Using Inertial Sensors to Quantify Changes Exhibited During Rehabilitation

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Technology for Rehabilitation

Simulated Environments
After stroke or injury, patients struggle with mobility and activities of daily living. Simulated environments promote functional independence by providing ecological context to therapy.

The Need for Mobility Assessment Tools
Therapists use experience to qualitatively assess progress. At inpatient facilities, patients are rarely mobile on admission. Since human motion is complex, quantifying mobility details throughout rehabilitation provides more information and insights than human observation alone.

Proposed Technological Solution
Wireless inertial sensors are a technology especially suitable for quantitatively tracking mobility in simulated environments. The sensors provide movement data, are relatively inexpensive, do not interfere with natural movement, and are quite portable, and are easy for non-technical staff to use.

Wireless Sensor Platform

Three Shimmer3 Inertial Measurement Units (IMU)
- www.shimmersensing.com
- Bluetooth communication and SD card logging
- Sampling rate set to 51.2 Hz

Experimental Design

Participants in the study performed an ambulatory circuit (AC) in an indoor, simulated community at SLRIs Rehabilitation Institute (SLRI) in Spokane, WA. The AC consists of rising from a chair in a hotel lobby, walking to the passenger side of an SUV, and transferring into the vehicle. Once loaded, the participant returns to the chair and sits down.

Data Processing Overview

Raw Data from Center of Mass
- Center of Mass Filtering
- Electrocardiogram (ECG) filtering
- Utilize additional modules within the simulated community
- Develop therapeutic feedback to impact recovery by:
  - Communicating the detected deficits to:
  - Help patients conceptualize movement strategies
  - Motivating patients with progress tracking
  - Help patients conceptualize movement strategies

Quantitative Changes Exhibited

Data were collected on the AC from participants receiving inpatient rehabilitation at SLRI. Data collection occurred in two testing sessions. Each testing session consisted of two separate trials on the AC. Minimum recovery requirements to qualify for Session 1 (S1) testing included a Mini-COG score above zero, aptitude for safe ambulation, and informed consent. Session 2 (S2) testing was conducted following a one week inpatient therapy course.

Preliminary data suggest that changes exhibited by individuals as a result of rehabilitation can differ dramatically (Figure 4). The large intersubject variability is grossly overshadowed when comparisons include a reference control group (Figure 4a and Figure 5). These results demonstrate that the current platform is sufficient for identifying injury related deficits in movement.

For some metrics, changes in variance may have a stronger correlation to progress during rehabilitation than the metric itself (Figure 6). This would indicate that consistency in performance is closely related to the recovery progress.

Clinical Relevance

The preliminary results with wireless sensors provide recovery information beyond the traditional clinical evaluation. This information can be utilized to make decisions about therapy, evaluate responsiveness to therapeutic regimens, and justify third party reimbursements for therapy units. Our collaboration with researchers and physical therapists at SLRI in the future aims to:

- Better understand how underlying injuries affect recovery
- Synthesize the environmental context with the sensor data
- Develop therapeutic feedback to impact recovery by:
  - Communicating the detected deficits to:
  - Help patients conceptualize movement strategies
  - Motivating patients with progress tracking

Acknowledgements: We wish to thank our project advisors Dr. Diane Cook and Dr. Douglas Weeks, our therapist collaborators at SLRI, and our funding source: NSF IGERT Program (DGE-0900781).