

Working at the Edge

Minos 2017

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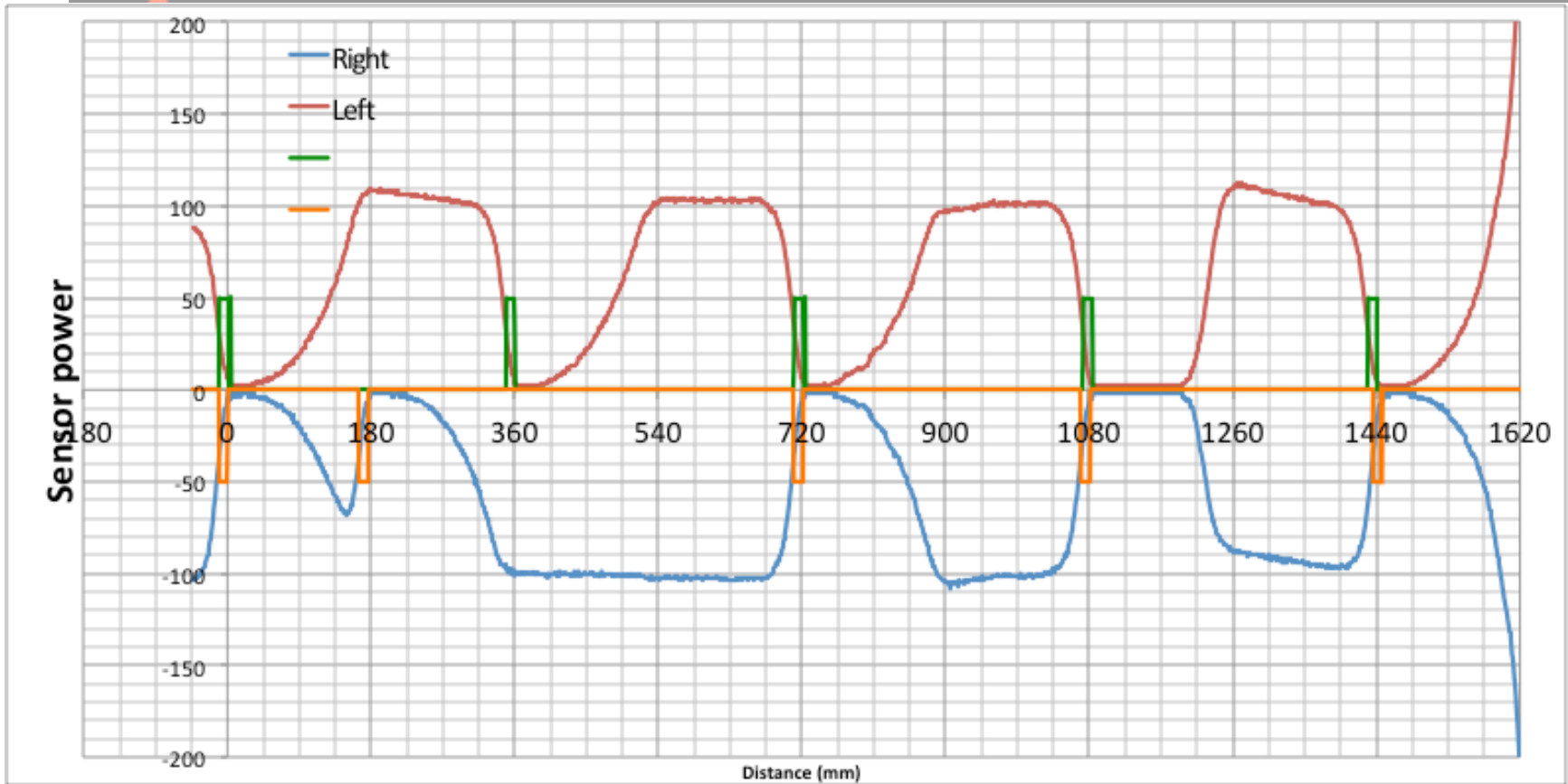
How important are the edges?

- Transition from wall to no-wall
- This is the sensor signal falling off as the mouse passes a post when travelling
- Important for forward error correction
- Critical for accurate triggering of turns
- Must be completely reliable, repeatable and accurate

Data logs from test maze

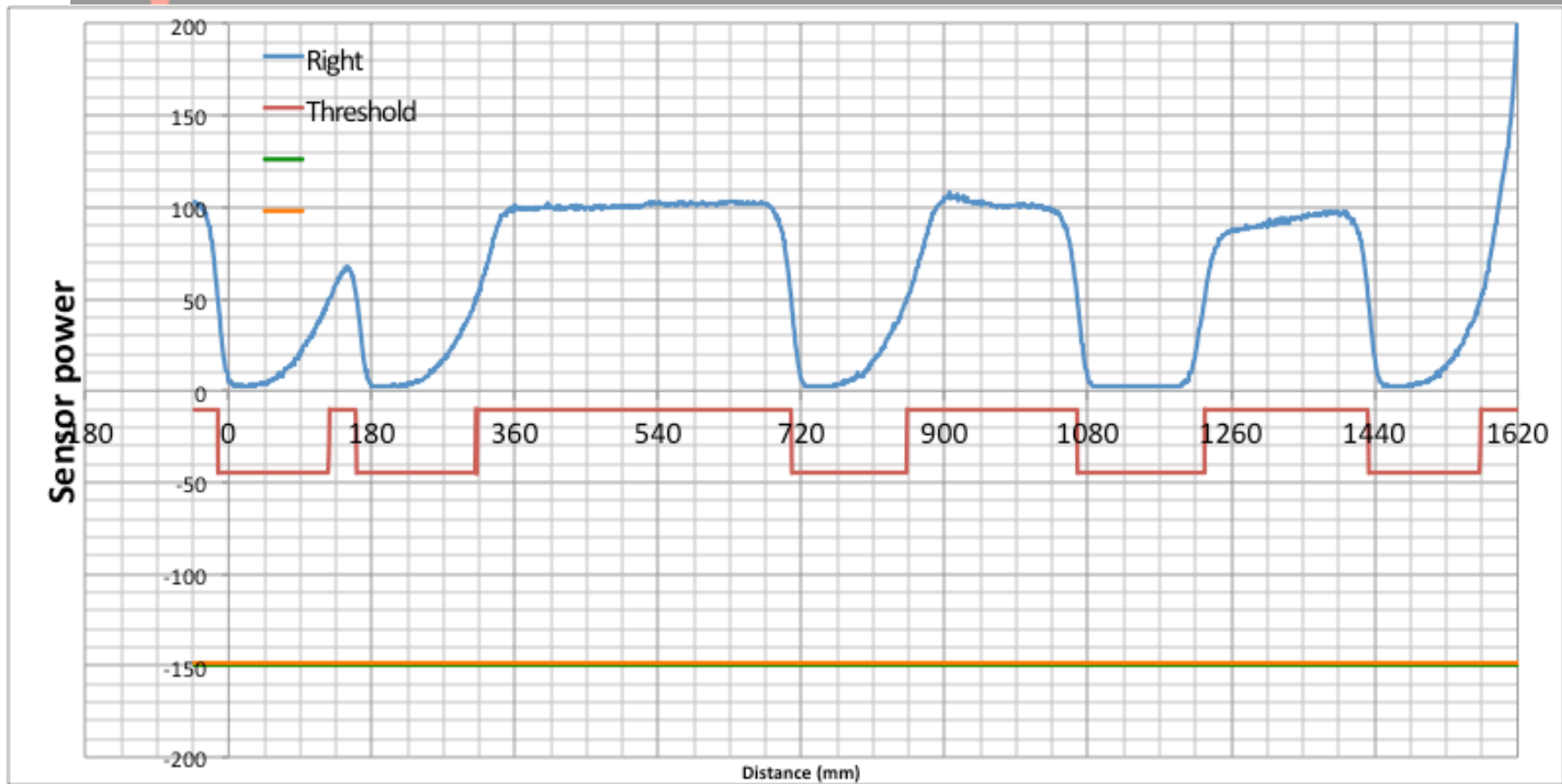
```
o---o---o---o---o---o---o---o---o---o---o
|299 286 279|234 227|182 175|140 124 115|
o o---o o o o o o o---o o
|308| x |260 253|208 201|156 149| x |107|
o o o---o---o---o---o---o---o o o
|324| x x x x x x x x | 98|
o o o o o o o o o o o o
|333| x x x x x x x x | 82|
o o---o---o---o---o---o---o---o o
|341| 0 13 26 37 46 54 61 67 73|
o---o---o---o---o---o---o---o---o---o---o
```

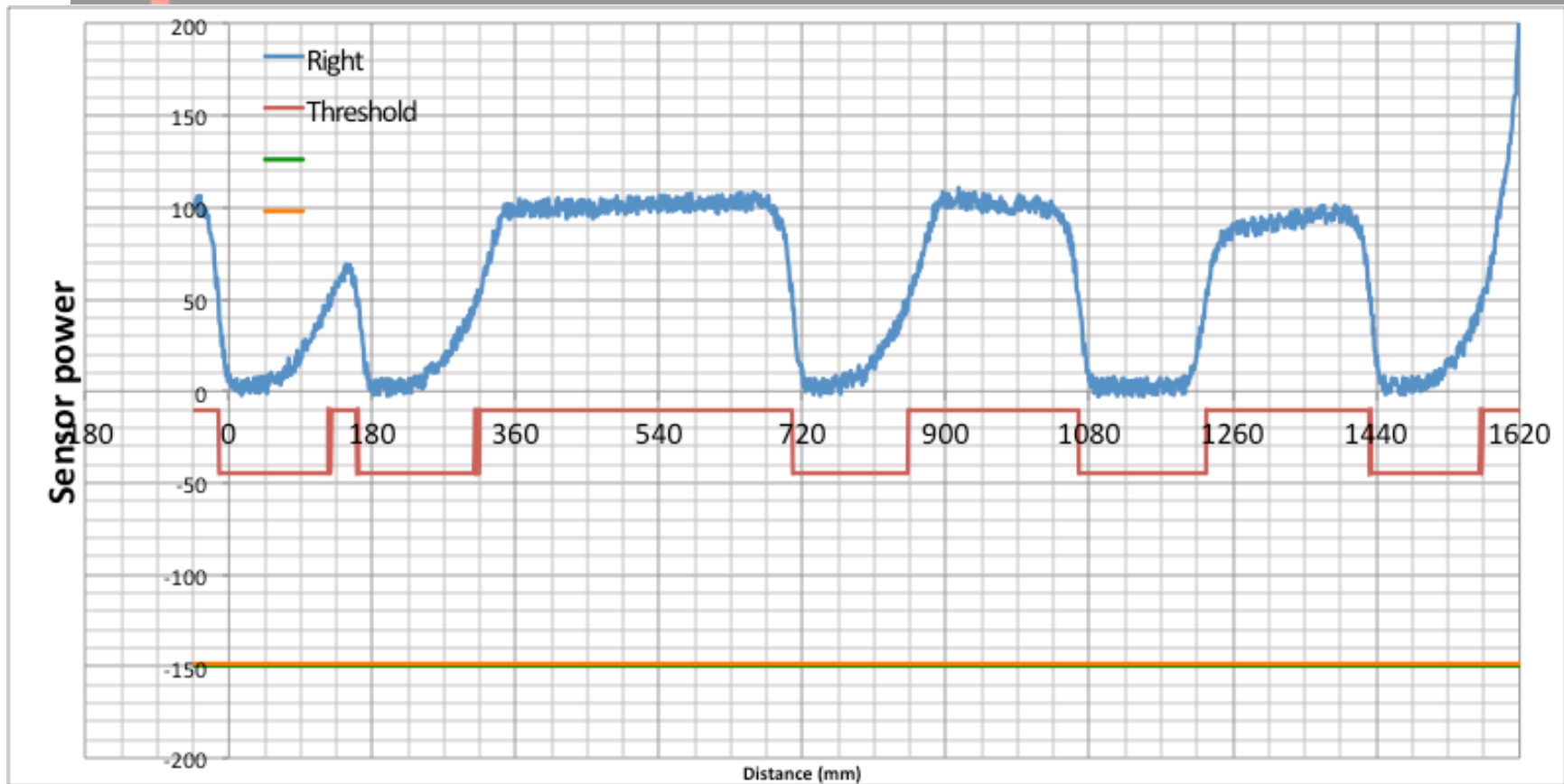




Simple Thresholding

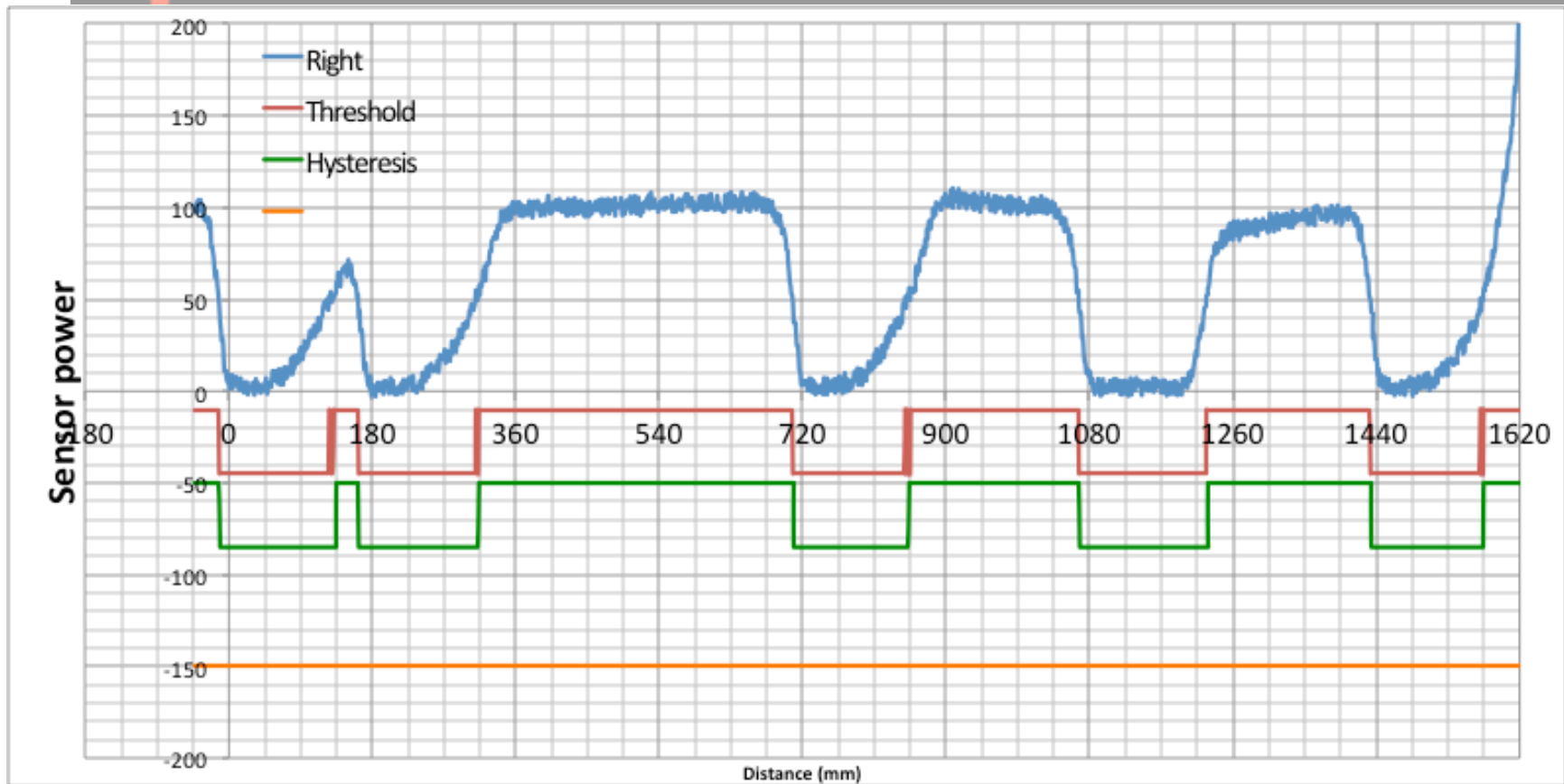
- Pick a sensor reference level
- Higher is a wall, lower is not
- Noise will give spurious transitions
- Different responses for diagonal and orthogonal movement
- Wall reflectance varies 10% on same maze
- Variation much greater between mazes – 30%?
- Lateral offsets change edge position
- Mouse speed changes edge slope





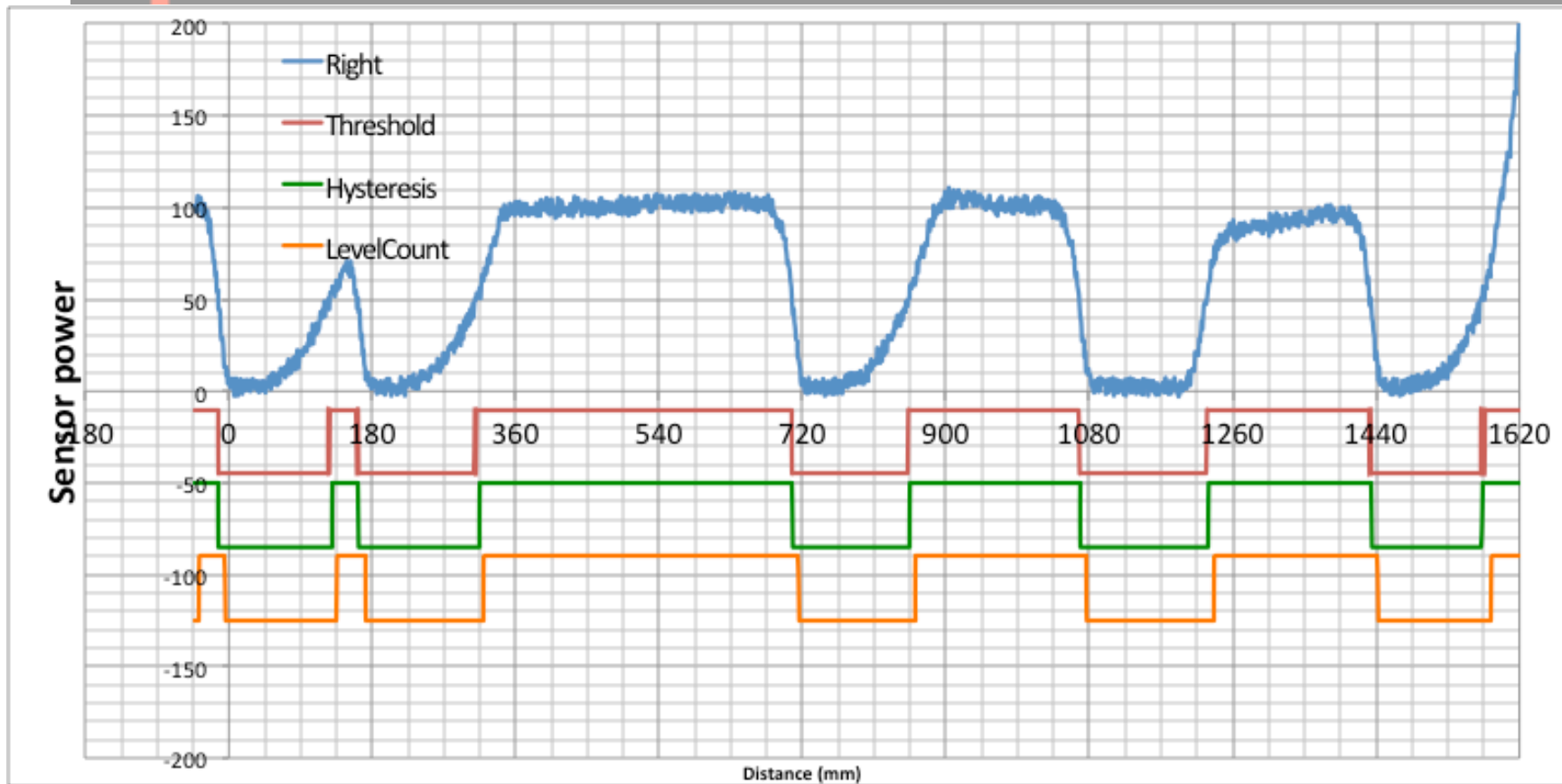
Threshold plus hysteresis

- Add hysteresis to the threshold
- Only change state when the signal changes by some additional hysteresis level
- Eliminates the effect of low level noise
- Does not help with all the other problems



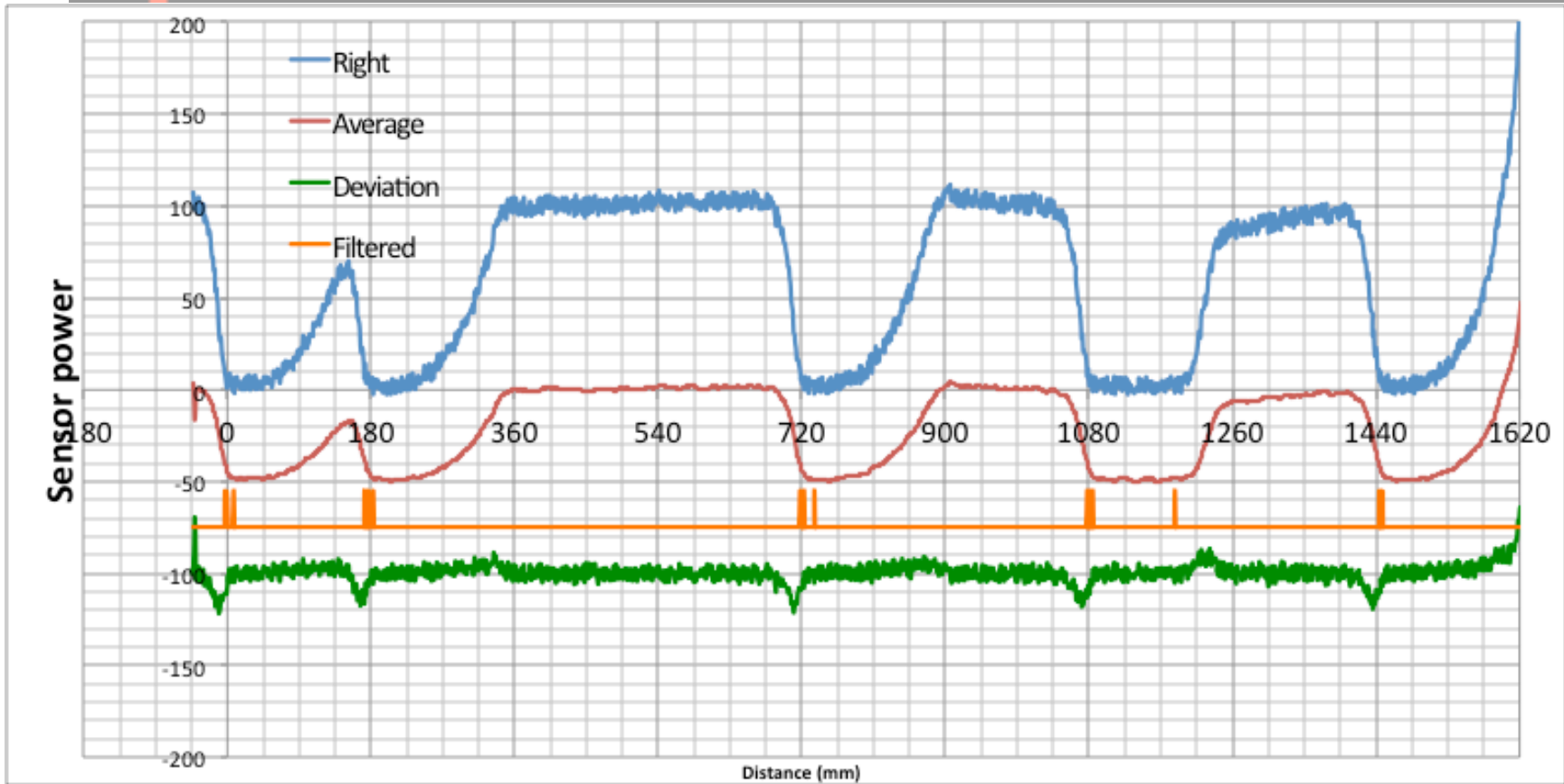
Level counting

- Several ways to do this
 - Increment a counter when signal is above the threshold
 - Decrement the counter when signal is below the threshold
 - Limit the counter to, say, +/- 3
 - Only change state when the limit is reached
 - Output has wall at +3, no wall at -3
- Robust with good noise elimination
- Edge position is delayed by the counting



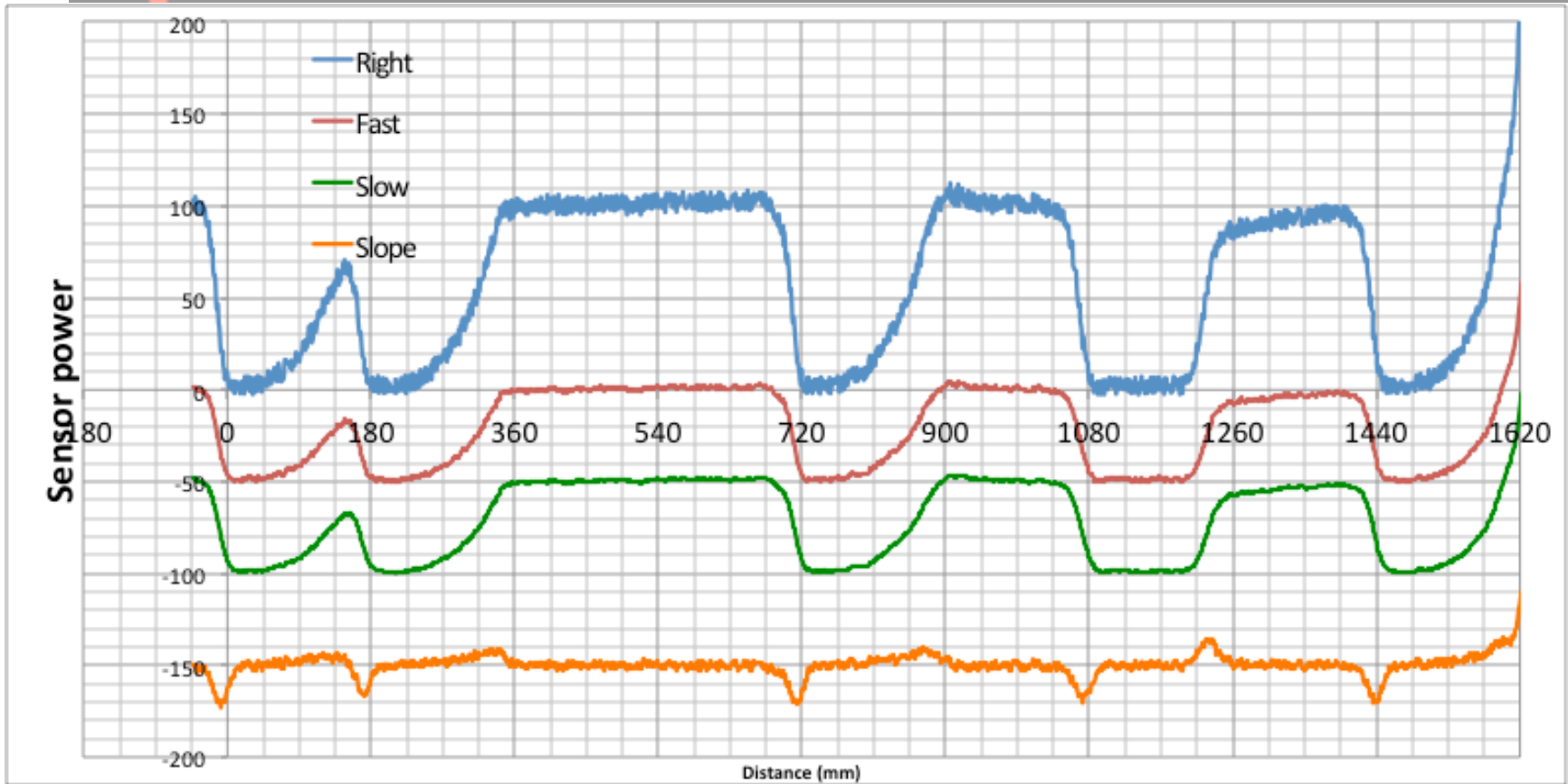
Slope detection - moving average filters

- Make a moving average of the signal
- Subtract the current value from the average.
- Negative peaks clearly indicate the edges
- Look for threshold changes during these peaks
- Averaging delays the result
- Even though the moving average is an ideal Gaussian noise eliminator, you put the noise right back with the subtraction



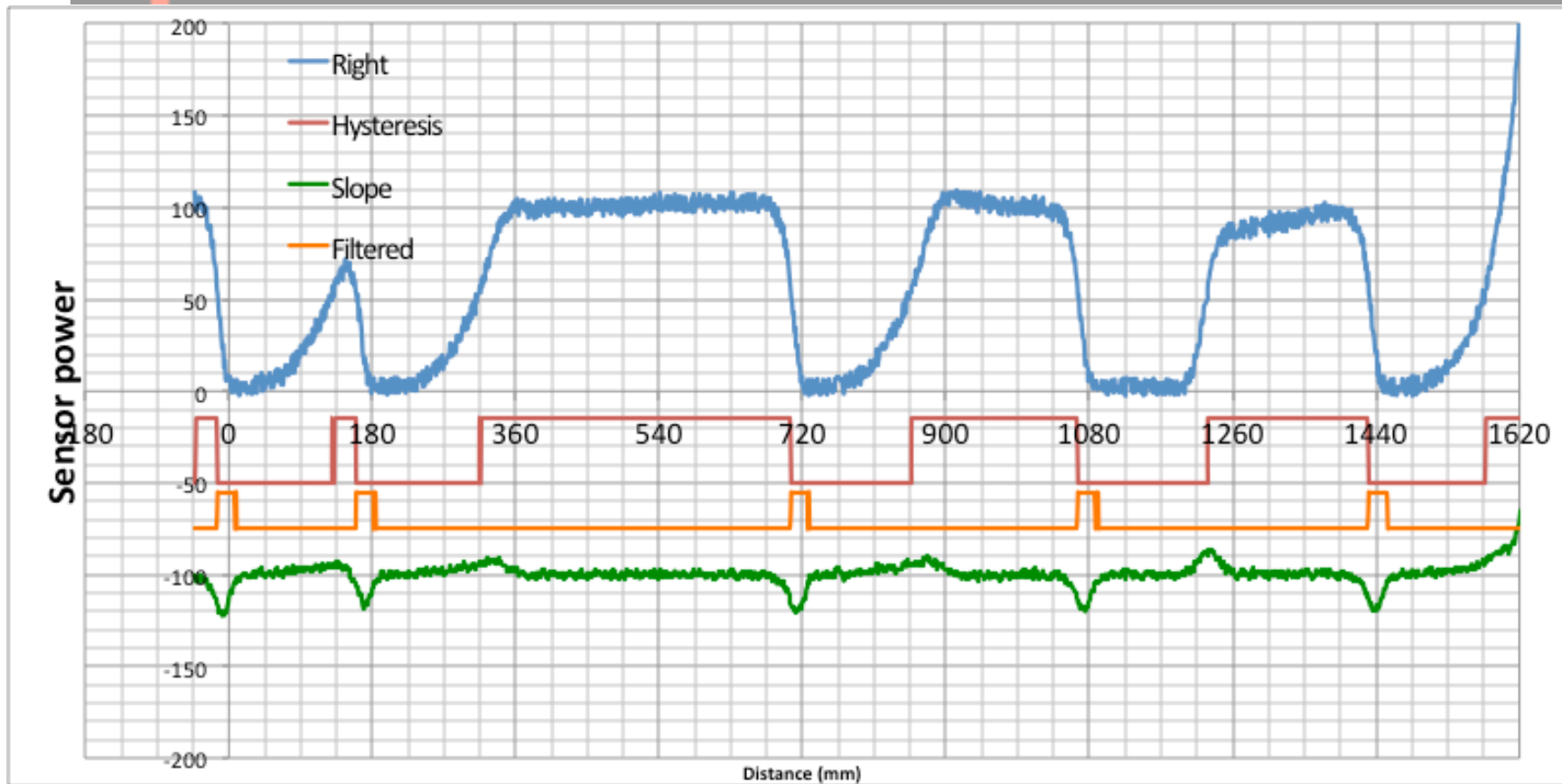
Slope detection - exponential filters

- Identify positive and negative slope in signal
- Two exponential filters – fast (K_f) and slow (K_s)
- $F_{n+1} = K_f X_n + (1 - K_f) F_n$
- $S_{n+1} = K_s X_n + (1 - K_s) S_n$
- $Y = F - S$
- Falling edges are negative peaks
- Look for threshold changes during these peaks

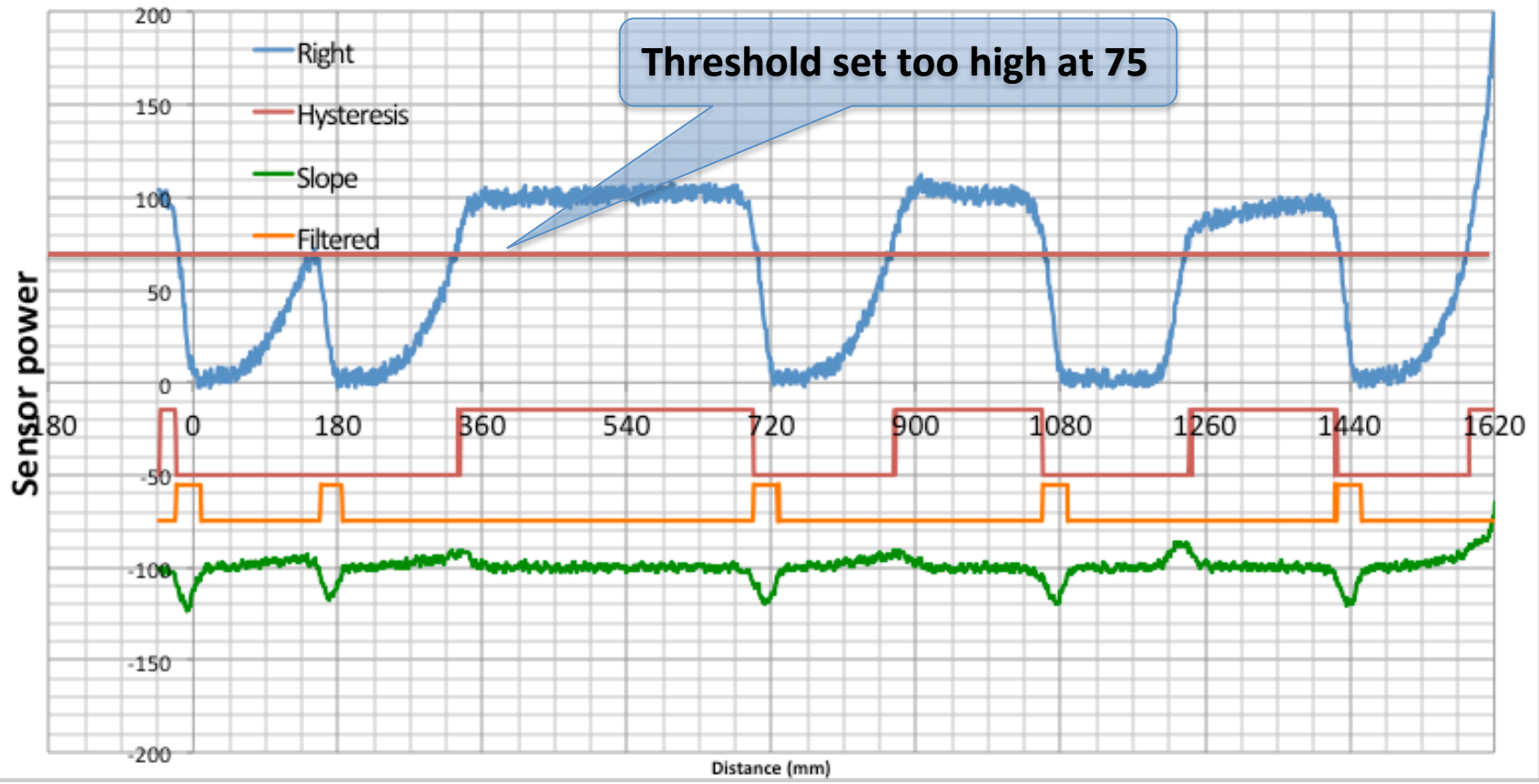


Combined filter and threshold

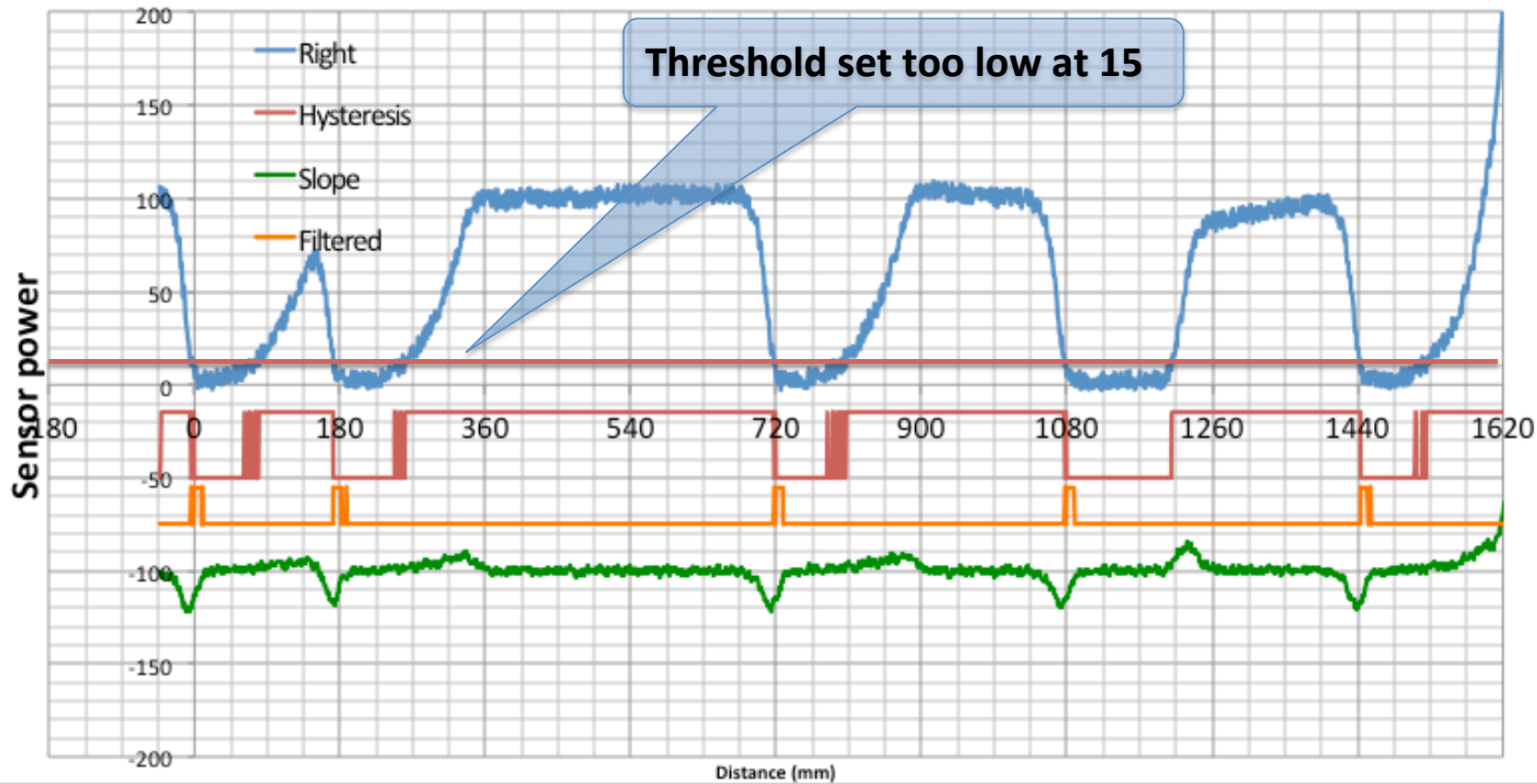
- Look for signal level below a threshold AND the slope is negative.
- Will only report falling edges
- More robust as signal levels change
- More tolerant of noise
- Faster response than counting levels
- More complicated



Threshold set too high at 75



Threshold set too low at 15

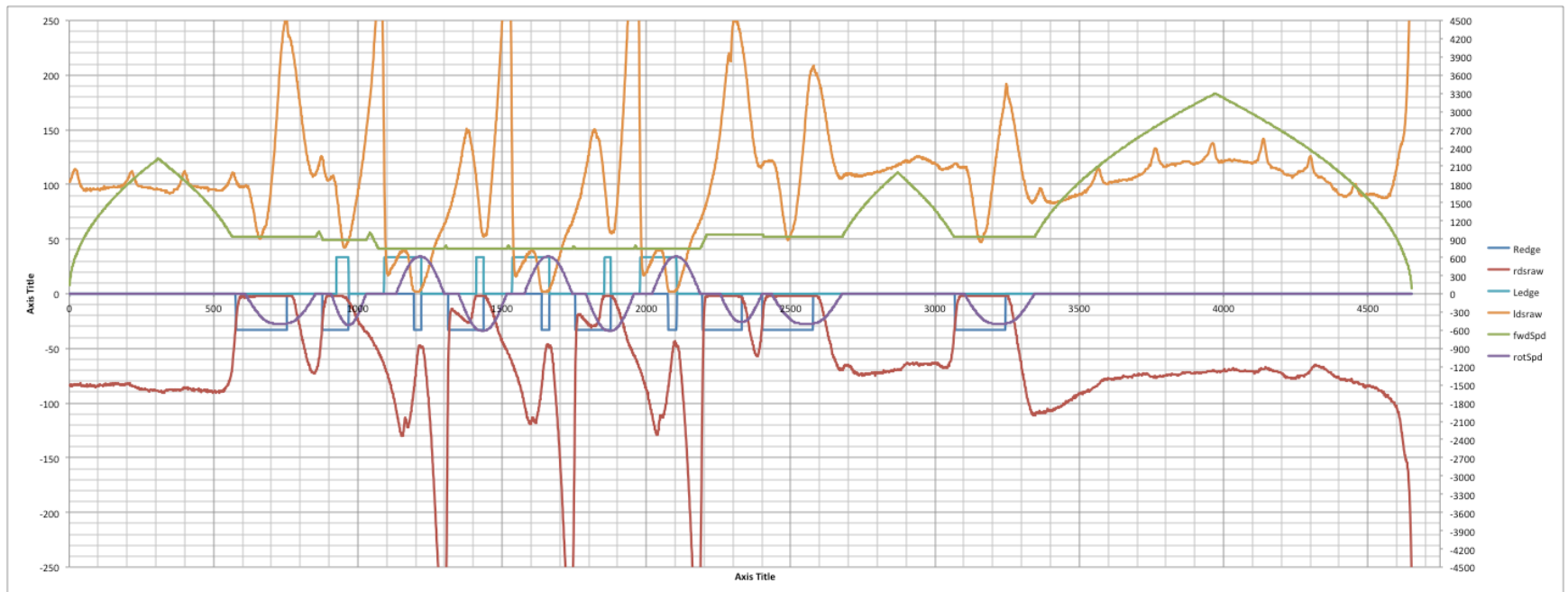


Actual data is much more complex

- Sensor signals affected by
 - Mouse alignment
 - Speed
 - Wheel Slip
 - Wall variations
 - Post shape

Data logs from test maze

```
o---o---o---o---o---o---o---o---o---o---o
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|324| x  x  x  x  x  x  x  x  | 98|
o  o  o  o  o  o  o  o  o  o  o  o
|333| x  x  x  x  x  x  x  x  | 82|
o  o---o---o---o---o---o---o---o---o  o
|341| 0 13 26 37 46 54 61 67 73|
o---o---o---o---o---o---o---o---o---o---o
```



THANK YOU