Characterization of Gait Patterns in Common Gait Rehabilitation Exercises

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Background
- In prior work [1], a gait and terrain monitoring system was developed and validated on people with known gait impairment on 5 terrain types: level ground, up stairs, down stairs, up ramp, and down ramp.
- A new and improved device allowed gait readings to be measured without the need for a laptop.

Motivation
- People undergoing gait rehabilitation may perform exercises that differ from the type of walking that occurs in standard community ambulation.
- People with gait impairments may traverse stairs in a step-to-step pattern, rather than the step-over-step pattern seen in normal gait [2].
- A tool to monitor walking activity as well as long-term changes in gait patterns is an important tool for clinicians.

Research Goal
Demonstrate the ability to quantify gait patterns during some of the unique walking activities performed in physical therapy such as sidestep, backwards walking, and step-by-step on stairs.

Experimental Procedure

<table>
<thead>
<tr>
<th>Test</th>
<th>Duration</th>
<th>Leading leg</th>
<th>Number of trials</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backward walking</td>
<td>100 feet approximate</td>
<td>N/A</td>
<td>5</td>
<td>Standard walking speed</td>
</tr>
<tr>
<td>Sidestep</td>
<td>50 feet approximate</td>
<td>Instrumented</td>
<td>3</td>
<td>Standard walking speed</td>
</tr>
<tr>
<td>Sidestep</td>
<td>50 feet approximate</td>
<td>Non-instrumented</td>
<td>3</td>
<td>Standard walking speed</td>
</tr>
<tr>
<td>Upstairs (step-to-step)</td>
<td>13 steps per flight</td>
<td>Instrumented</td>
<td>4</td>
<td>Standard walking speed</td>
</tr>
<tr>
<td>Upstairs (step-to-step)</td>
<td>13 steps per flight</td>
<td>Non-instrumented</td>
<td>4</td>
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<td>4</td>
<td>Standard walking speed</td>
</tr>
</tbody>
</table>

Results and Discussion

- Representative plots are shown here.
- Standard deviations on coefficients were small, even for downstairs data that is impacted by the approaching stairway landing.
- Transitions from one terrain type to another can be difficult to predict. Downstairs results show one possible means to alleviate that challenge.
- Patterns from all level ground walking types are visibly different.
- Patterns from all stair ascent and descent trials are all visibly different.
- Distinct differences in data sets make terrain prediction (as opposed to monitoring) a possibility.

Experimental Equipment

Data Analysis
- Complete analysis procedures are outlined in [1]
- Data were fit to 4th order Fourier series in Matlab using a modified RANSAC (RAandom Sample Consensus) algorithm.
- Fourier coefficients are relatively insensitive to frequency, so all raw data were scaled to a common frequency to compensate for slight variations in walking speed.

Conclusions & Future Work
- Distinct gait patterns can be captured for unique walking activities seen during rehabilitation and physical therapy.
- Differences in gait patterns between leading and trailing leg can be captured.
- This monitoring device may be helpful in monitoring gait symmetry.
- This monitoring device may be helpful in monitoring client’s use of “up with the good leg, down with the bad leg” [2] stair walking routines.

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References