Quantifying Activity via Actigraphy:
An Automated Algorithm for Holistic Application

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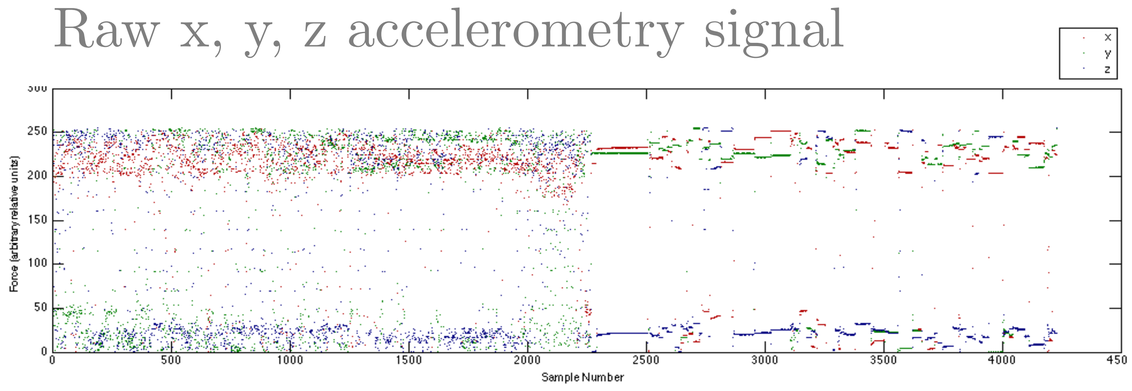
The Aim Actigraphy can be used to monitor chronic conditions, predict or alert on debilitating episodes, objectify current wellness, or for specific clinical assessments. I present a fully-automated, efficient and robust function for data handling and three automated algorithms of activity quantification.

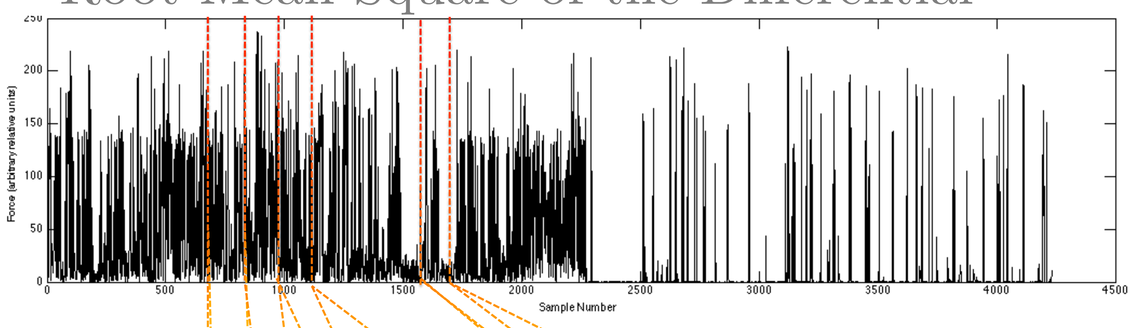
- Method 1 uses spectral analysis to break down activity by frequency;
- Method 2 is a fast and robust method of binary sleep/wake detection;
- Method 3 is capable of learning to identify different forms of activity.

Raw x, y, z accelerometry signal

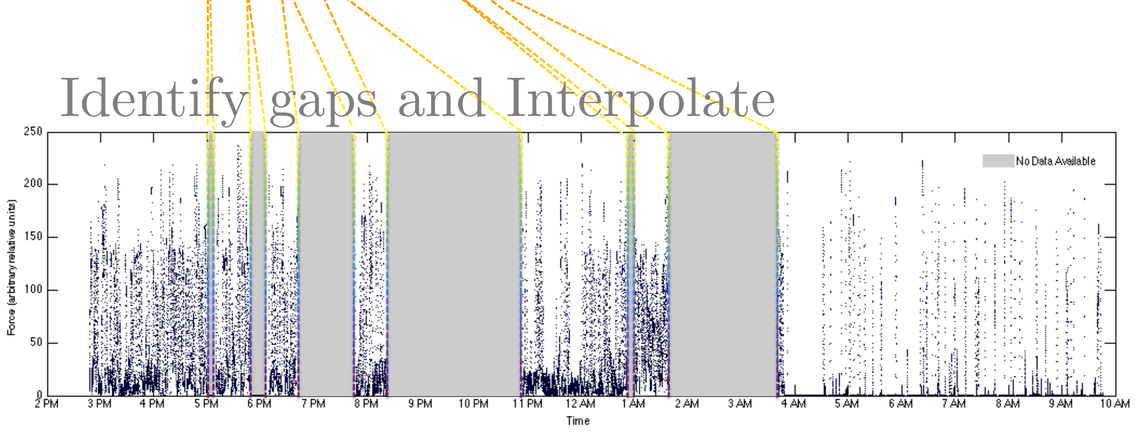


The device outputs the g-force on each axis. This value is an intractable function of force due to movement and gravitational pull (DC bias), which can be removed effectively by taking the 1st order differential.

Root Mean Square of the Differential



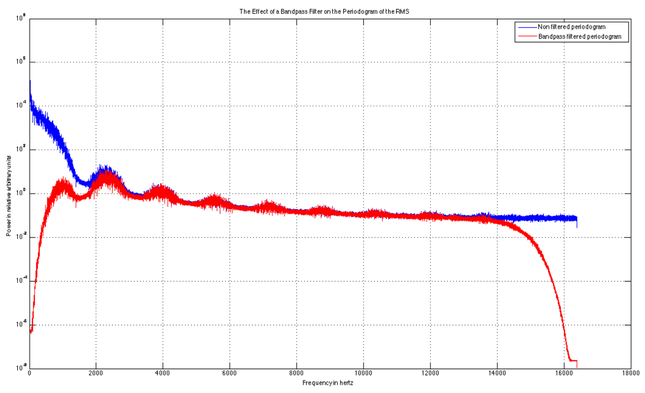
Identify gaps and Interpolate



The sampling frequency is not necessarily uniform over the signal so data was interpolated to maximal resolution. The algorithm intelligently identifies significantly-sized gaps. It is also able to detect unrealistically static signals when the device is not being worn but remains sampling.

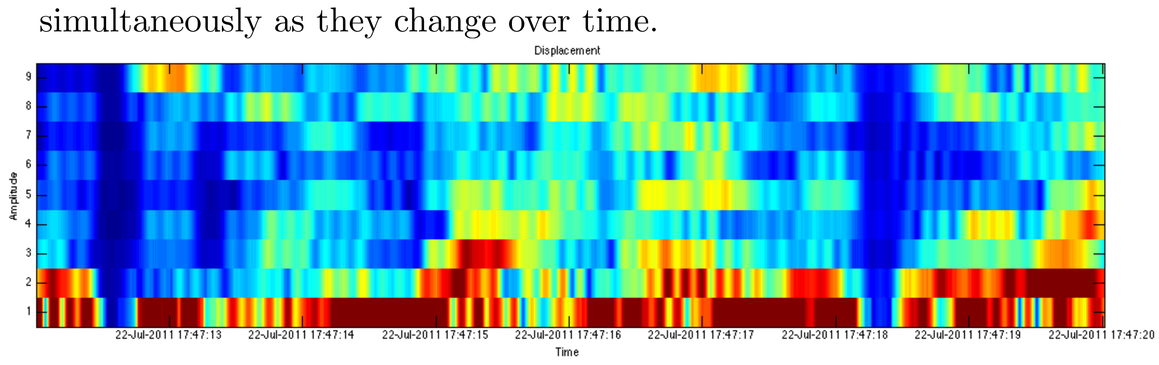
Bandpass Filter

By estimating the signal as a function of its energy per frequency, it is possible to filter for the frequencies that are associated with conscious human movement; the remainder are attenuated.

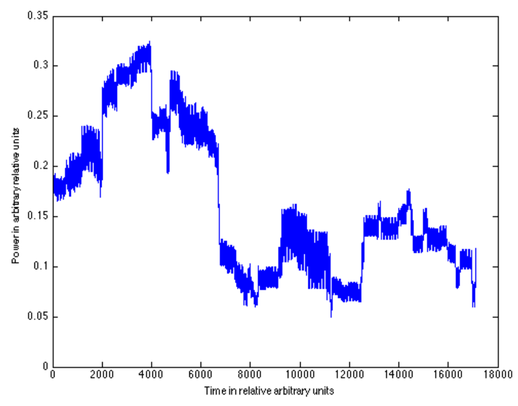


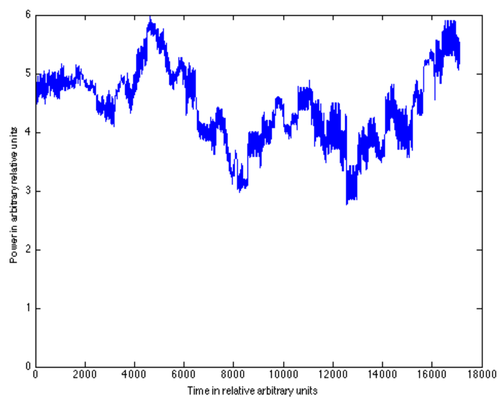
Method 1: Fourier Analysis

Using a sliding window and performing Welch's method of averaged periodograms allows for several frequencies to be studied simultaneously as they change over time.



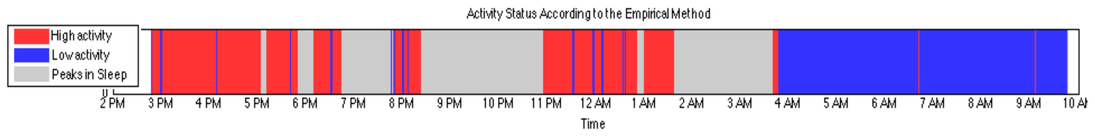
Particular frequencies of interest can be filtered to potentially identify individual activities.





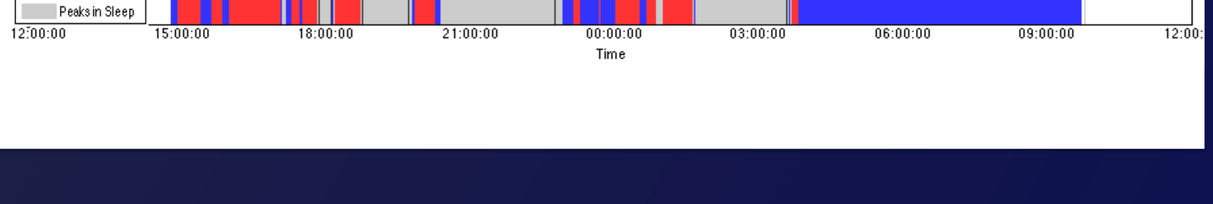
Method 2:

An autonomously-generated threshold was designed that is repulsive to signals approaching from either side; thereby allowing simple-thresholding to assign low/high activity status.



Method 3: Linear Regression Analysis

A database of normal actigraph statistics during sleep and during wakefulness was created. These statistics are compared to statistics generated from an 11 minute window of the current signal, which is assigned a sleep probability score based on the result of the comparison.



Further Work

- Large controlled trials for fine-tuning and comparison
- Teach algorithm a wider spectrum ofactivities
- Automatic sync to web and port code to a web-app
- Intergretaion with other automated monitoring systems

References

- A Sadeh, PJ Hauri, and DF Kripke. *The role of actigraphy in the evaluation of sleep disorders*. Sleep, 1995.
- DF Kripke, JB Webster, DJ Mullaney, and S Messin. *Measuring sleep by wrist actigraph*. 1981.

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