

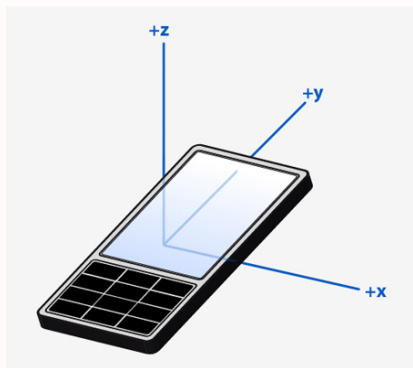
# Processing and Analysis of Accelerometer Data from Wearable Devices

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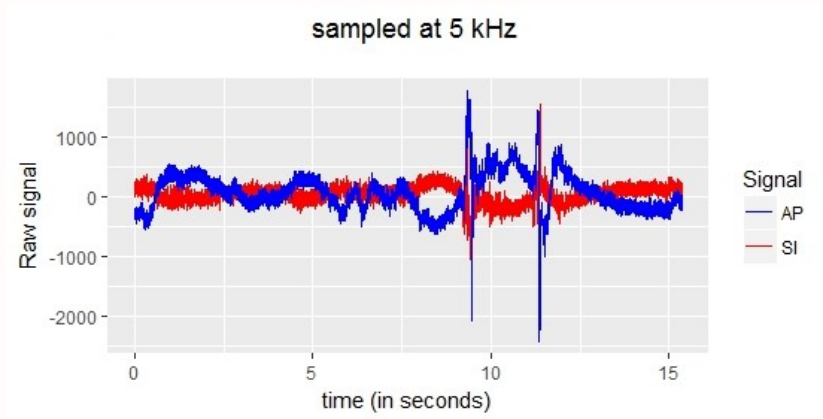
- Accelerometers are sensors that measure the acceleration of moving objects.
- They can measure motion along either 2 or 3 reference axes.
- The small form factor allows them to be used as embedded devices in wearable units.



- Accelerometers are good for measuring body movements brought about by skeletal muscles.
- Used in physical activity, energy expenditure, fall detection, gait etc.
- Important for studying neuromuscular disorders like stroke and Parkinson's disease.

- To study dysphagia - difficulty in swallowing.
- According to a study done in 2014, it affects over 9 million adults and 0.5 million children in the US.
- In this case study we were looking to detect dysphagia using a device worn around the neck.
- The device has an embedded dual-axis accelerometer that picks up movements in muscles of the oesophageal wall that occur during swallowing.
- The objective was to detect the presence of dysphagia based on the output signal from the accelerometer.

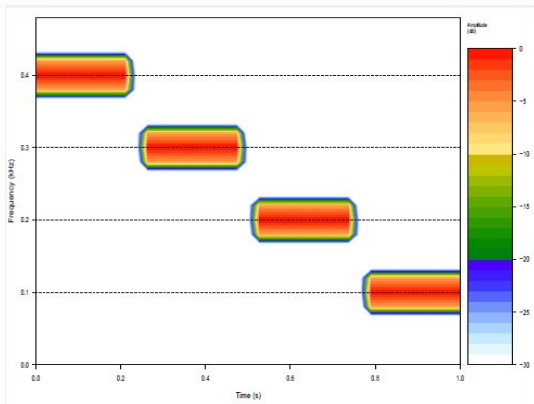
- The data was a time series obtained from the wearable device.
- The data was collected while subjects were asked to swallow food of a certain consistency.



- The signal is filtered using a low-pass filter to block all signals that are higher than 1 kHz.
- This is done to remove unwanted noise signals that may be generated from the electronic circuits of the embedded device.
- Cut-offs such as these are unique to applications and can be determined only after consulting domain experts.
- Thereafter, the signal is downsampled, i.e., every alternate sample of the signal is discarded. The 5 kHz signal is now effectively a signal that were sampled at 2.5 kHz.
- This is done to reduce the processing time.

- Characteristic frequencies in a signal can be mapped to certain aspects of the physical process.
- The time-domain signal is transformed into an equivalent frequency-domain representation using Fourier transformation.
- Signals are split into time windows and a discrete Fourier representation of the signal is computed for each such window.
- This is the short-time Fourier transform. Its advantage is that it preserves the time information at which frequencies of interest occur.





- Feature engineering is the process of creating features that can be useful for the learning problem of interest.
- This needs extensive domain knowledge both in terms of engineering as well as physiology.
- These can be of various kinds such as -
  - ▶ sound direction based features
  - ▶ basic spectrogram features
  - ▶ features characterising head motion
  - ▶ entropy-based features etc.

- These features are extracted from the spectrogram in the range of 5 Hz to 500 Hz. They characterise the sounds produced during the swallowing activity.
- An example of such a feature would be the sum of the absolute value of the signal's spectrum in this bandwidth multiplied by the frequency resolution of the spectrum. The average of these sums over all windows can be used as a measure of the sound produced during the activity.
- Another feature is the rate curve which is the ratio of the SI spectrum to the AP spectrum. This measure can characterise the angle of motion of the muscles in the region.

- Once the features have been created, classifier models are built to classify the signals as being from a normal vs. a disturbed swallow.
- Based on classifier performance and interpretability, features are re-engineered.
- These steps are repeated, with each feeding back into the other until a satisfactory model is obtained.

- Bhattacharyya N. The prevalence of dysphagia among adults in the United States. Otolaryngol Head Neck Surg. 2014 Nov;151(5):765-9.
- P. Welch, "The use of fast Fourier transform for the estimation of power spectra: A method based on time averaging over short, modified periodograms," in IEEE Transactions on Audio and Electroacoustics, vol. 15, no. 2, pp. 70-73, June 1967.