

Problem Statement

The SenseWear₂ Armband™ (BodyMedia, Inc.) uses five different sensors to detect whether the wearer is active, but does not detect the specific activities being performed by the user.



Physical Activity Detection Using BodyMedia SenseWear₂ Armband

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Project Objectives

Develop an algorithm using MATLAB that:

- Inputs signals from SenseWear₂ Armband (SWA)
- Differentiates jogging and wheelchair propulsion from other activities (85% CI)
- Outputs activity analysis
- Is accessed via graphical user interface (GUI)

Methods

Data Collection

- 10 subjects performed 10 different activities
- Data collected were used to design the algorithm
- 5 additional subjects performed the same 10 activities to test the developed algorithm

Engineering Analysis

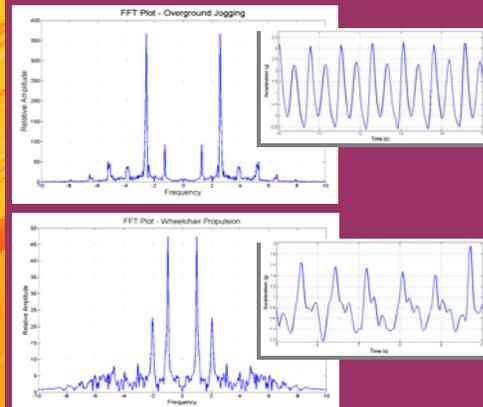
Signal Processing

Filtering

- A biaxial accelerometer in SWA was used to obtain acceleration signals in longitudinal and transverse directions.
- Acceleration signals were filtered using a Butterworth 3rd Order Filter.

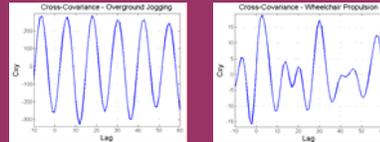
Fast Fourier Transforms (FFT)

- Fast Fourier Transforms were applied to the longitudinal and transverse acceleration signals for 20 second time periods before and after the 2nd minute of a given activity.
- The amplitude and frequency of the largest two peaks of each FFT were recorded in a spreadsheet.



Cross-Covariance

- Cross-covariance was used to determine if a relationship existed between longitudinal and transverse acceleration signals.
- The first negative and positive peaks of the covariance graphs were recorded in a spreadsheet for given activities.



Algorithm Development

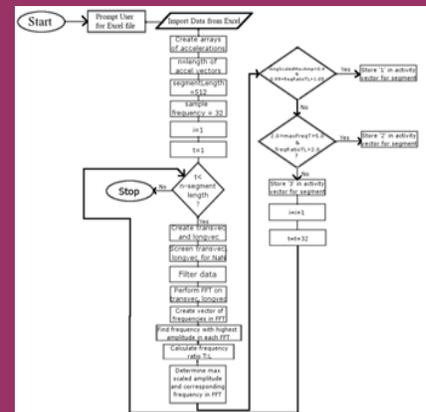
Criteria for jogging

- If Scaled Max Amp > 0.4 &&
- If $0.99 < \text{Freq Max Ratio TL} < 1.05$

Criteria for wheelchair propulsion:

- If $2.0 < \text{Trans Freq Max} < 5.0$ &&
- If $\text{Freq Max Ratio TL} > 2.0$

Activity Analysis Program



Acceleration data from SWA are imported into the program from the biaxial accelerometer outputs. Activity differentiation starts by separating the vectors into moving 512-element segments (16 seconds each) using a 'while' loop. Each segment is passed through a Butterworth 3rd order filter and FFTs are applied. Critical values are determined and passed through the algorithm to determine if jogging or wheelchair propulsion occurred during the recorded time. The loop repeats with another 16 second segment starting one second after the start of the previous segment until the process is complete. 'ActivityVector' is created through the process and contains elements which depict the activity of the subject at each second recorded by SWA.

Graphical User Interface



- Easy access to activity analysis program
- Incorporates inputs regarding signal
- Outputs time period jogging and wheelchair propulsion occurred

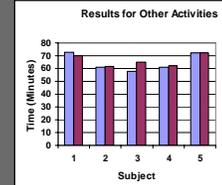
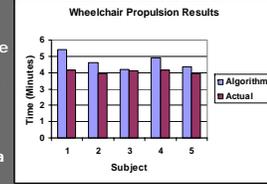


Results



Algorithm time (36.6 min) closely matched Actual jogging time (36.4 min), reflecting a 99% accuracy rate for all trials.

Algorithm time (23.5 min) closely matched Actual wheelchair time (20.2 min), reflecting an 86% accuracy rate for all trials. Greater error due to methodology used during wheelchair data collection.



Algorithm time (325.3 min) closely matched Actual other activity time (331.3 min), reflecting a 98% accuracy rate for all trials.

Conclusions

The algorithm developed differentiates jogging and wheelchair propulsion with greater than the required 85% accuracy. Future testing will be done to determine accuracy of start and stop times for each activity. This assessment will involve both ambulatory and non-ambulatory adults in the "free living" environment to determine efficacy in the clinical setting.

Applications

Development of these algorithms will:

- Help healthcare professionals in a rehabilitation setting better quantify what activities their clients are doing in the "real world," away from the clinic.
- Provide the wearer a system of measurement that will aid in management of physical activity behavior
- Enable refinement of exercise-specific energy expenditure algorithms in the armband to provide more accurate estimates of energy expenditure.