Classification of Movement of People with Parkinson’s Disease Using Wearable Inertial Movement Units

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Parkinson’s Disease

• Parkinson’s disease is a progressive movement disorder caused by degeneration of dopamine generating cells.

**Movement Symptoms:**
• Tremors
• Slowness
• Impaired gait

**Non-Movement Symptoms:**
• Speech / Language disorders
• Cognitive impairment
• Fatigue
• Psychotic episodes
Remote Monitoring Research

- Movement & mobility
- Wellbeing
- Voice & Language
- Medication
- Activity / Mood Diaries
- Legal & ethics
Remote Patient Monitoring Platform

1. Person with Parkinson’s:
   - Carrying smartphone
   - Wearing sensors

2. Use of interactive apps
   - Bluetooth
   - Smart phone with apps
   - HTTPS

3. Bluetooth room “beacons”

4. Clinical Care System
   - Clinical Data Warehouse
   - Clinician Portal
   - HTTPS

5. Web browser
   - Clinical Care Team
   - Collaboration

6. Clinical Research System
   - De-identified Research Data Warehouse
   - Researcher Portal
   - HTTPS

7. Web browser
   - Researcher

Face-to-face clinical feedback, advice and instruction

Smartphone enabled clinical feedback, advice and instruction (Video, Voice, SMS & in-app messaging)
Wearable *Shimmer* Devices

- Tri-Axial Gyroscope & Accelerometer
- Bluetooth / SD-Card Logging
Research Questions

1. What sensors are the most significant for estimating Parkinson’s disease severity?

2. What wearable location is the most significant for estimating Parkinson’s disease.
Data Collection

• Participants attended a single physiotherapy assessment

• MDS-UPDRSIII Score was evaluated for each participant.

• Five Shimmer devices were placed on the legs, arms & back.
Participants

• 14 People with mild to moderate symptoms
• Two experienced freezing of gait
• Two had deep brain stimulation
• Five had fallen in 12 months prior
• Two had observable tremors
Assessments

• Six-Minute Walk (Indoors / Outdoors)
• Up & Go (Motor, Cognitive)
• Sit to Stand
• Functional tasks
Empirical Mode Decomposition

• Real world produces complex signals with many components

• EMD Breaks the signal into sub-components called **Intrinsic Mode Functions**
Feature Extraction From the IMFs

1. Amplitude
2. Energy
3. Wavelength
## Best Sensors & Features

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Position</th>
<th>Axis</th>
<th>IMF Mode</th>
<th>Feature</th>
<th>Correlation</th>
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<tbody>
<tr>
<td>Gyroscope</td>
<td>Right Leg</td>
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<td>1</td>
<td>Amplitude-Min (Mean)</td>
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<tr>
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<td>Left Arm</td>
<td>x</td>
<td>1</td>
<td>Energy</td>
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<td>Energy</td>
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</tbody>
</table>
Hypotheses

• People with greater motor symptom severity have a less powerful heel strike motion.

• People with greater motor symptom generally have smaller/slower movements particular of the legs & back.
Support Vector Machine Prediction

![Graph showing MDS-UPDRS for different participants with real and predicted values.]
Present Work

• In-home monitoring
• Algorithms for predicting:
  1. Falls
  2. Freezing
  3. Off-times
• Algorithms for automated assessing of physiotherapy tasks
Thank you

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