University of Peradeniya

# Functional Connectivity Biomarkers for Early Detection of Neurodegenerative Disease

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Abstract- Alzheimer's Disease (AD) and Frontotemporal Dementia (FTD) are progressive neurodegenerative diseases characterized by loss in memory. Lacking a definitive cure to halt or reverse the degenerative process, these require early diagnosis in order to treat and manage patients. This study focuses on identifying the changes in brain connectivity patterns associated with AD and FTD using EEG-based source-level functional connectivity analysis. With the paired t-test, we sought to pinpoint specific connections that exhibited statistically significant variations ($p < 0.001$) among the conditions.

## Introduction

Neurodegenerative diseases cause both structural and functional changes in the brain affecting the connectivity of brain regions. Studies on the anatomical organization of neural connections within the brain (the structural connectivity) show that the physical pathways of nerve fibers gradually break down in AD patients compared to healthy conditions (HC). However, as the functional connectivity analyzes the brain activities between the distant brain regions, functional connectivity-based biomarkers have emerged as promising tools for the early detection of dementia.

## Methodology

### Dataset

- **Publicly available dataset**
- **88 Subjects**
  - 36 AD patients
  - 23 FTD patients
  - 29 Healthy Conditions

### Signal Processing

- **Filtering (0.5Hz-60Hz)**
- **Precise electrode positioning**
- **Scout time series generation**
  - 68 sources
  - Using Desikan-Killiany atlas

### Feature Extraction

- **Connectivity matrix generation**
  - Connectivity measurement
    - Coherence
- **For 5 frequency bands**
  - delta (< 4 Hz)
  - theta (4–7 Hz)
  - alpha (8–12 Hz)
  - beta (13–30 Hz)
  - gamma (>30 Hz)

### Data analysis

- **The connections that satisfy the following were selected**
  - Coherence thresholds >0.5
  - Subject Overlap = 90%
- **Isolated the specific connections that exhibited statistically significant variations among at least two conditions.**
  - Method - Paired T-test
  - p-value < 0.001

### Classification

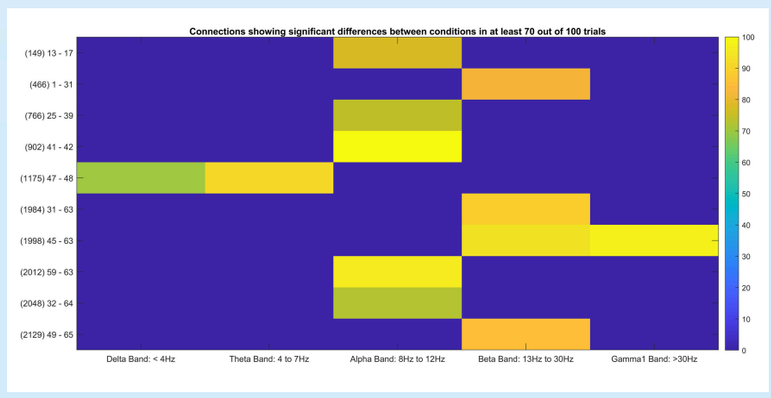
**STAGE I :**

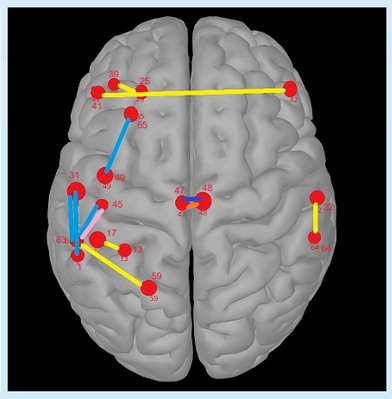
- **The data were randomly divided into two**
  - Training dataset = 70% of data
  - Testing dataset = 30% of data
- **Data analysis performed on training dataset**

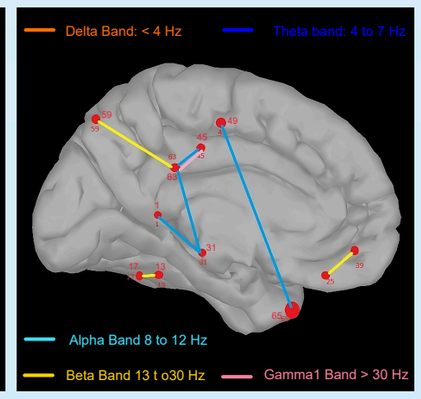
**STAGE II :**

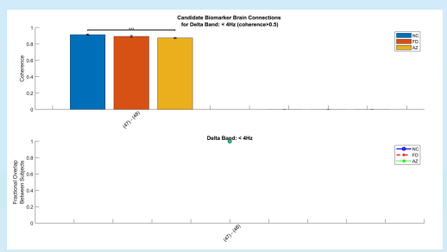
- **The process in STAGE I was repeated 100 times**
- **Identified the connections which resulted in at least 70 trials**

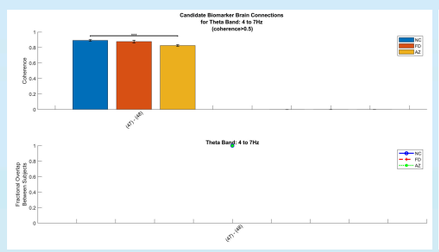
## Results

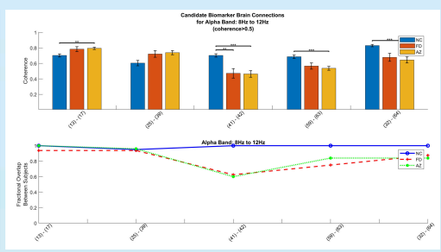


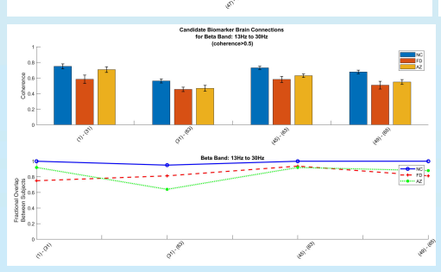



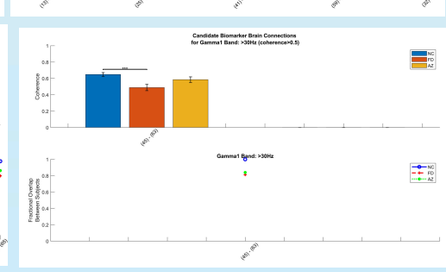



**(1) bankssts L**
**(13) fusiform L**
**(17) inferior temporal L**
**(25) lateral orbitofrontal L**
**(31) middle temporal L**
**(32) middle temporal R**
**(35) parahippocampal L**
**(39) pars orbitalis L**
**(41) pars triangularis L**
**(42) pars triangularis R**
**(45) postcentral L**
**(47) posterior cingulate L**
**(48) posterior cingulate R**
**(49) precentral L**
**(59) superior parietal L**
**(63) supramarginal L**
**(64) supramarginal R**
**(65) temporal pole L**

## Conclusion

The following can be observed from the obtained results.

- **Isolated connections consistently demonstrate a reduction in coherence values in both AD and FTD compared to the NC group across all the bands except the Alpha band.**
- **Fractional overlap of the subjects where the connections exhibit reduced connectivity, yet coherence >0.5 is also notably lower in both FTD and AD groups compared to the NC, enhancing the confidence of the connectivity reduction observed in the given connections.**
- **Overall, the left hemisphere is greatly affected compared to the right.**

According to the obtained results it is evident that EEG data can be used to identify the significant changes occurred in several brain connections due to AD and FTD.

### Future Work

However, instead of statistical analysis we can improve this to utilize Artificial Neural Networks by providing EEG time series data as the input to the network. This will enhance the accuracy and specificity of diagnostic models, leading to improved early detection and intervention strategies for neurodegenerative diseases. Hence, in future we planned to develop Recurrent Neural Networks (RNN), to enable capturing the temporal dependencies in connectivity patterns.

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