“Digital Biomarkers” for Huntington's Disease using Multiple Body-affixed, Light-weight Sensors

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## MC10 BioStampRC Sensor: Specifications and Advantages

<table>
<thead>
<tr>
<th>Mode</th>
<th>Sampling Rate</th>
<th>Dynamic Range</th>
<th>Recording Time (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer</td>
<td>31.25, 50, 100, 200 Hz</td>
<td>2, 4, or 8 G</td>
<td>8-35 hours</td>
</tr>
<tr>
<td>ECG</td>
<td>125, 250 Hz</td>
<td>0.2 V</td>
<td>17 hours</td>
</tr>
<tr>
<td>EMG</td>
<td>250 Hz</td>
<td>0.2 V</td>
<td>17 hours</td>
</tr>
<tr>
<td>Accel.+ECG</td>
<td>50 Hz (Accel.), 125, 250 Hz (ECG)</td>
<td>2, 4, or 8 G (Accel), 0.2 V (ECG)</td>
<td>11-22 hours</td>
</tr>
<tr>
<td>Accel.+EMG</td>
<td>50 Hz (Accel.)</td>
<td>2, 4, or 8 G (Accel), 0.2 V (EMG)</td>
<td>11 hours</td>
</tr>
<tr>
<td>Gyro.+Accel.</td>
<td>25, 50, 100, 250 Hz</td>
<td>2, 4, 8, 16 G (Accel) Off, 250, 500, 1000, 2000 /sec (Gyro)</td>
<td>2-4 hours</td>
</tr>
</tbody>
</table>

- Light weight (7 grams)
- Unobtrusive, body affixable
- Low power
- Long recording time
Pilot Study Overview

- Focus on motor symptoms in Huntington's and Parkinson's Diseases (HD/PD)
- 10 HD, 4 pHD, 16 PD, and 15 Controls enrolled
- Five accelerometers for each participant
- In-clinic assessment + two day in-home recording
Body-affixed vs Body-worn Sensors

More than 93% of participants are
- Comfortable with sensors
- Experience no interference with daily activities
- Pleased with overall experience
- Ready to re-enroll in future

Contrast with body worn sensors
- ...
- ...
- ...
- ...
Advantages of Multiple Sensors

- Potential for better/more information through
  - Targeted selection of individual sensors for analysis
  - Joint exploitation across sensors
- Allow for effective motion analysis without being invasive to individuals' privacy (as compared to video alternatives)
Preliminary Study Results
Lack of Coordination in HD (walk)

Normalized vector cross-correlation of the sensor data from left leg and right leg for control.

![Normalized vector cross-correlation graph](image-url)
Lack of Coordination in HD (walk)

Normalized vector cross-correlation of the sensor data from left leg and right leg for HD
Lack of Coordination in HD (walk)

－Normalized vector cross-correlation of the sensor data from left leg and right leg

Control vs HD
Lack of Coordination in HD (walk)

Scatter plot
Control vs HD
Step Duration Identification

![Graph showing step duration identification with time lag and mean step duration for Control and HD groups.](image)
Effect of Medication on HD

For one individual
- On/off TetraBenazine
- Three 10 m walk tests, each

- Mean step duration (HD-off) = 0.67 seconds
- Mean step duration (HD-on) = 0.55 seconds
On/Off Medication for Parkinson's

Patient with severe at rest tremors
Spectrograms of principal acceleration component

Off-medication (Levodopa)  

On-medication (Levodopa)

PD-off

PD-on
On/Off Medication for Parkinson's

Patient with severe at rest tremors
Relative power in characteristic 5Hz band and first harmonic
On/Off Medication for Parkinson's

Patient with mild at rest tremors
Spectrograms of principal acceleration component

Off-medication (Levodopa)

On-medication (Levodopa)
On/Off Medication for Parkinson's

Patient with mild at rest tremors
Relative power in characteristic 5Hz band and first harmonic
Summary

- The time is ripe for broad adoption of sensors health data analytics
  - Light weight, body-affixed, low power, long-duration recording abilities
  - Effective in combination with data analytics/signal processing
    - Multiple sensors are advantageous: analysis can target specific individual sensors or exploit jointly
- Preliminary analyses show clear signatures of clinically observed motor symptoms in Huntington's and Parkinson's
  - Lack of limb co-ordination in HD: apparent in cross-correlation analysis between sensors on left and right legs
  - Slowing of gait in HD upon going off medication apparent in auto-correlation analysis of chest sensor
  - At rest tremors in PD apparent in spectral analysis of the hand sensors, also impact of medication
More Information

• Come see our poster:
  ▪ “Wearable Sensors for the Objective Measurement of Motor Features of Huntington Disease - a Pilot Study”, Jamie Adams et al, Presidential Boardroom A, Nov. 4, 10:30 am-11 am and 2:45 pm-3:15 pm and Nov. 5, 11:30 am – 12:15 pm (Presented by: Mulin Xiong)
  ▪ Catch us for a conversation
    ▪ We're looking for partners to take the work further
Team Members

Karthik Dinesh
Mulin Xiong
Jamie Adams
Nirav Sheth
A.J. Aranyosi
Ray Dorsey
Gaurav Sharma
Thank You