Biomechanical Indicators of Movement Disorders in Parkinson’s Disease

Roy SH1,2, Shiwani B1,2, Kline JC1,2, Ravi RH1,2, Saint-Hilaire MH3, Thomas CA3, De Luca G1,2
1Delsys, Inc, Natick, USA; 2Altec, Inc, Natick, USA; 3Dept. of Neurology, Boston University Medical School, Boston, USA

 Motivation
- Sensor-based technology is needed for implementing personalized therapeutic approaches in PD.
- Continuous sensor-based monitoring of multiple motor symptoms of PD during daily activity is important to track the medication response, but has not yet been achieved.

Objective
- To develop wearable sensor-based biomechanical indicators and real-time algorithms for automated detection of multiple PD symptoms during unscripted activities of daily living.

Data Collection

(1) Subject Population

<table>
<thead>
<tr>
<th>Number</th>
<th>n = 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>60.8 ± 11</td>
</tr>
<tr>
<td>Male/Female</td>
<td>17/12</td>
</tr>
<tr>
<td>PD Duration (y)</td>
<td>6.5 ± 5.4</td>
</tr>
<tr>
<td>Total Data</td>
<td>5000 min</td>
</tr>
<tr>
<td>Mean of FAH-Yahr</td>
<td>4.4</td>
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</table>

(2) Sensor Placement

Trigno IM™ wireless sensors (Delsys Inc) recorded EMG and IMU measurements from upper- and lower-limb (see Fig.).

(3) Data Acquisition Protocol
- Data were recorded during 3 hours of unscripted activity in a simulated home setting.
- Video recordings were annotated by experts to determine the presence/absence of PD symptoms.

Approach
- Defined PD symptoms based on motor impairments listed in UPDRS.
- Selected sensors (Trigno IM™) that can provide both muscle activity (EMG) and inertial movement. Current work focuses on only movement based metrics.
- Because PD symptoms manifest differently during gait, walking and non-walking segments were automatically classified prior to PD symptom detection.
- Assessed PD motor impairments by tracking changes in the magnitude of sensor-based metrics.

Algorithm Design

Trigno IM™ Sensor Data

Non-Walking Activity

Walking Activity

Dyskinesia

1. Duration
2. Spectral Energy

Tremor

1. Duration
2. Spectral Energy

Bradykinesia

1. Amount of movement
2. Speed of movement

Dyskinesia

1. Duration
2. Spectral Energy

Bradykinesia

1. Range of leg swing
2. Speed of leg swing

PD State Determination

Dynamic Neural Network Based Classification

Automated Detection of Multiple PD Symptoms based on Biomechanical Sensor Metrics

Normal Movement
- Frequent Movements
- High Spectral Energy

Bradykinesia
- Sparse Movements
- Low Spectral Energy

Tremor
- Involuntary Periodic Trembling
- Spectral Peak in 4-7 Hz

Dyskinesia
- Involuntary Fidgeting Movements
- Broad range of High Spectral Energy

Automated Tracking of PD (L-Dopa) Medication Response based on Biomechanical Sensor Metrics

Case 1: Wearing off following PD Medication
As the medication starts wearing off, the duration and speed of movements start decreasing, monitoring a presence of bradykinesia.

Case 2: Sustained improvements following PD Medication
Both amount and speed of voluntary movements improves following PD medication; indicating improvements in unprompted following medication.

Conclusion
First achievement of a wearable system that can be used during normal daily activities to provide:
- Continuous monitoring of unscripted activities
- Simultaneous tracking of a broad spectrum of PD motor symptoms
- Objective biomechanical metrics to quantify motor effects of PD medication

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References