Using Linear Predictive Coding for real-time detection of Parkinson’s Disease

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**Background**

**Parkinson’s Disease**
- Neurological disorder
- Caused by midbrain cell death
- Changes brain activity

**Measurement of brain activity**

**Local Field Potential (LFP)**
- Micro-electrode array
- Signal acquisition
- LFP time series

**Electroencephalography (EEG)**
- Scalp Electrodes
- Signal acquisition
- EEG time series
Detection of Parkinson’s disease with LFP
• Helps advanced therapies like deep brain stimulation

Detection of Parkinson’s disease with EEG
• Can provide quick and affordable way of diagnosis

Traditions methods for Detecting of Parkinson’s disease
• Time consuming
• Expensive and sensitive to medication
• Moderate diagnostic accuracy

Can we detect Parkinson’s disease in real time using EEG and LFP?
Linear Predictive Coding

Summarizes the signal into a few Parameters

Input Signal → Linear Predictive Coding → Parameters $[a_1, a_2, \ldots, a_k]$

Power Spectral Density of the signal

Approximate Power Spectral Density

LPC capture dominant features of Power Spectral Density
Detecting Parkinson’s disease with LFP

Dataset
- 4 LFP recordings from mouse model of Parkinson’s disease (PD)
- 4 LFP recordings from mouse with normal condition as control

Goal: Separate the LFP recordings of Parkinson’ disease from the controls

Feature Identification
Power spectral density comparison

Outcomes after analyzing with LPC
LPC can separate the PD and Control data for various signal duration

Significant shape difference
**Computational Efficiency**

LPC provides best separation.

Next best candidate with a good separation.

**Classifier Performance**

Performance Comparison

- **LPC**
- **PD**
- Control

- Beta power Little et al. 2016
- PAC Lopez et al. 2010
- PAC Hemptinne et al. 2013
- PAC Sanders et al. 2013

Total Computation time (seconds): 1, 1.5, 2.1, 3.1, 4.5, 6.6, 9.7, 14.1, 20.6, 30.1, 44, 64.3, 93.8, 137, 200.
Real time Performance

LPC predictor is stable after 1 minute

Separation of PD and control with 1 minute of real time data
Detecting Parkinson’s disease with EEG

Dataset
- EEG recordings from 27 subjects with Parkinson’s disease
- EEG recordings from 27 healthy control subjects

Goal: Classify subjects with Parkinson’s disease and controls using EEG

Feature Identification
Power spectral density comparison

LPC can separate the PD and Control

Outcomes after analyzing with LPC

Significant shape difference
### Performance Comparison

#### Classifier Performance

<table>
<thead>
<tr>
<th>Method</th>
<th>Traditional methods</th>
<th>LPC-based</th>
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<tbody>
<tr>
<td></td>
<td>Chaturvedi et al., 2017</td>
<td>Vanneste et al., 2018</td>
</tr>
<tr>
<td>AUC %</td>
<td>74.3 (60.8-87.9)</td>
<td>78.3 (66.9-90.7)</td>
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<tr>
<td>Accuracy%</td>
<td>72.2 (58.4-83.5)</td>
<td>72.2 (58.4-83.5)</td>
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<tr>
<td>Sensitivity%</td>
<td>74.1 (53.7-88.9)</td>
<td>70.4 (49.8-86.3)</td>
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<tr>
<td>Specificity%</td>
<td>70.4 (49.8-86.3)</td>
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#### Computational Efficiency

- **LPC** provided best separation with a 13% increase in accuracy.

- **LPC** method was 2500x more efficient in total computational operation compared to traditional methods.
Real time Performance

Classifier outcome with incoming data

Classifier accuracy with incoming data

Reliable classification within 2 minutes of data