GymAware Sampling Method

GymAware uses a Variable Rate Sampling with Level Crossing Detection to capture data points. It then limits(down samples) this to a maximum of 50 points points per second. Note that this is NOT equivalent to a traditional 50Hz continuous sampling system as position points are time-stamped with a high resolution (35 microsecond) time value .

This is a relatively new sampling method that has a number of advantages:

- Data is only recorded during movement
- High frequency sampling noise is rejected
- Lends itself to digital optical encoders

How it works
Optical pulses from the digital optical encoder are continuously fed into the position counter which then keeps track of the current tether position. Every 20 milliseconds the sensor waits for a transition on the position counter. When a transition is detected it is time-stamped and recorded. This has the effect of removing noise associated with quantisation and periodic sampling seen in traditional sampling methods.
A simple way of comparing this method with a traditional 50Hz systems is to look at the data.

GymAware data points look like this:

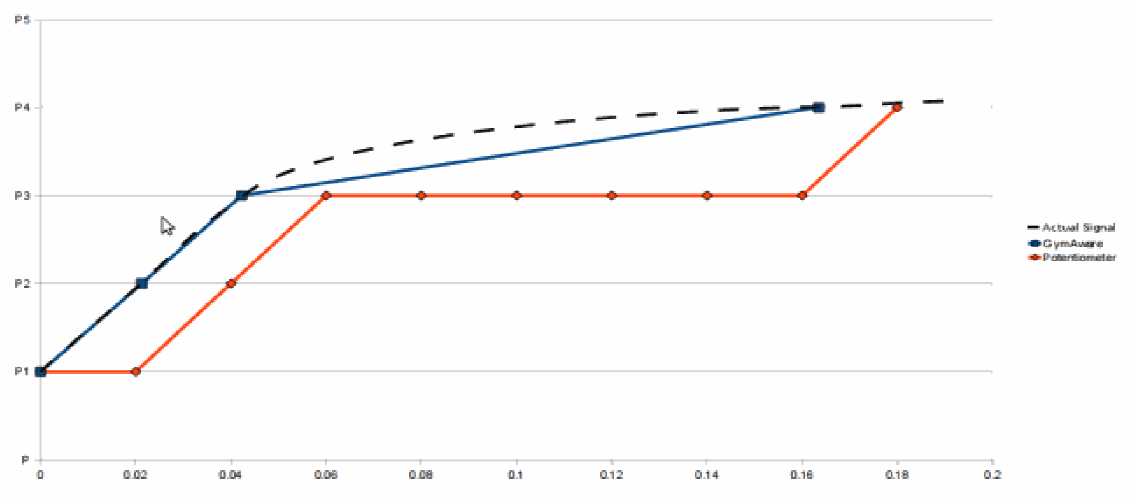
Position	Time
P1	0.0000
P2	0.0213
P3	0.0422
P4	0.1634

While the 50Hz system to record the same movement would record these points:

Position	Time
P1	0.0000
P1	0.0200
P2	0.0400
P3	0.0600
P3	0.0800
P3	0.1000
P3	0.1200
P3	0.1400
P3	0.1600
P4	0.1800

Where P1,P2,P3, and P4 are equivalent encoder marks(GymAware) or A/D quantisation levels(potentiometer)

These data are shown below and a the actual signal has be drawn in(dashed) to illustrate the relationship to the sampling methods.



The GymAware points contain more information because they are recorded precisely when the position changes and accurately time-stamped so that the data points far more closely represent actual points on the signal. The traditional approach on the other hand just records every 20 milliseconds irrespective of the position.
Notice the change from P3 to P4. GymAware reports this as a line between P3 0.0422 and P4 0.1634 (0.1212 seconds apart) while the potentiometer system shows only difference of 0.02 seconds. This truncation of the time due to quantisation error causes high frequency noise that is characteristic of traditional potentiometer systems, and is amplified when differentiating for velocity and acceleration, hence the need for filters.

Also note that the example above shows two systems with equal positional resolution while the reality is that GymAware has a default positional resolution of 600 microns which at this time is the highest resolution supported on commercially available sensors. So this would further improve the tracking of the signal above.

The 50Hz Vs 200Hz question.

GymAware is often criticised for "only being a 50Hz system" As shown above it is clear that GymAware is not a 50Hz system but in fact employs a far more sophisticated sampling system that actually adapts to the rate of change in the signal. The criticism could easily be countered by just setting the down sampling to 200Hz instead of 50Hz, the change is technically very simple, just a few lines code to change, and would appease the critics. The reason this is not done is because it is simply not necessary and more importantly, it would change the character of data recorded over the last 7 years which could in turn raise doubts about comparability of data pre and post making the change.

Filtering

One of the key benefits of this approach is that it requires no filtering. Systems that rely on filtering to get smooth data will report vastly different values depending on the cut-off frequency. Some systems even allow the user to adjust the filter cut off frequency, leading to a lack of quality control in ensuring comparability of results. GymAware suffers none of these issues as results from all GymAware sensors are recorded under exactly the same conditions.

More detail on the adaptive rate sampling can be found in this paper:

Adaptive Rate Sampling and Filtering Based on Level Crossing Sampling
Saeed Mian Qaisar, Laurent Fesquet (EURASIP Member) and Marc Renaudin
EURASIP Journal on Advances in Signal Processing
Volume 2009 (2009)