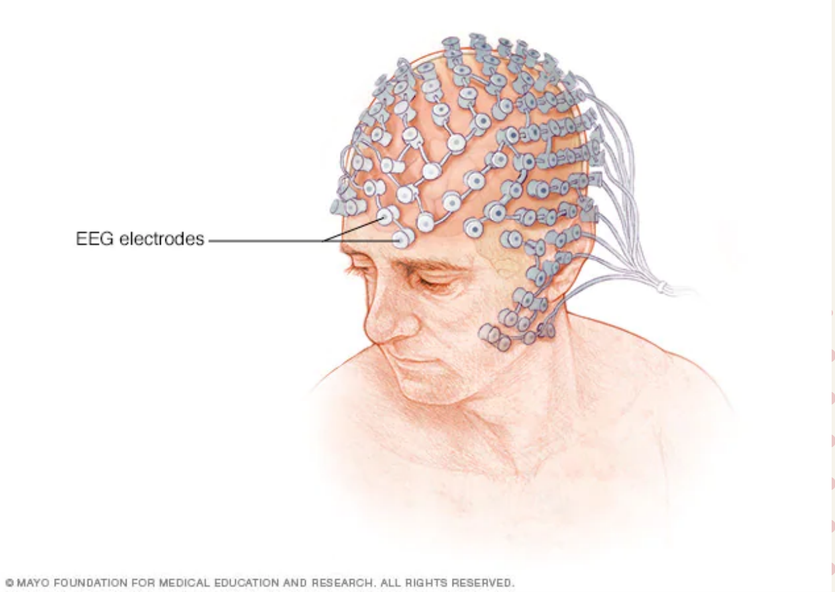
- In Graph Signal Processing (GSP), data is represented as graphs, with nodes denoting entities and edges symbolizing relationships.
- Graph Learning addresses data generated from graph-based interactions, aiming to enable machines to learn the original graph structure.
- This methodology finds applications across diverse domains GSP offers promising avenues for detection, pre-detection, prediction, and understanding specific network alterations indicative of epileptic activity.

INTRODUCTION

- **Epilepsy Focus : Epilepsy is a primary concern in neurological disease detection.**
- **Challenges : Identifying epilepsy, prediction, and understanding network dynamics.**
- **GSP Solution : Using GSP for EEG data analysis to develop tools for diagnosis and prediction.**

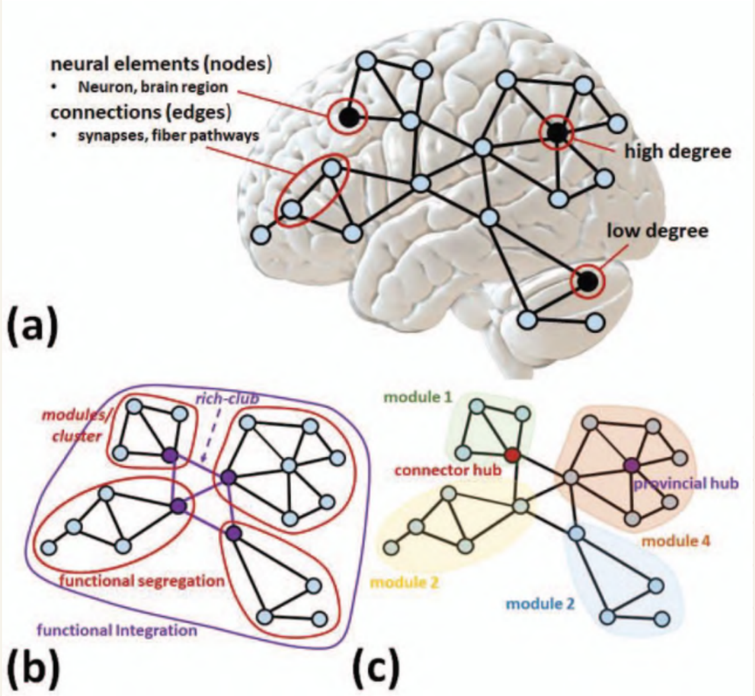
SOME IMPORTANT TERMS

- Epilepsy is a neurological disorder characterized by recurrent seizures, which are sudden, brief changes in the brain's electrical activity.
- EEG is a non-invasive technique used to record the electrical activity of the brain.
- Theta band refers to a specific frequency range of brain waves recorded by EEG, typically between 4 and 8 Hertz (Hz).



SOME IMPORTANT TERMS

- Brain as a graph: involves conceptualizing the brain's structural and functional connectivity as a network of nodes (representing brain regions or neurons) and edges (representing connections or interactions between them).



WHAT WE HAVE

1. The current approach to epilepsy detection primarily relies on band-pass filtering, particularly focusing on the theta band, and time-frequency analysis (TFA)

2. Graph Learning techniques have been applied to TFA data to analyze network metrics of interest.

3. Additionally, accuracy calculation methods utilizing Convolutional Neural Networks (CNN) have been explored.

WHAT WE'LL FOCUS ON

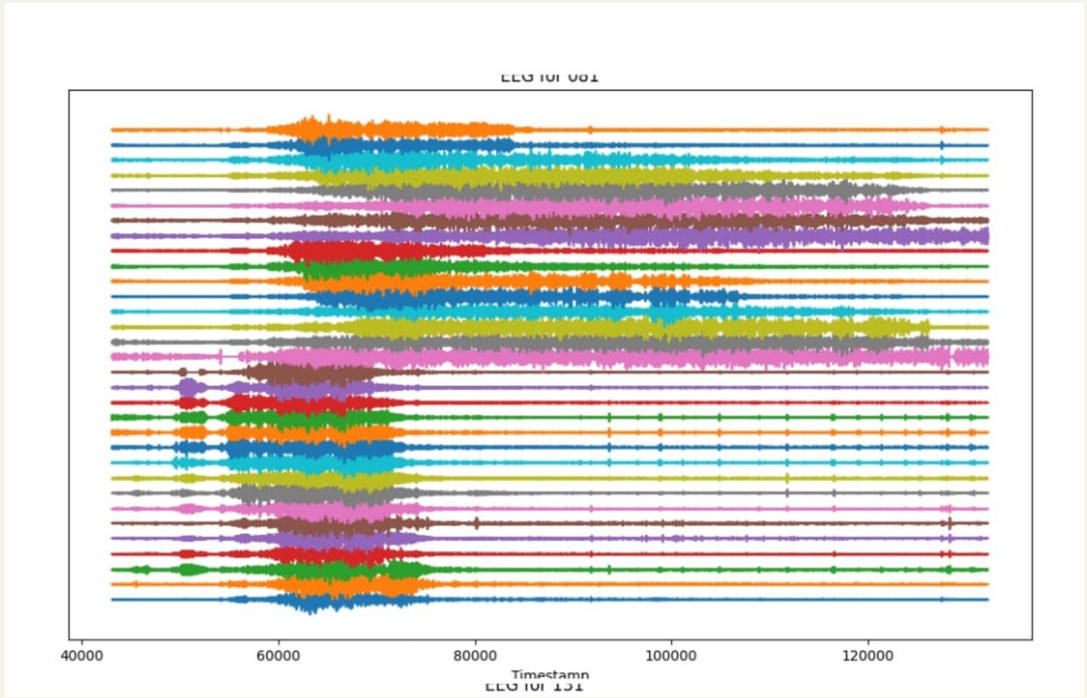
1. Time Series Extraction Objective : Extract time series data encompassing seizure occurrences, with a buffer of 5000 data points before and after each event, to capture seizure onset and offset points.

2. Selection Process: Clinically identified seizure timing guides selection, validated through amplitude analysis.

3. Data Visualization and Analysis Techniques:
   - Frequency Distribution: Refers to frequency domain analysis, achieved through Fourier transform techniques.
   - Network Analysis: Constructing correlation matrices using mutual information enables comprehensive network analysis.

OVERVIEW

- Analyzed data spans 445 seconds, with 395 seconds corresponding to active epilepsy.
- Remaining time divided into pre-epileptic and post-epileptic phases, each lasting 25 seconds.
- Temporal distribution offers a framework for studying epilepsy progression, including pre-epileptic signals, epileptic events, and recovery periods.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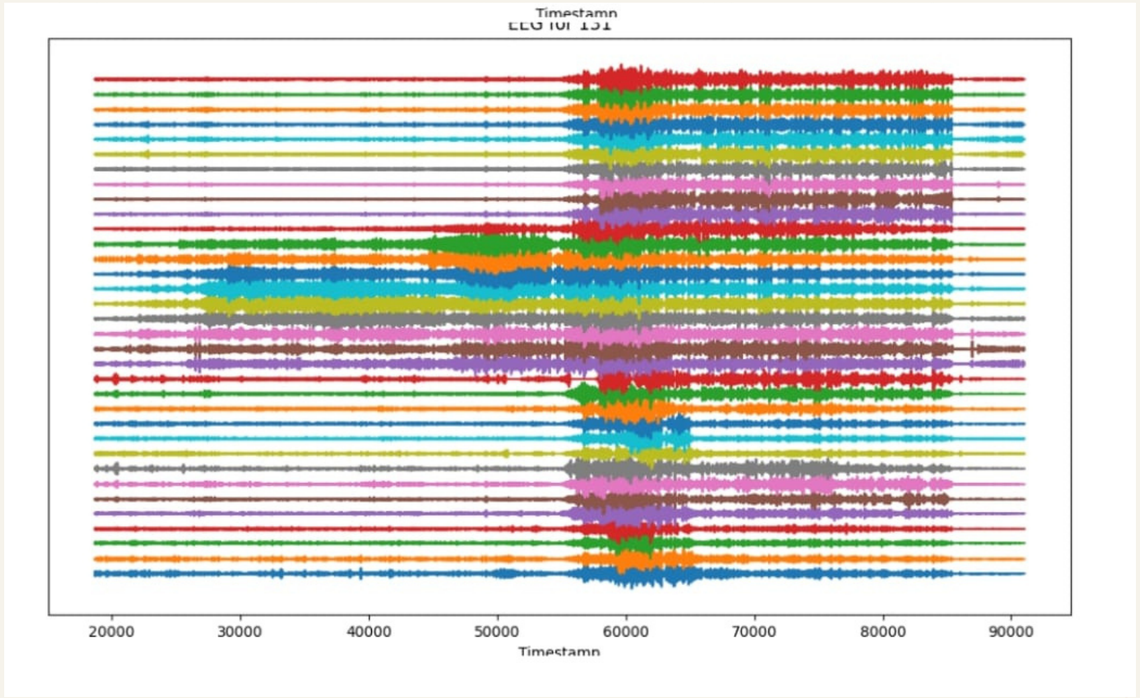
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DEGREE

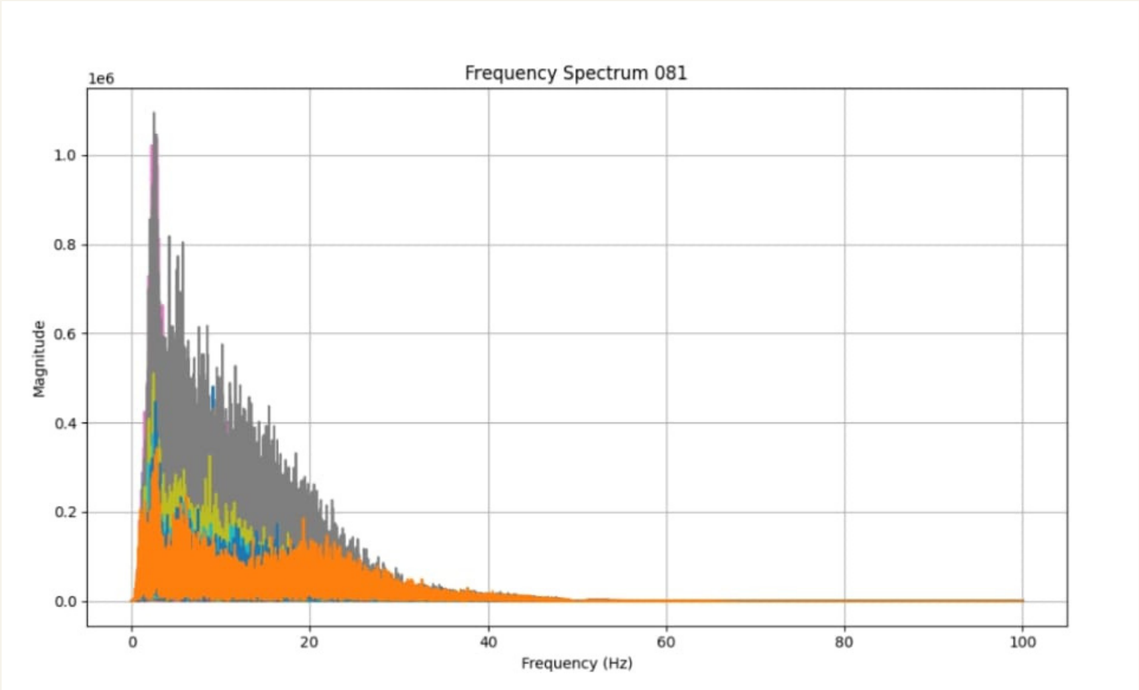
- Alpha Band Filtering:
  - Data filtered using the Alpha Band (8-12 Hz) to focus on a specific frequency range.
  - Alpha Band associated with brain states like relaxation and alertness, crucial for brain activity analysis.
- Pearson Correlation (PC):
  - Measures linear relationship between continuous variables (-1 to 1).
  - Good for detecting linear trends but lacks capturing nonlinear associations.
- Mutual Information (MI):
  - Assesses total shared information between variables, capturing linear and nonlinear relationships.
  - Calculated from joint and marginal probability distributions, offering flexibility.
  - Better suited for complex systems, detecting intricate relationships without linearity constraint.

DEGREE

Aspect	Mutual Information (MI)	Pearson Correlation (PC)
Relationship Type	Captures both linear and nonlinear relationships	Primarily captures linear relationships
Measurement Range	Measures total shared information	Measures strength and direction of linear relationship
Calculation Method	Calculated from joint and marginal probability distributions	Computed from covariance and variance of variables
Flexibility	Offers greater flexibility in identifying complex connections	Limited to detecting linear trends
Applicability	Suited for exploring complex systems with intricate relationships	Effective for detecting straightforward linear trends

- **Seizure Onsets Localization:**
  - **Both datasets show seizure onsets from left mesial temporal lobe.**
  - **Consistent finding suggests specific region for seizure origination across datasets.**

BEFORE BAND FILTERING



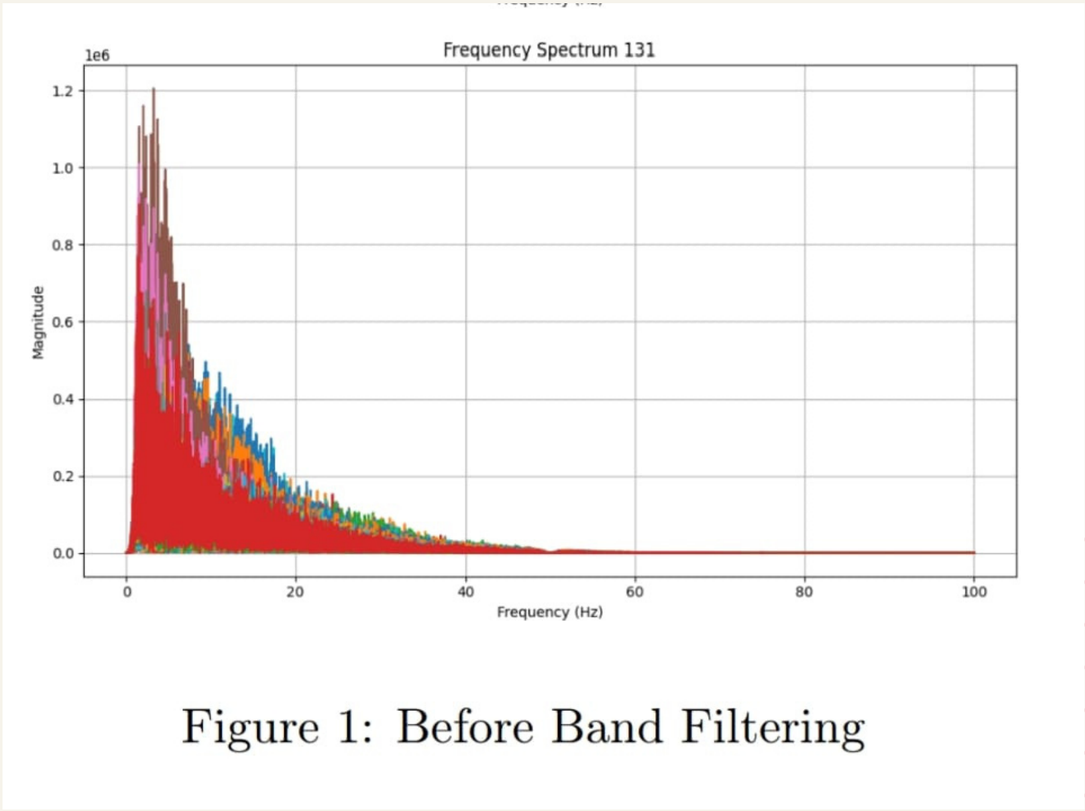
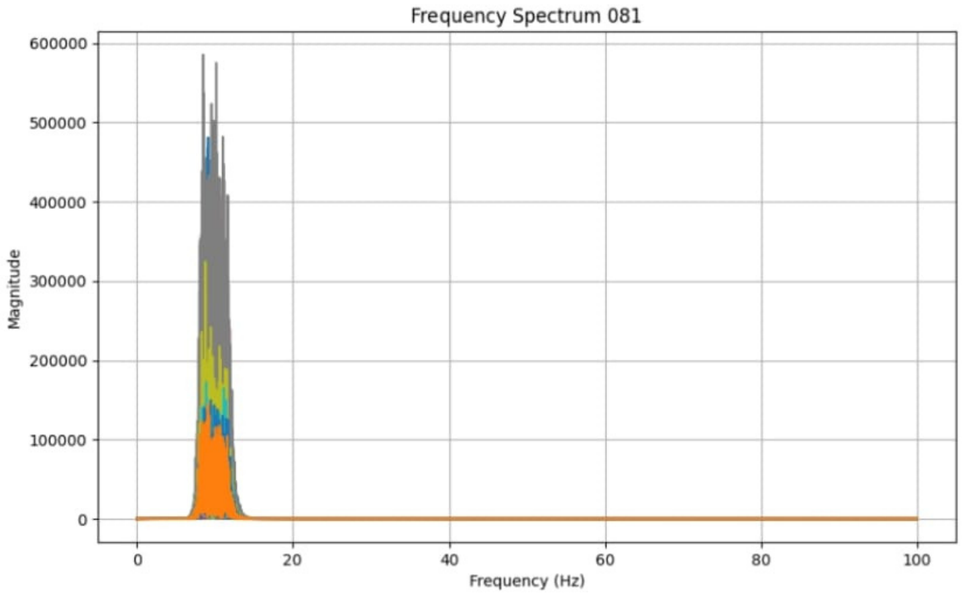


Figure 1: Before Band Filtering

AFTER BAND FILTERING



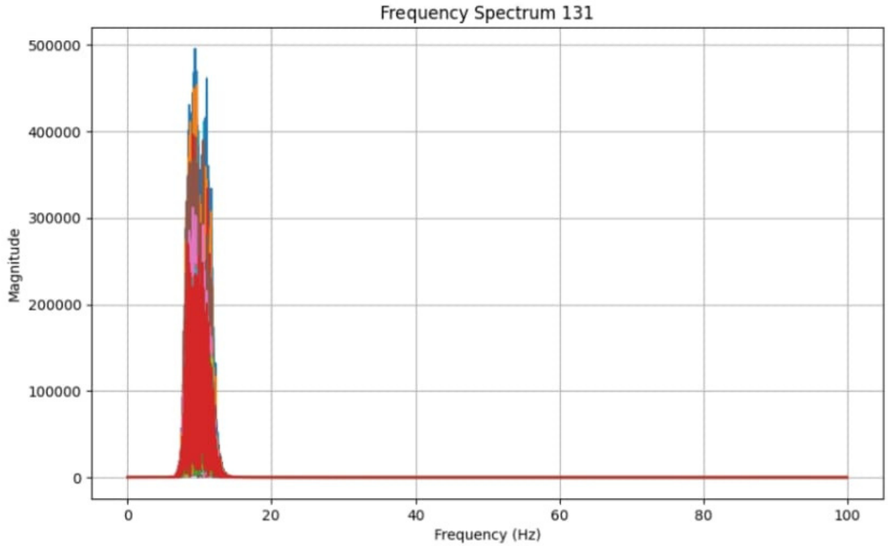


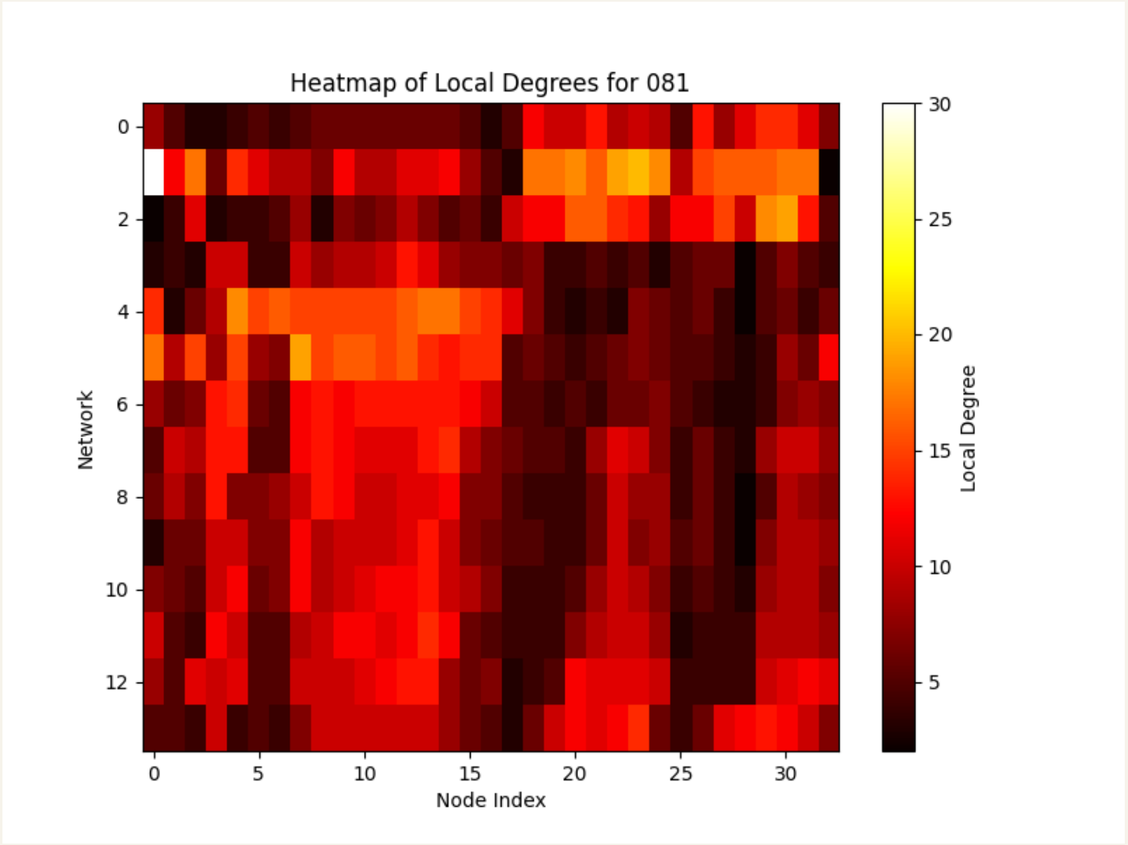
Figure 2: After Band Filtering

SOLUTION

- Correlation Matrix Segmentation:
  - Generated correlation matrix using mutual information.
  - Divided into 14 segments:
    - 2 for Pre-epileptic phase.
    - 10 for Epileptic phase.
    - 2 for Post-epileptic phase.
  - Allows for detailed analysis of correlation structure at different stages of epilepsy.
- Degree Analysis:
  - Local degree: Number of connections a node has with immediate neighbors.
  - Identifies patterns and clusters indicating epileptic activity.
  - Pinpoints nodes with unusually high or low connectivity.

SOLUTION

- Assortativity Analysis:
  - Measures tendency of nodes to connect based on certain attributes.
  - Indicates whether nodes with similar characteristics form connections.
  - High assortativity implies grouping of similar connectivity nodes; low implies random pattern.
- Clustering Coefficient Analysis:
  - Measures likelihood that two neighbors of a node are connected.
  - Indicates level of local interconnectedness or clustering.
  - Higher coefficient suggests more interconnected nodes; lower suggests dispersed network structure.


Heatmap of Local Degrees for 081
Network
Node Index
Local Degree
0
2
4
6
8
10
12
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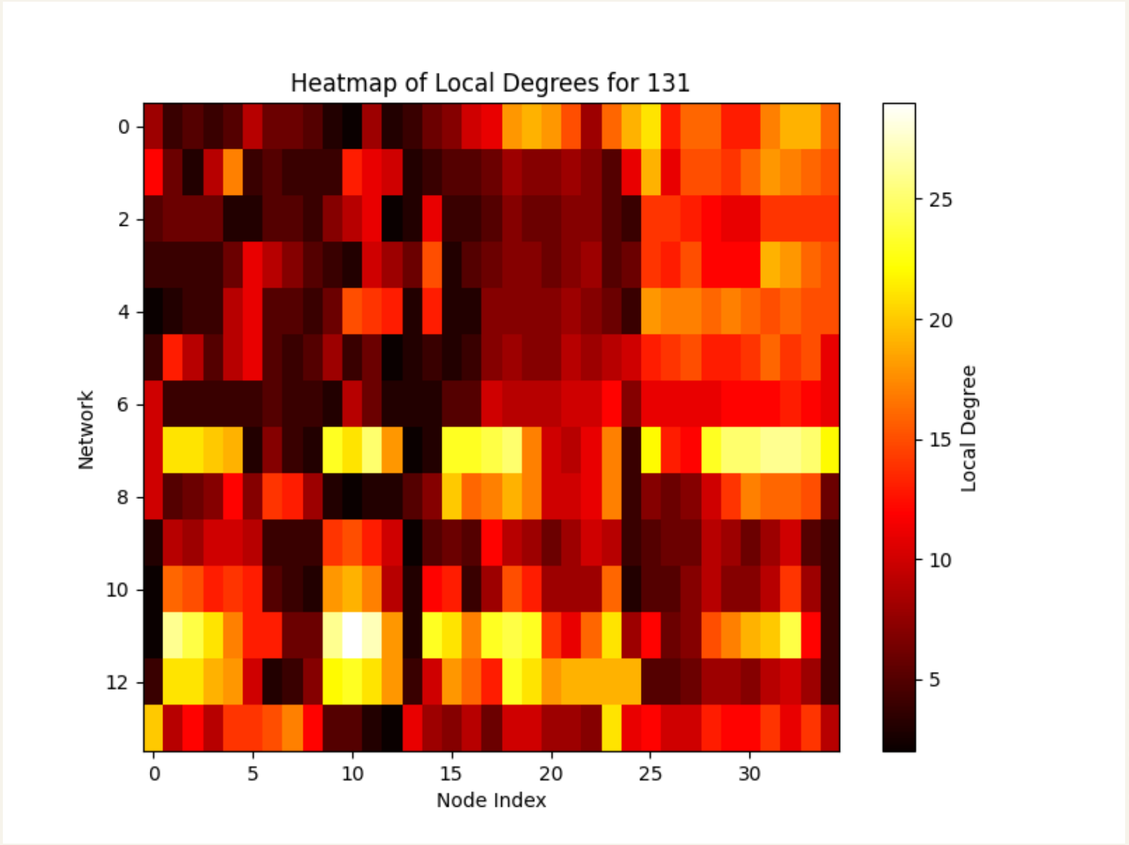
Heatmap of Local Degrees for 131
Network
Node Index
Local Degree
0
2
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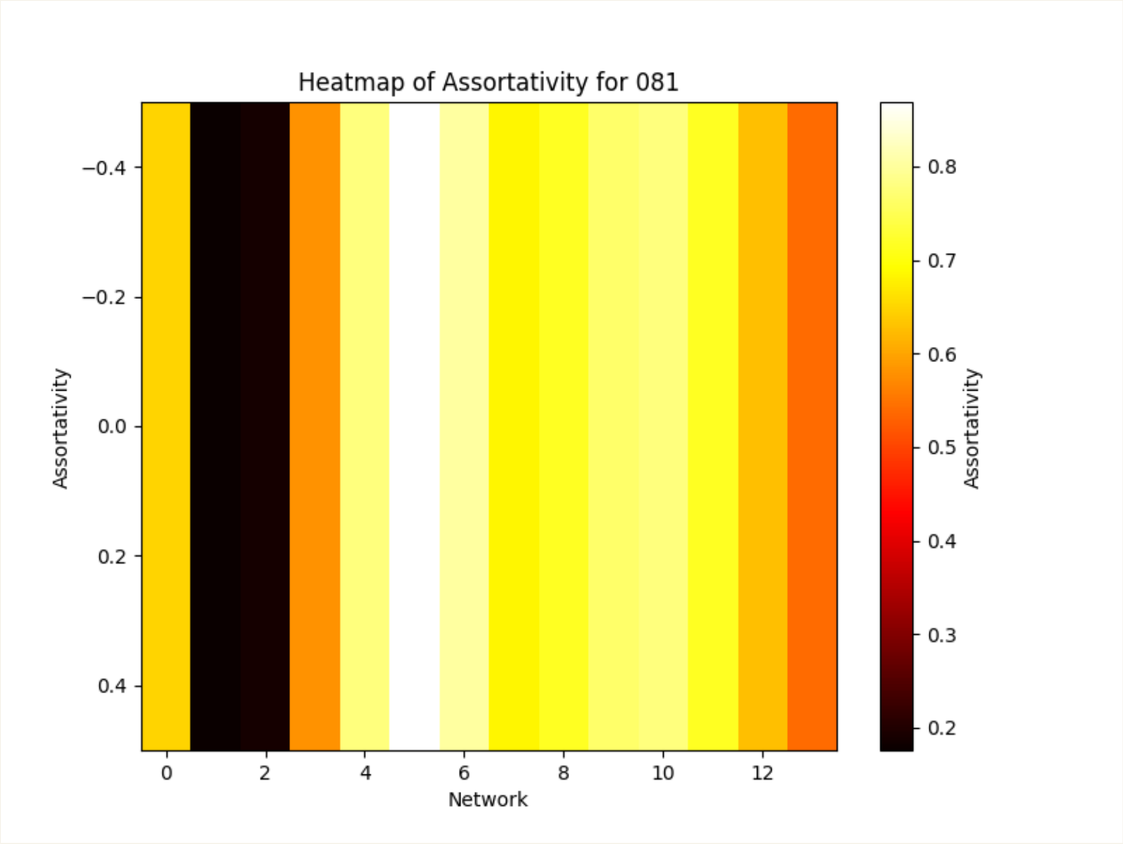
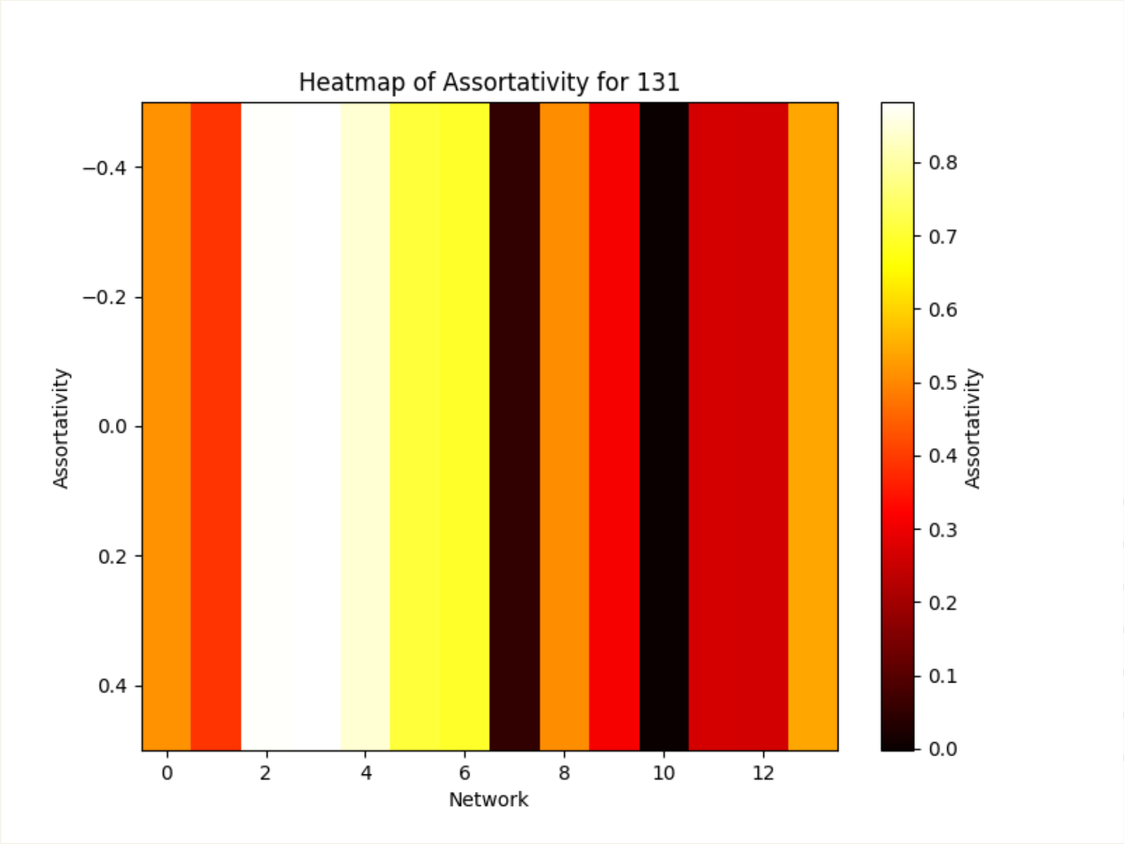
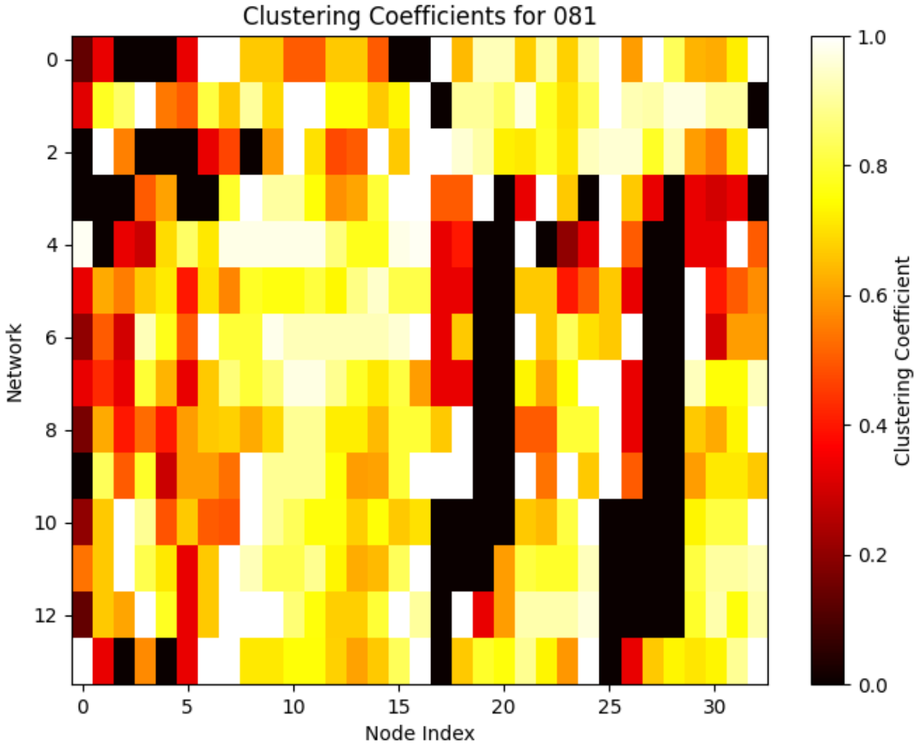
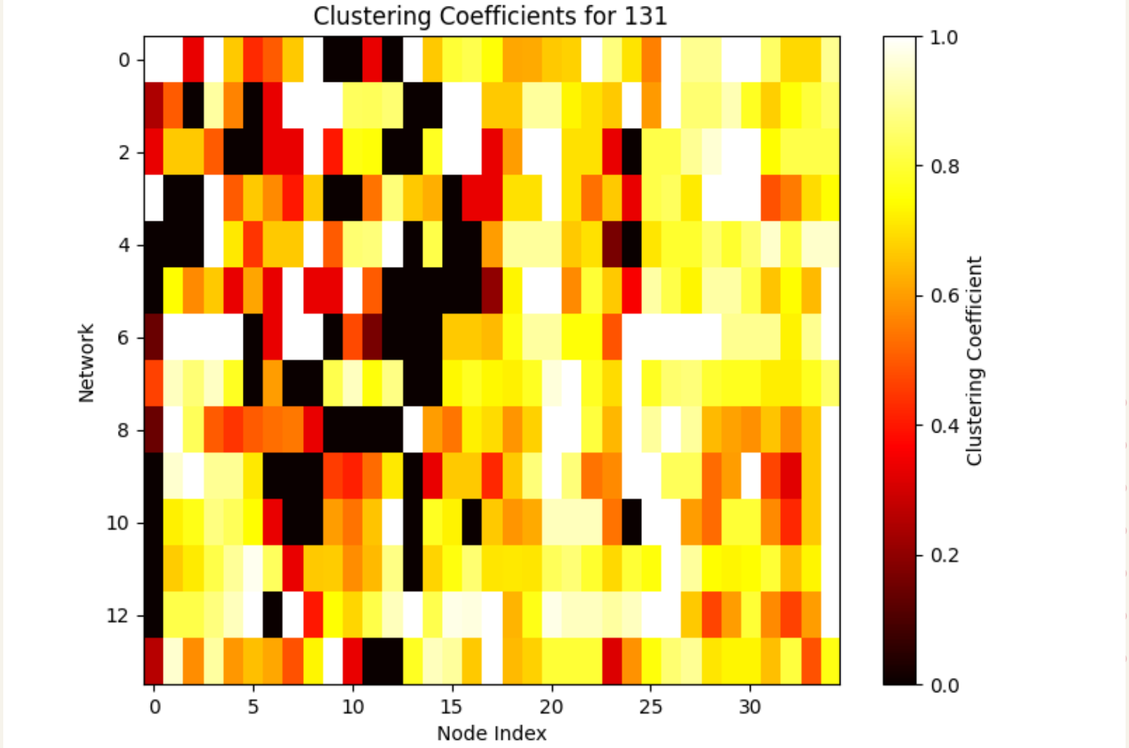
ASSORTIVITY OF NODES





CLUSTERING COEFFICIENT





CONCLUSION

- Studied EEGP6 signals to understand epilepsy perception and response in the left mesial brain region.
- Investigated Alpha band to explore specific frequency range associated with epilepsy activity.
- Discovered patterns and correlations in EEGP6 data, revealing dynamics of epileptic episodes.
- Potential implications for epilepsy diagnosis and treatment improvement.
- Future directions include exploring additional EEG signals and advanced analytical techniques.

THANK YOU

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