Early and Accurate Differentiation between Parkinson’s Disease and Essential Tremor

[Introduction]

Nearly 28% of the elderly population endure the burden of movement disorders (MD), namely that of Parkinson’s Disease (PD) and Essential Tremor (ET). Due to the similar clinical manifestations of the diseases, the accuracy rate of diagnosis is 25% in general practitioners, 50% in general neurologists, and 80% in MD specialists. Clinical observation suggests that 65% of MD patients will have their diagnosis changed at least once due to difficulties in early diagnosis. 300 million dollars is spent annually on treatments due to misdiagnosis. Though scientists understand the basic pathophysiology behind these diseases, inaccuracy stems from the lack of quantitative evaluation.

[Table 1. Metrics differentiating PD and ET]

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Parkinson’s Disease</th>
<th>Essential Tremor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tremor Amplitude</td>
<td>High (2.7x)</td>
<td>Low</td>
</tr>
<tr>
<td>Tremor Frequency</td>
<td>3-7Hz</td>
<td>4-12Hz</td>
</tr>
<tr>
<td>Frequency Dispersion</td>
<td>1.66Hz</td>
<td>0.89Hz</td>
</tr>
<tr>
<td>Frequency Distribution</td>
<td>Unilateral</td>
<td>Bilateral</td>
</tr>
<tr>
<td>Tremor Type</td>
<td>Rare/Postural</td>
<td>94.7%/Postural</td>
</tr>
<tr>
<td>Head Metrics</td>
<td>76-100%</td>
<td>76-100%</td>
</tr>
<tr>
<td>Prevalence of Tremor</td>
<td>Up to 17%</td>
<td>Up to 54%</td>
</tr>
<tr>
<td>HPI Metrics</td>
<td>Older age (&gt;60y)</td>
<td>All age groups</td>
</tr>
<tr>
<td>Age</td>
<td>Rare (&lt;20%)</td>
<td>Positive (&gt;60%)</td>
</tr>
<tr>
<td>Family History</td>
<td>Rare (&lt;20%)</td>
<td>Positive (&gt;60%)</td>
</tr>
</tbody>
</table>

[Design Requirements]

1) Distinguish between and diagnose early PD and ET
2) Measure frequency and amplitude of head and hand
3) Incorporate a task table to elucidate the underlying pathology
4) Match or exceed precision exhibited by trakSTAR 6 DOF tracking system
5) Commercial availability for $200 or less

[Project Objective]

The purpose of this project is to develop a low-cost device capable of facilitating accurate differentiation between early stage PD and ET. Deliverables include the following:
- Hand tracking system and head tracking system to detect tremor
- An algorithm to evaluate processed data and facilitate diagnosis
- A tablet-based application to interface between the user and the device

[Design]

[Figure 1. Block diagram of logic flow.]

Final design incorporates the Leap motion C++ SDK and a head tracking device running on Arduino. The head tracking device consists of a 3DOF accelerometer connected to a LilyPad Arduino. The Arduino is then connected to an Xbee module for WiFi transmission. Both modalities upload data to the computer via serial ports. The data is then analyzed using our Matlab based software and displayed using an easy to use GUI.

[Figure 2. Final Design]

(A) Headband used to track frequency and amplitude for head tremors (B) LeapMotion gathering frequency and amplitude of hand tremors

[Figure 3. Proof of Concept with Positive Control for Hand Tracking]

(A) Testing setup, with a model hand attached to a mirror galvanometer. (B) Position data from 3Hz oscillation test. (C) Fourier Transform results (D) Spectrogram showing constant frequency content over time

[Figure 4. Spiral Test Results]

(A) Compares spiral drawn by a healthy subject to a spiral drawn with tremor. The spiral test, up until this point, was a classic qualitative measure of tremor. (B) Applying novel quantitative analysis, the spiral was “unraveled” and error from the normal is displayed.

[Figure 5. Head Tracking Results.]

(A) Acceleration in terms for G in the X direction. (B) Frequency response for the acceleration data

[Testing and Results]

[Acknowledgments]

We would like to thank our partners at the Hunter Holmes McGuire VA Medical Center and the Movement Disorder Clinic at Virginia Commonwealth University.