chapter 3-3

A/D Example:

Measuring Dynamic Skinfold Compression

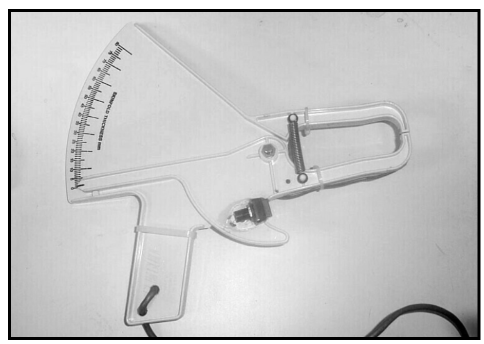
Introduction

This next two chapters present two examples of analog to digital data acquisition. This chapter focuses on a simple, inexpensive example of A/D data collection using a skinfold caliper, whereas the subsequent chapter focuses on EMG, a common procedure employed in kinesiology, where electrodes are used to sense a biological signal.

In this example a potentiometer was added to a Slim Guide skinfold caliper to produce a voltage proportional to jaw opening. Data collected using this modified skinfold caliper were used to model dynamic skinfold compression. This model was presented in chapter 2-12.

Modified Skinfold Caliper

A stock Slim Guide skinfold caliper was modified by adding a military grade potentiometer inserted through the center pivot and physically affixed so that rotation of the measuring jaw/indicator arm would directly rotate the potentiometer (Figure 3-3.1). Micro-switches were attached to both caliper jaw contact surfaces and wired in series with a 3-volt battery. These micro-switches would then be triggered when contact was made with the skin. A/D acquisition was triggered when both switches were closed, at which point both jaw surfaces were in contact with the skinfold and compression of the skinfold was commencing.



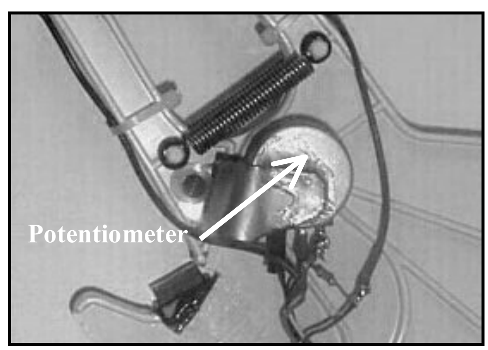


Figure 3-3.1: Modified Slim Guide skinfold caliper (top), potentiometer attached to pivot of skinfold caliper (bottom)

A custom LABVIEW program was written for data acquisition. The first question was what frequency should be used for sampling? Figure 3-3.2 shows a typical skinfold compression curve collected using the modified caliper. Notice that the compression is most rapid in the first 0.2 seconds. Since the purpose of the data collection was to have data to model, sufficient discrete data points were required to allow for curve fitting. After trying various sampling rates and subsequent model curve fitting it was decided that a sampling frequency of 100hz would be adequate. This would mean that during the first 0.2 second period 20 data points would be collected, which was adequate for subsequent modeling.

Skinfold compression data were initially collected for 5.5 seconds at 100 Hz, providing 550 data points during the period of compression. However, it became apparent that there was little useful information in the data collected after 2 seconds, so the procedure was modified to collect just the first two seconds of data and thus 200 data points. A 12-bit A/D board, configured at ±5 volts full scale range was used. A laboratory grade DC power supply was used to provide a constant voltage of ~35v to the potentiometer. The supply voltage and potentiometer orientation were chosen to provide an output voltage from the potentiometer of ~0.5–4.75v over the caliper range of 0–70mm of skinfold thickness. Linearity of the system was determined by taking repeated measures of a calibration block and also checking for hysteresis. Hysteresis occurs when loading and unloading results in different calibration curves, however none was found in this situation. In practical application, ~4.5v corresponded to 60mm of caliper excursion, resulting in a resolution of ~0.04mm.bit^{-1}.

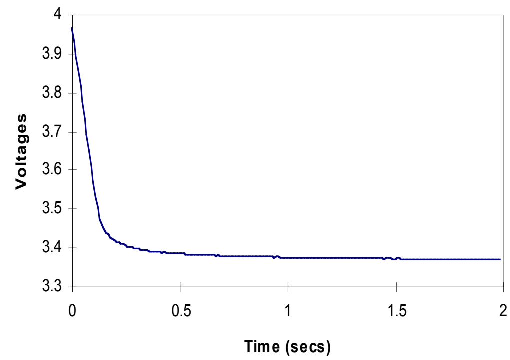


Figure 3-3.2: Typical dynamic skinfold compression curve collected by modified Slim Guide caliper

Signal Averaging

It became obvious that one trial did not give a reliable representation of the curve for any given skinfold. So a tactic of collecting 10 trials of each skinfold was adopted. All the curves would then be visually examined and any that were unacceptable in terms of noise or not decreasing monotonically were eliminated. This occasionally resulted in the elimination of 1 or 2 of the curves. Figure 3-3.3 shows eight trials of an abdominal skinfold. Two trials had been eliminated because they were

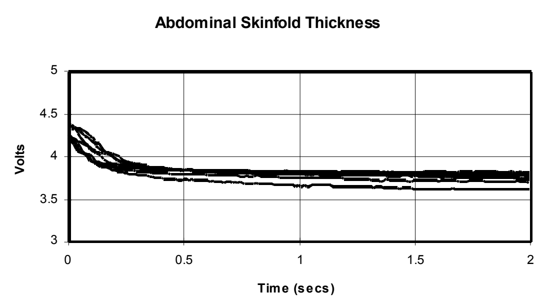


Figure 3-3.3: Repeated trials of an abdominal skinfold thickness

very atypical. In order to produce data for one representative curve for modeling a signal averaging procedure was adopted. Average curves for each site on each subject were calculated by signal averaging from the trigger point of closure of both jaw surface switches. In subjects where curves were eliminated, the average curves were produced from the remaining curves. No extra trials were carried out to replace those eliminated.

Calibration

As with all transducers, calibration of the signal coming from the caliper potentiometer was vital. The LABVIEW software would prompt for two 2 second data collections; calibration of the skinfold caliper was carried out with the caliper closed (0mm), and then open at 50mm. This data was used to produce the gain and offset values necessary for the transformation of voltage values into skinfold thickness values. The 2 seconds of 0mm (closed caliper) data was averaged to produce a voltage representing 0mm, and the same was done for the 50mm 2 second data collection. Because there was some resistance in line even when the caliper was closed there was a finite voltage at 0mm. The difference between this and 0 volts is referred to as the offset. The voltage difference is the voltage change for a 50mm change in thickness.

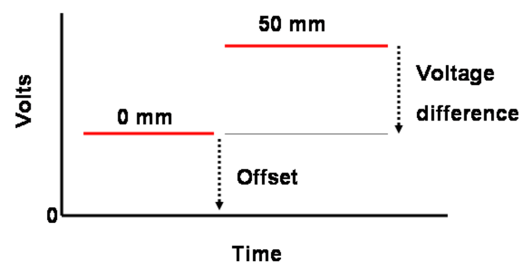


Figure 3-3.3: Modified Slim Guide skinfold caliper calibration procedure

Gain = Voltage difference / 50mm

Once the gain has been calculated, any voltage value from the caliper can be transformed into the appropriate skinfold thickness using the gain and the offset.

Skinfold thickness = (Voltage - Offset) / Gain

An assumption inherent in this calculation is that there is a linear relationship between voltage and thickness. Although this was the case for this potentiometer setup, this is not always the case for all transducers. One of the first tests you should do therefore is to check the calibration curve to determine whether or not you have linearity or some other curvilinear relationship. The other check usually made is for hystereses, determining whether or not calibration stays the same as the caliper is being loaded or unloaded.

Summary

The electronic skinfold calliper is presented as an example of a basic A/D setup. The addition of a potentiometer allowed for the collection of data that was impossible to obtain previously. The setup proved to work very well to collect quality data used in modeling dynamic skinfold compression (Ward et al., 1999).

Further Reading

Ward, R., R. Rempel and G.S. Anderson. 1999. Modeling Dynamic Skinfold Compression Am. J. of Hum Biol. 11:531-537.