Understanding Wearable Activity Trackers for Wheelchair Users

Handouts

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350% increase
Benefits of using fitness wearables

- Increased intention/expectation to exercise \(^{(1)}\)
- Increased physical activity \(^{(2)}\)
- Increased time spent in moderate-to-vigorous activities \(^{(3)}\)
- Feedback to enhance performance \(^{(4)}\)
- Decreased BMI \(^{(2)}\)
- Decreased blood pressure \(^{(2, 3)}\)

\(^{(4)}\): Jauho et al. (2015), *PMR* 2: 628–634.
Do the wearables provide relevant information?

- General Public
  - Step counts
  - Running speed
  - Heart rate
  - Energy expenditure

- Wheelchair users
  - Push counts
  - Propulsion efficiency
  - Distance traveled
  - Energy expenditure

How many sensors do we need to quantify physical activities in wheelchair users?

Two moving components
I. Wheelchair Sensors

**SensorTag**
- 3-axis accelerometer (± 2/4/8/16 g)
- 3-axis gyroscope (± 250/500/1000/2000 °/s)
- Pressure sensor
- Light sensor
- Temperature sensor
- Magnetometer
- Sampling rate: 1 – 30 Hz
- Go to "sleep" after 45 sec of being inactive

$30

**PanoBike**
- Magnet system
- Revolution
- Speed
- Sampling rate: 0.83 Hz

$40

**Datalogger**
- 3-axis gyroscope
- Sampling rate: 30 Hz

Custom made
II. User Sensors

**SenseWear**
- Worn at the upper arm
- 3-axis accelerometer
- Galvanic skin response sensor
- Temperature sensor
- Heat flux sensors
- Sampling rate: 0.0167 (1 min) – 32 Hz

**ActiGraph**
- Worn at the upper arm or on the wrist
- 3-axis accelerometer (± 8g)
- Data storage: 240 days
- Battery life: 25 days (continuous usage)
- Sampling rate: 30 – 100 Hz

$225
Microsoft band

- Worn on the wrist
- 3-axis accelerometer (31 – 32 Hz)
- 3-axis gyroscope (31 – 32 Hz)
- Heart rate (1 Hz)
- GSR (only in the new version)
- UV sensor
- Ambient light sensor
- Barometer (Microsoft band 2 only)
- GPS

$250

What about the quality of the movements?

Inertial Measurement Unit (IMU)

- IMU is a broad term used for a device that can measure acceleration and angular rotations about all the axes in a three dimensional space.
- IMU consists of multiple sensors
  - 3-axis accelerometer (±8g, 2.4GHz)
  - 3-axis gyroscope (±250/500/1000/2000 °/s, 2.4GHz)
  - Magnetometer or GPS.
- Different types available depending on applications and accuracy required

$235
Applications of IMUs

Manufacturing Quality Control [7]

<table>
<thead>
<tr>
<th>Reference</th>
<th>Device/Usage</th>
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</thead>
<tbody>
<tr>
<td>FoxTV²</td>
<td>Invertor Head Tracker</td>
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<tr>
<td>S. Wen et al.²</td>
<td>Fixture Totrack</td>
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<tr>
<td>S. Wen et al.²</td>
<td>Fixture Tool Tracker</td>
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Navigation systems [7]

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<tr>
<td>T. R. Bajaj et al.²⁷</td>
<td>GPS Track Detection</td>
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<tr>
<td>A. Zid and D. Hanly²⁷</td>
<td>Quadrant Stabilizer</td>
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<tr>
<td>Johny Han et al.²⁷</td>
<td>N2 Hap Building</td>
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Applications of IMUs

Sports learning [7]

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<td>N. C. Parkin²⁷</td>
<td>Measuring sports equipment trajectory</td>
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<tr>
<td>K. King et al.²⁷</td>
<td>Measuring golf swing trajectory</td>
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<tr>
<td>Yi Choo Hong et al.²⁷</td>
<td>Measuring golf swing trajectory</td>
</tr>
<tr>
<td>X. King et al.²⁷</td>
<td>Measuring bowling swing trajectory</td>
</tr>
<tr>
<td>Tong-Min Hsu et al.²⁷</td>
<td>Measuring hand’s end trajectory</td>
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<tr>
<td>Parks S. McCarville et al.²⁷</td>
<td>Measuring motion of floor robot</td>
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Applications of IMUs

Robotics [7]

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<tr>
<td>Jung H. Yi et al.²⁷,²⁸</td>
<td>Skid-steered mobile robot</td>
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<tr>
<td>Chen C. Y. and Karl augenris¹⁰</td>
<td>Wheel city detection</td>
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<tr>
<td>Michael Blum et al.²⁷,²⁸</td>
<td>Legged robot</td>
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Augmented Reality Systems [7]

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<tr>
<td>R. Aubez et al.²⁷</td>
<td>Personal Outdoor Navigation</td>
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Applications of IMUs

Medical Rehabilitation [7]

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<tr>
<td>W.-W. Wang and L.C. Loo</td>
<td>Exoskeleton for Rehabilitation</td>
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<tr>
<td>Caven Clemen et al.</td>
<td>Exoskeleton for Rehabilitation</td>
</tr>
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<td>Jo-Nam Kam et al.</td>
<td>Post-stroke Rehabilitation Monitor</td>
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<td>Jon Erkko et al.</td>
<td>Post-stroke arm rehabilitation</td>
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<tr>
<td>Y. Q. Dong et al.</td>
<td>Arm posture correction</td>
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<tr>
<td>Classic Tens and Gory Stark</td>
<td>Post-traumatic movement analysis</td>
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Big Question

How do we use these wearable sensors to provide meaningful information to wheelchair users or their healthcare providers?