Design and Fabrication of an Instrumented Cane for the Blind

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Presentation Overview

• Introduction and Background
• Scope and Project Requirements
• Component Selection
• Design Implementation
  • Component Validation
  • Cane Assembly
  • Vibration Characterization
  • Muscular Exertion Validation
• Experimental Trial
• Conclusions and Future Work
Introduction and Background

Wooden
Fiberglass
Aluminum
Carbon Fiber

What makes a good cane?
What is known

Cane performance - Ability to detect drop offs and obstacles

<table>
<thead>
<tr>
<th>Performance</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Rigidity</td>
<td>● Weight</td>
</tr>
</tbody>
</table>

Two-point Touch and Constant Contact
Scope and Project Requirements

- Ongoing research into cane effectiveness
- Interest in Vibration characteristics
  - Resonant Frequencies
  - Damping
- Previous experimentation very simplified
Design Objectives

The Department of Blindness and Low Vision Studies set a primary and secondary goal for our project:

- Vibration and Force Analysis
- Muscle Exertion Measurement

Additional desired operating conditions:
- Wireless
- Lightweight
- No restriction of user’s motion
PCB 352C22 Uniaxial Accelerometer

- ½ Gram
- About the size of a raisin
- Already owned by WMU
- ±800 g pk range
- 10 mV/g sensitivity
PCB 208B02 Force Gauge

- 22.7 g (AA battery or 4 quarters)
- Size: 0.625” (Whopper Candy)
- Already owned by WMU
- 100 lb range
- 50 mv/lb sensitivity
NI-9234 Analog Input Module

- Already owned and used by WMU
- 5 oz. in weight
- Automatic filtering
- 4 Channels
- Reliable
- 51.2 kHz sampling rate
NI-9191 Wireless Chassis

- 8 oz.
- $380
- Automatic buffering
- Reliable
- Range: 30 m indoor or 100 m line of sight
Talentcell 12 V, 6 Amp-hour Lithium Ion Battery

- 1 lb
- $30
- 8 hour life
- 5” x 3.4” x 1”
Muscle Exertion

- Electromyographic sensors
- Technique for evaluating and recording muscular activity
- Sensors detect the voltage generated by muscles
Myo Armband

- $200
- Bluetooth (no loose wires)
- Easy to wear
- 93 g (slightly less than an Iphone)
Design Implementation

- Component Validation
- Tabletop Wireless validation
- Sensor Calibration
  - Measure Accelerometer sensitivity
  - Confirm Force gauge nominal sensitivity
Force gauge sensitivity to oblique impact

It is important to know how accurate the force gauge is when impacted at an angle.

<table>
<thead>
<tr>
<th>Angle (degrees)</th>
<th>% Error</th>
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<tbody>
<tr>
<td>0</td>
<td>2.09</td>
</tr>
<tr>
<td>10</td>
<td>1.32</td>
</tr>
<tr>
<td>20</td>
<td>8.29</td>
</tr>
<tr>
<td>30</td>
<td>29.76</td>
</tr>
<tr>
<td>40</td>
<td>17.21</td>
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</table>
Cane Assembly

- Accelerometers attached to cane
- Force gauge mounting scheme
  - Custom Tip
- Fishing Vest
Vibration Characteristics

- Cane was tested for resonant frequencies using mounted sensors.
- Performed with and without force gage.
- Cantilevered and held in hand.
Results
Results
Results
Results

![Graph showing frequency vs. dB Ref (Rms) for 101.97 m gal N, with labeled peaks at 1, 2, 3, 4, and 5.]
Myo Testing

- Duration Test
- Gripmaster Test
- Cane Tap Test
- Real Time Demo
Experimental Trial with Blind Participant

- As a proof of concept, force and acceleration data was collected with a blind participant.
- Observations about the data show that the system is working correctly.
- Four conditions tested:
  - Two-touch, carpet
  - Constant contact, carpet
  - Two-touch, concrete
  - Constant contact, concrete
Results

Magnitude of force and vibration

Two-Touch method, carpet

Constant Contact method, carpet
Results (continued)

Natural Frequencies agree between laboratory and experimental conditions.

- 20 Hz
- 70 Hz
- 145 Hz
Conclusions

An instrumented cane was designed and fabricated

- Vibration and force measurements
- Wireless
- Muscle exertion
- Ergonomic
- Proof of concept
Future Work

This project created a new research tool to investigate the blind cane. Some possible areas of research include:

- Impact of tip force on drop-off discrimination
Future Work (continued)

- Relation between cane tap and vibration felt in the hand
- Determination of ground surface
- Vibration parameters and cane effectiveness
Acknowledgements

- James Bowman and Nathan Wortman
- Dr. Koorosh Naghshineh
- Dr. Dae Kim
- Dr. Robert Wall Emerson
- WMU Department of Mechanical and Aerospace Engineering
Questions?
References


- http://www.flexvoltbiosensor.com/
- https://noexcuseshealth.wordpress.com/2013/03/13/forearm-exercise-wrist-curls/
Experimental Trial Results

Muscle Exertion: