

EECS 192: Mechatronics Design Lab

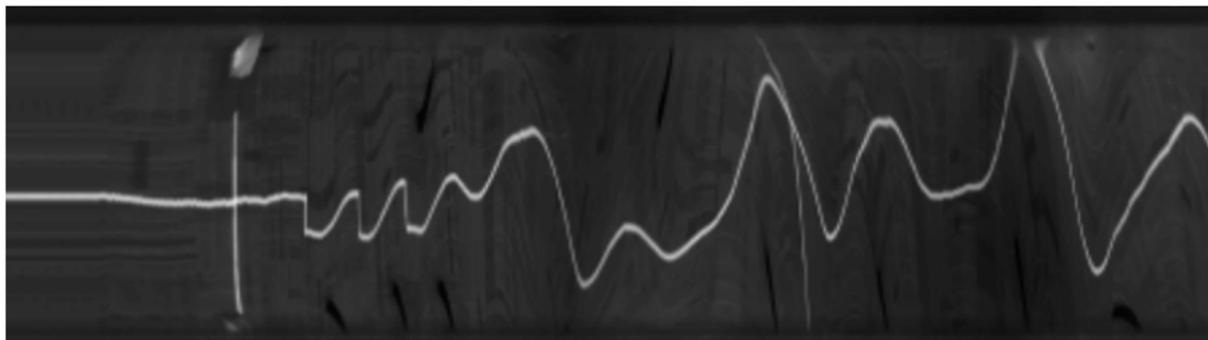
Discussion 4: Camera

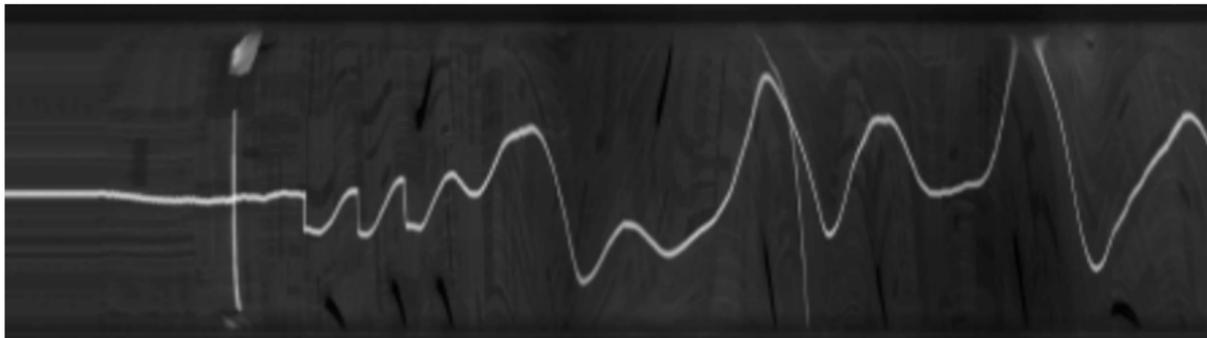
GSI: Andrew Barkan

10 Feb 2021 (Week 4)

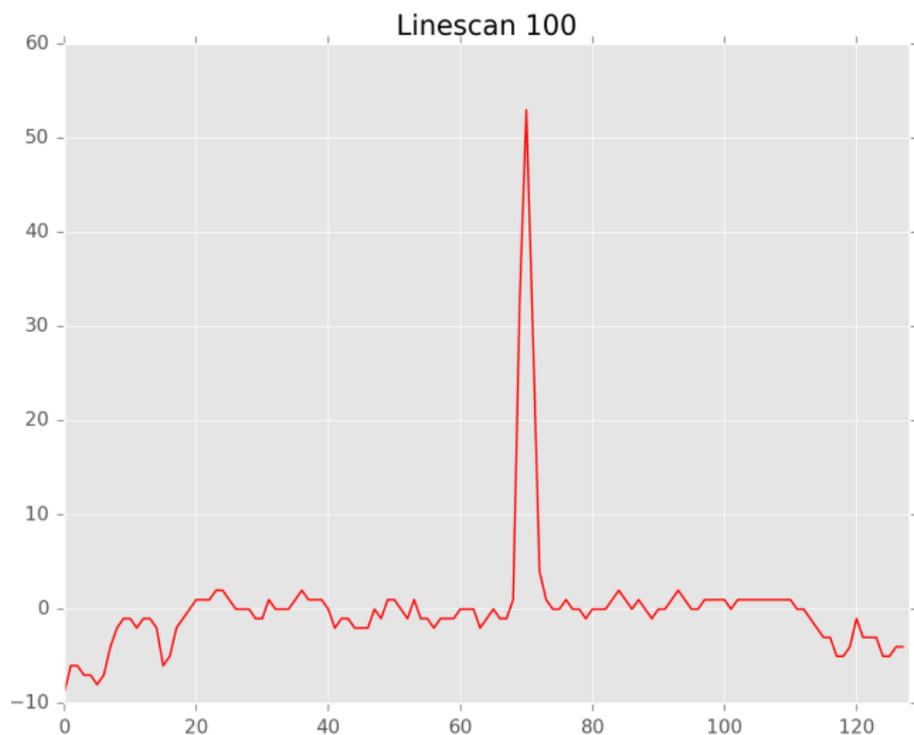
- Line Sensing
- Camera Demo
- Summary

Line Sensing

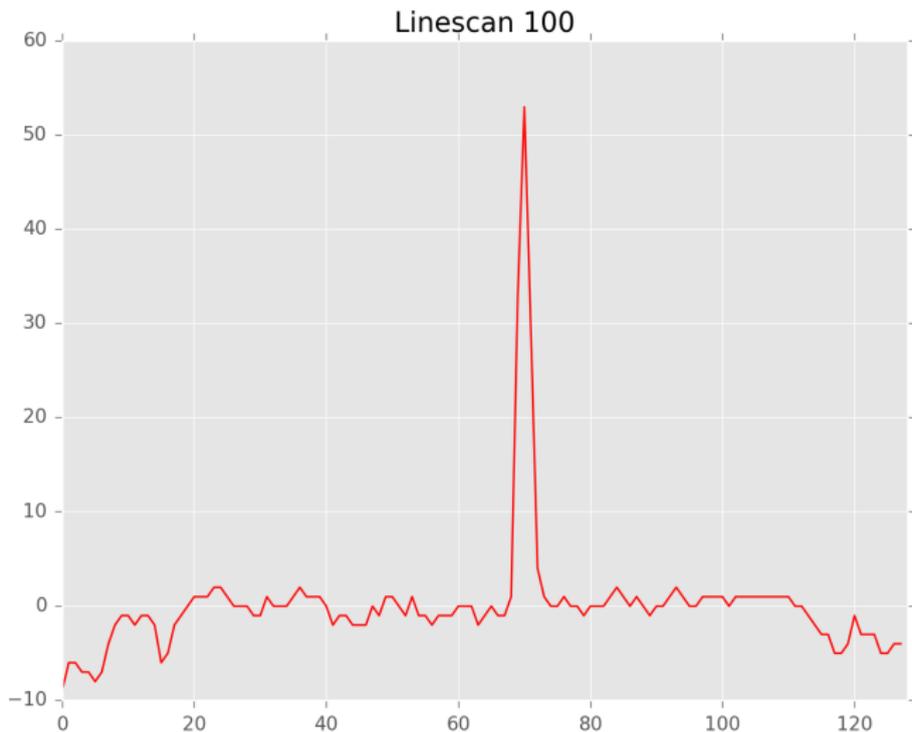




Let's look at one specific frame

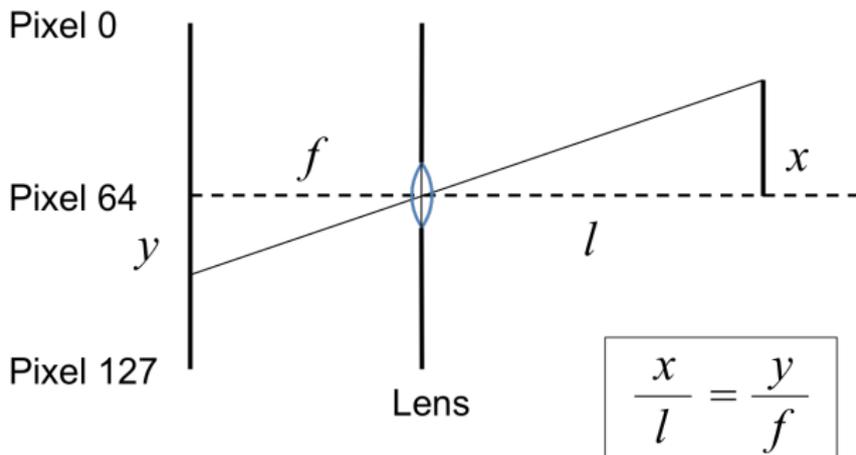


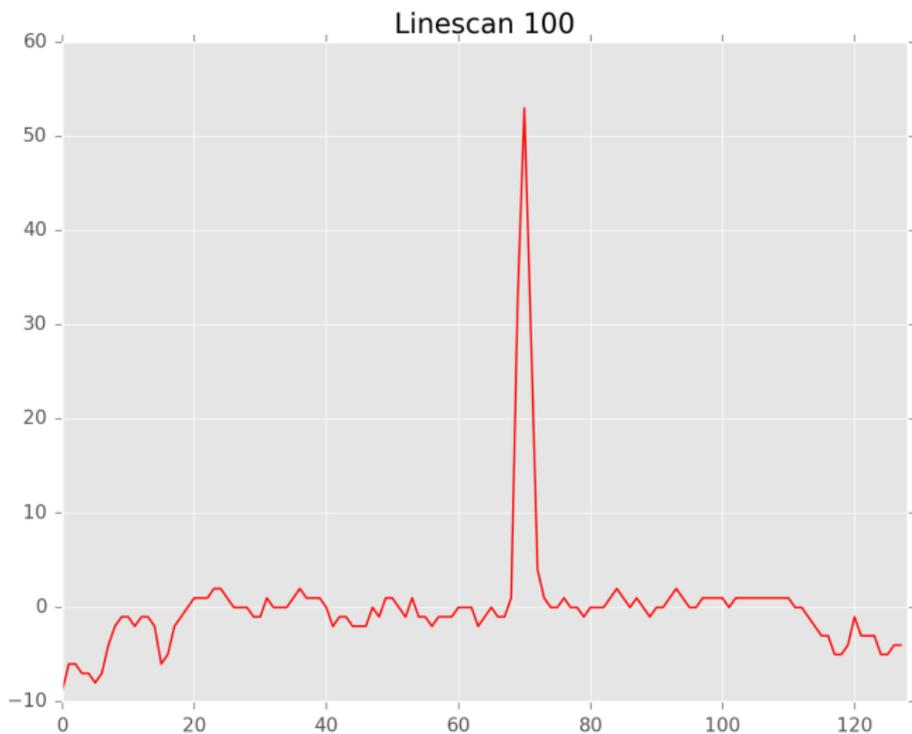
$\text{frame}[100] - \text{mean}(\text{frame}[100])$



Which pixels correspond to which points in front of the car?

- ▶ Pinhole camera model
- ▶ Can calibrate centimeters-to-pixels gain for a fixed camera distance





How can we find the index of the line?

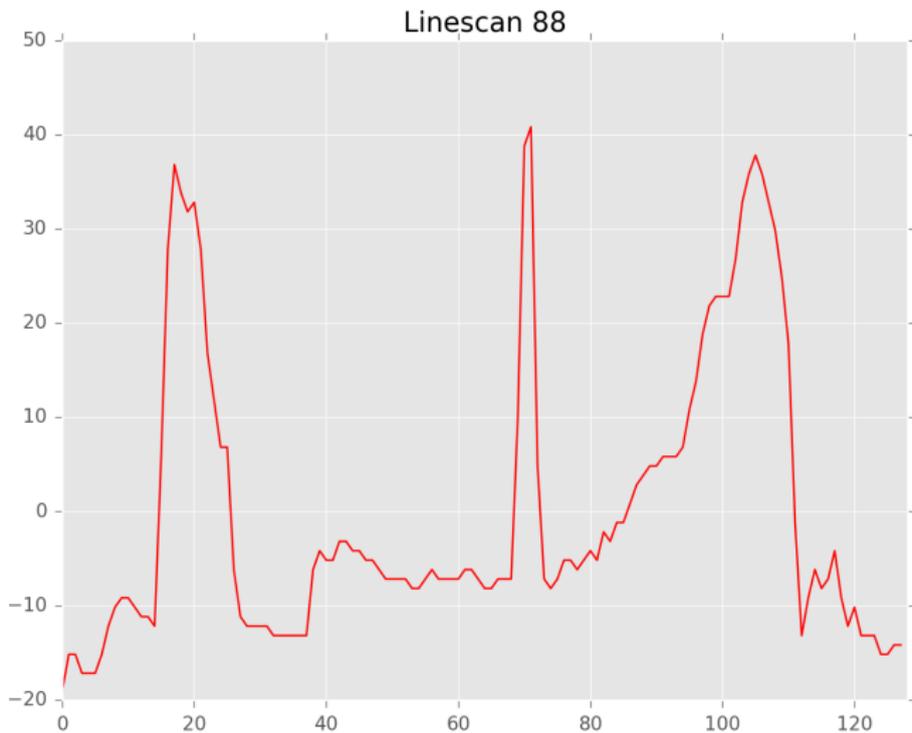
Take the argmax!



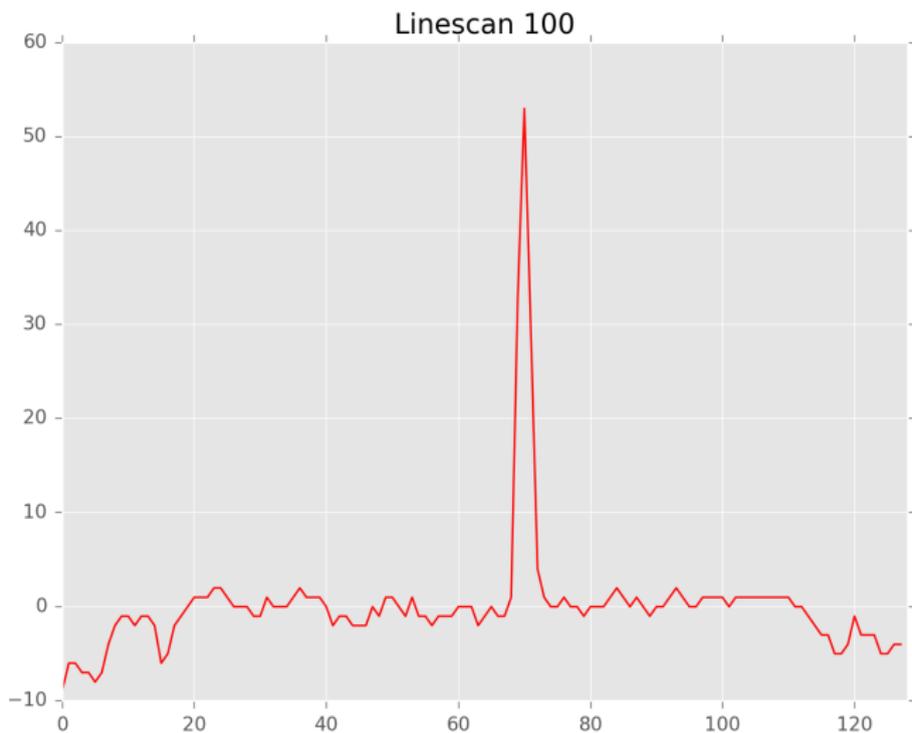
Any potential issues?



What about- noise, track crossings, other bright objects, etc.?

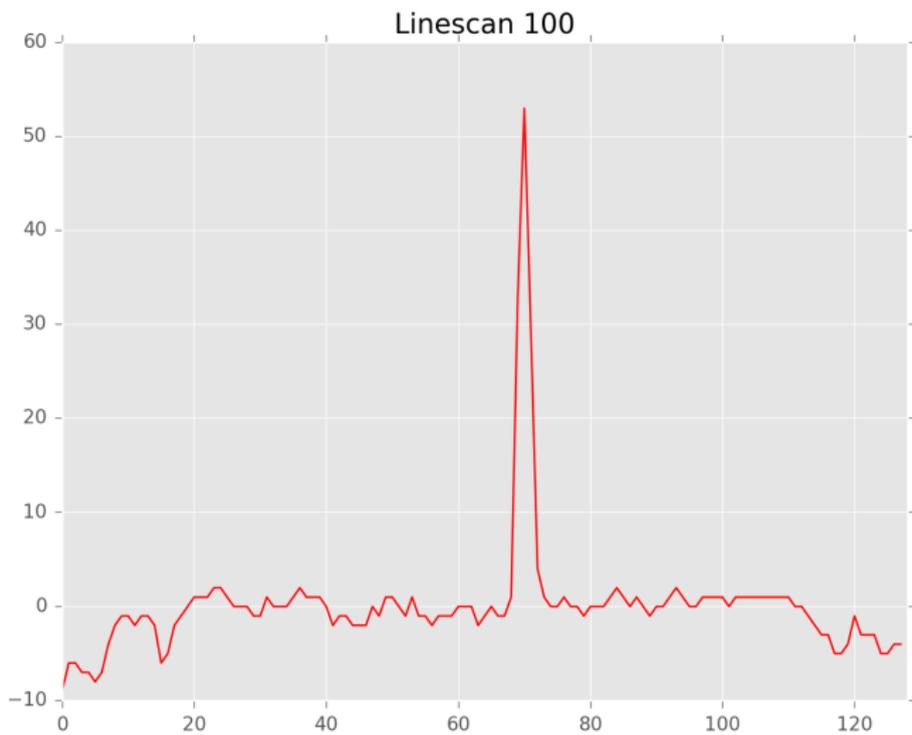


What about- noise, track crossings, other bright objects, multiple peaks, etc.?



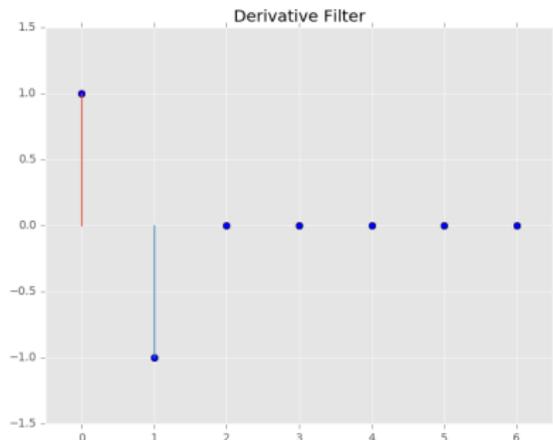
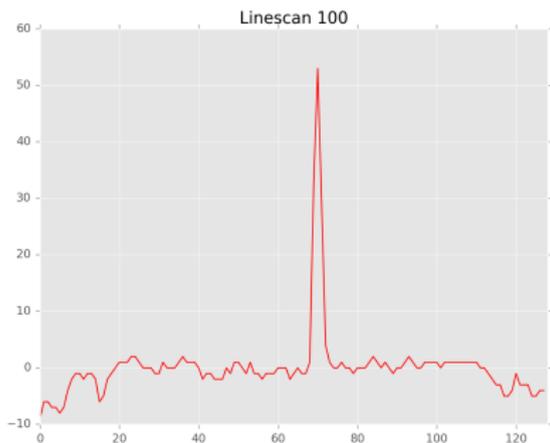
$I(x,t)$ = Intensity at pixel x

What if we look at the derivative $\frac{dI(x)}{dx}$?



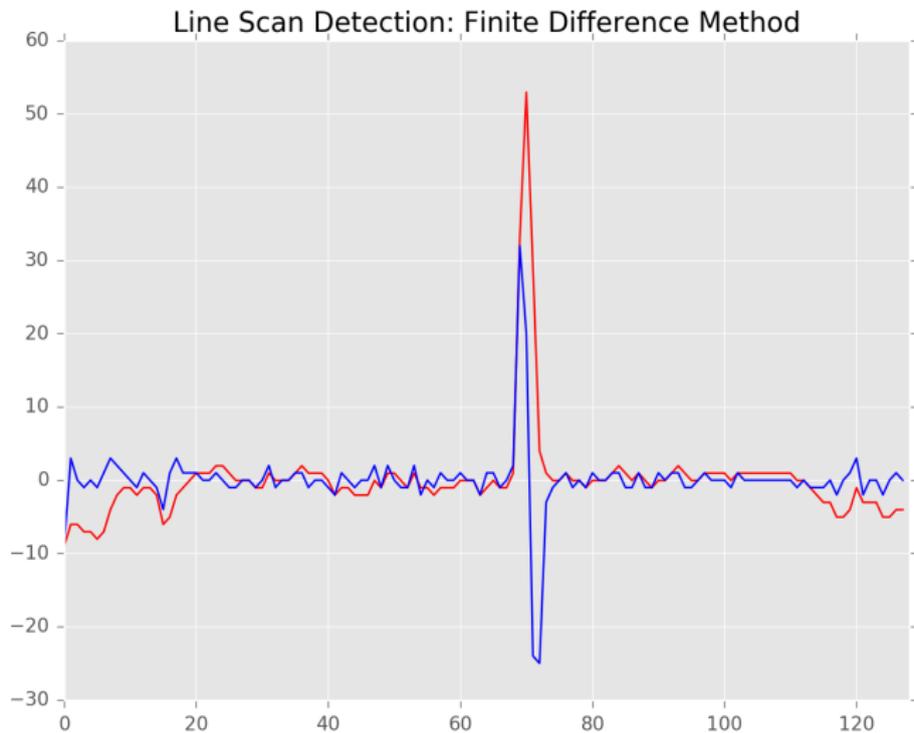
$$\frac{dI(x)}{dx} \approx \frac{I(x+1) - I(x)}{1}$$

Convolution!



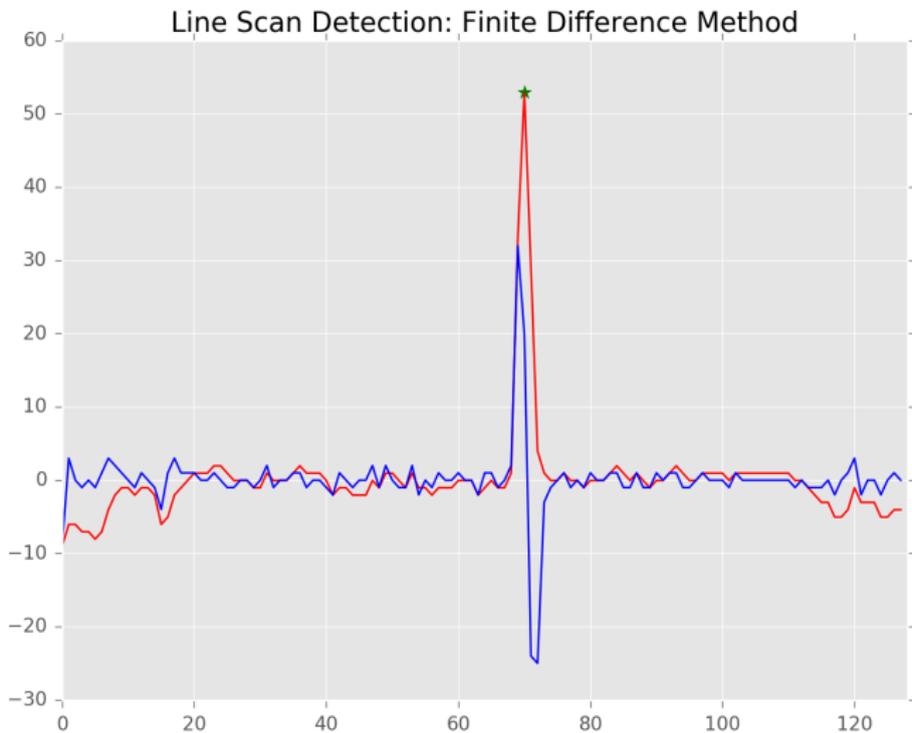
$$\dot{I}(x) = I(x+1) - I(x) = I * [1, -1]$$

Convolution!



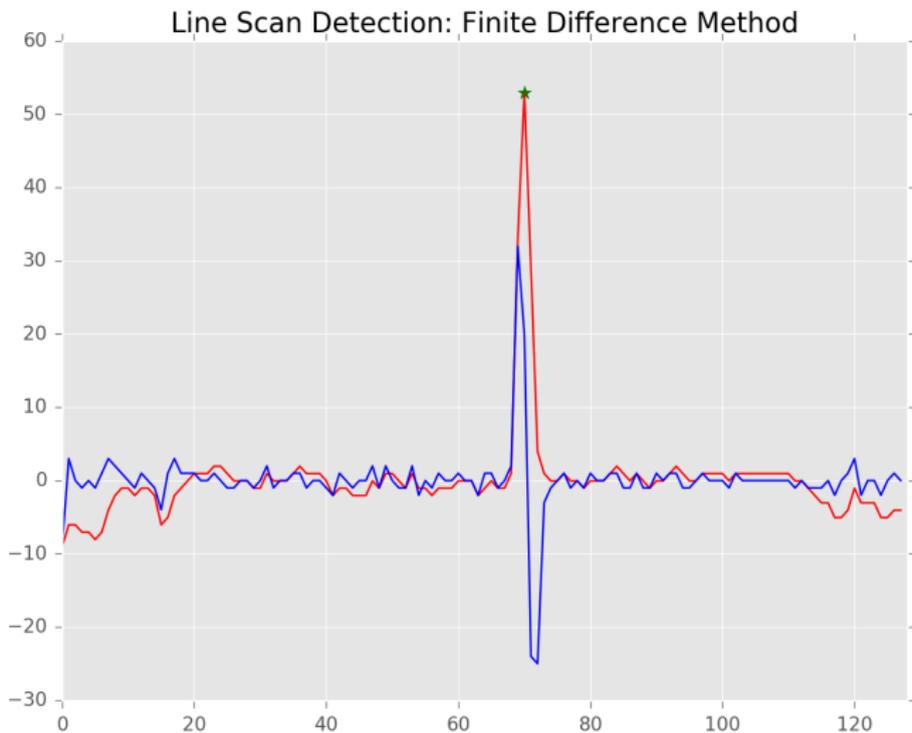
$$\dot{I}(x) = I(x + 1) - I(x) = I * [1, -1]$$

Convolution!



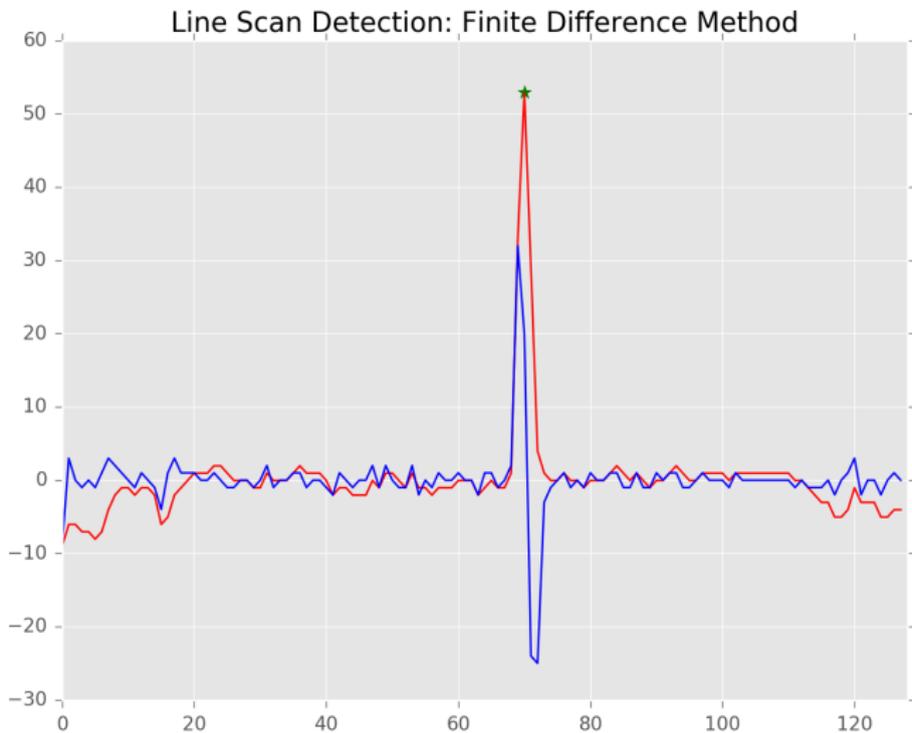
$$\dot{I}(x) = I(x+1) - I(x) = I * [1, -1]$$

Convolution!



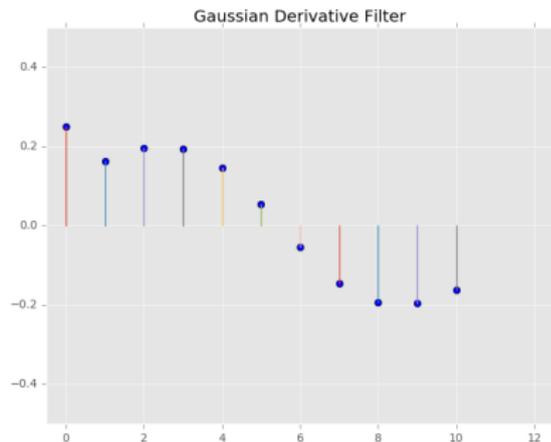
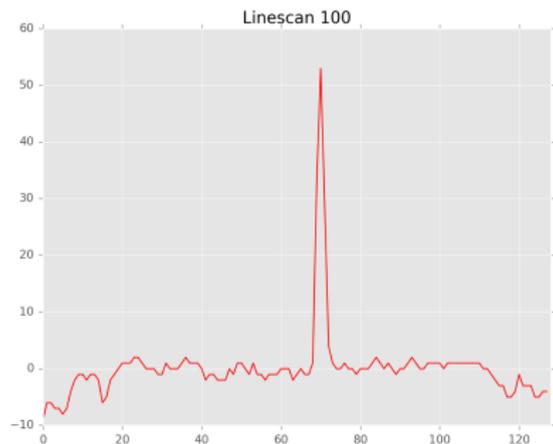
What about all that **high frequency** noise?

Low Pass Filter!



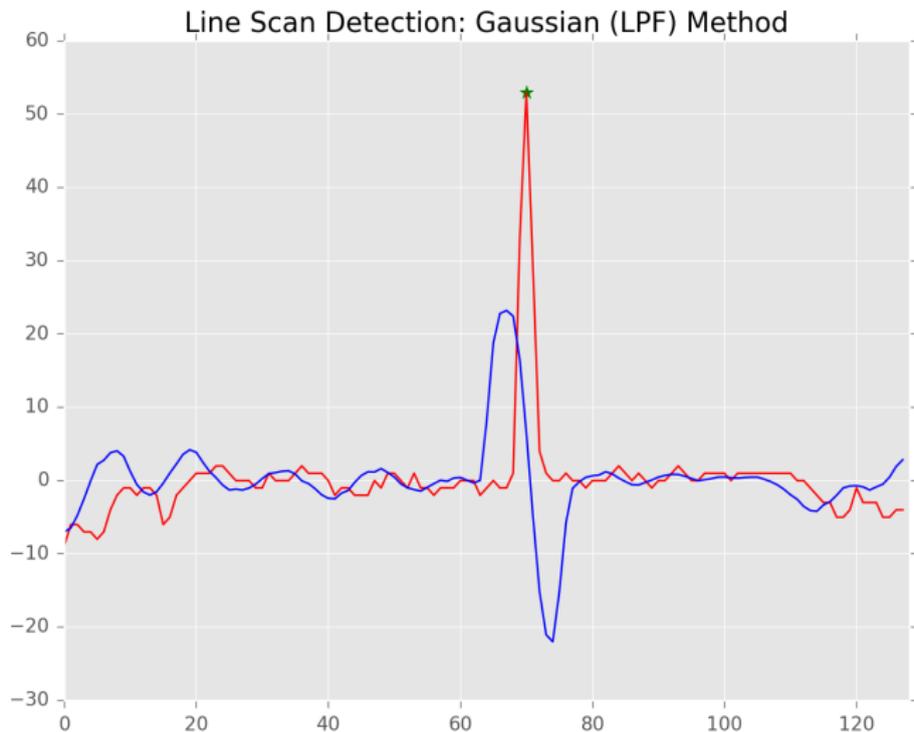
$$I(x) * LPF * [1, -1] = I(x) * (LPF * [1, -1])$$

Low Pass Filter (Gaussian)!



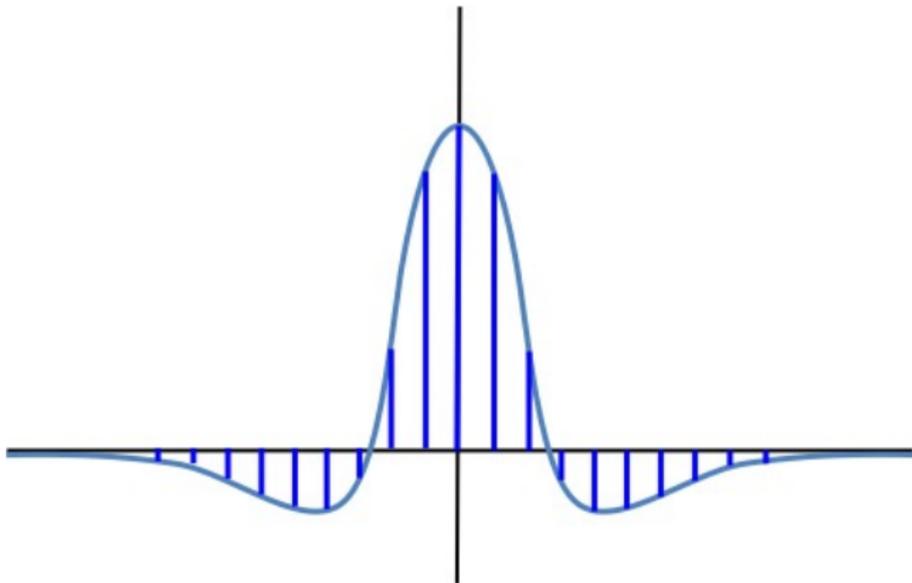
$$I(x) * LPF * [1, -1] = I(x) * (LPF * [1, -1])$$

Low Pass Filter (Gaussian)!



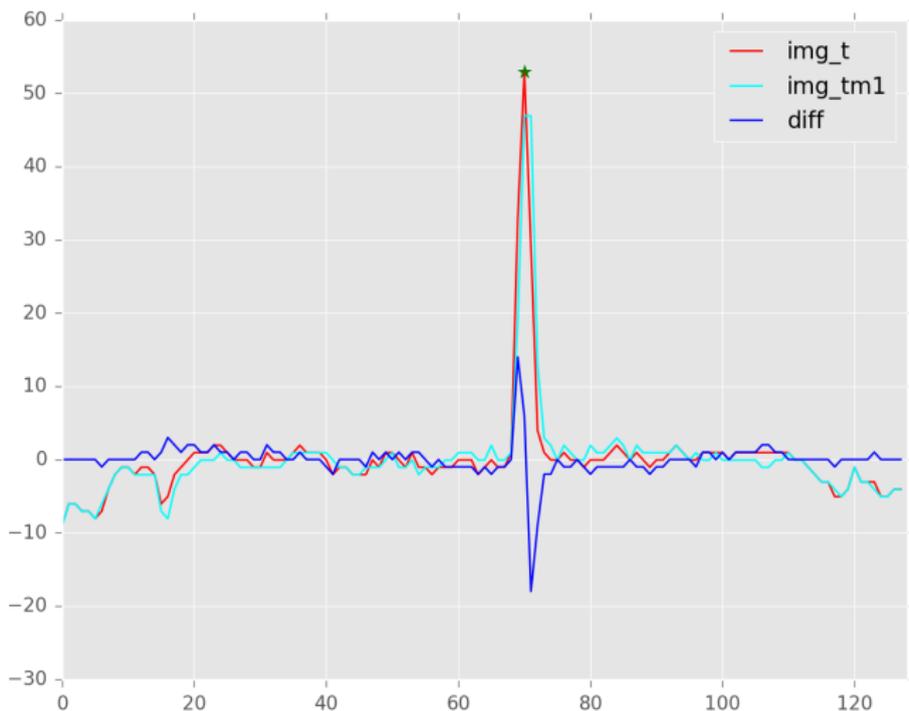
High frequency noise gone!

Laplacian of Gaussian (low-passed second derivative)
Can also be approximated with difference of Gaussians



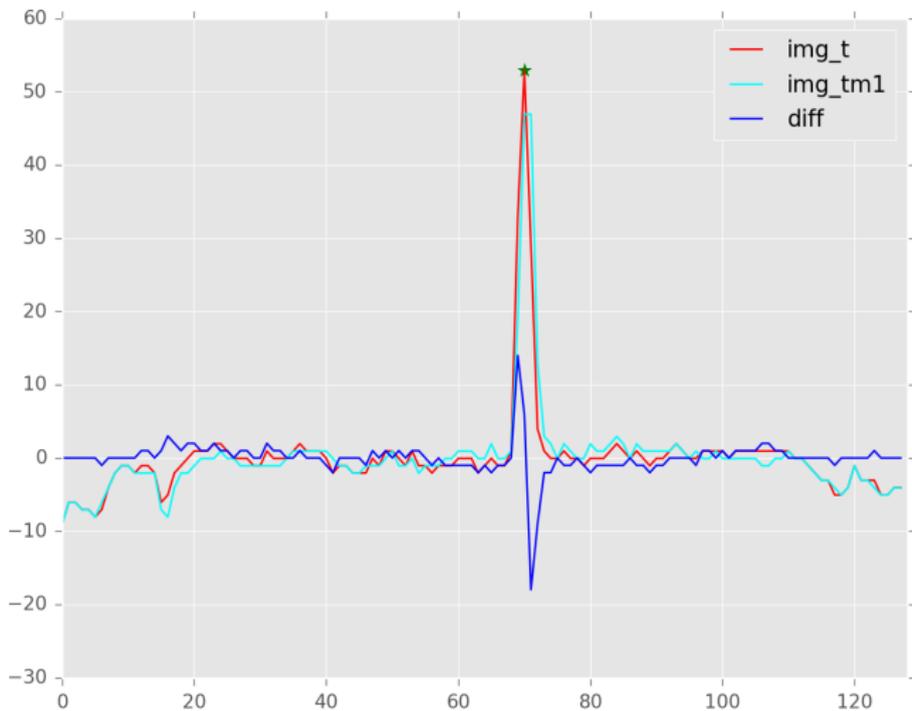
Detect a bright line of the expected width

What about... Temporal Differencing?



$$\frac{dI(x)}{dt} \approx \frac{I(t) - I(t-1)}{\Delta t}$$

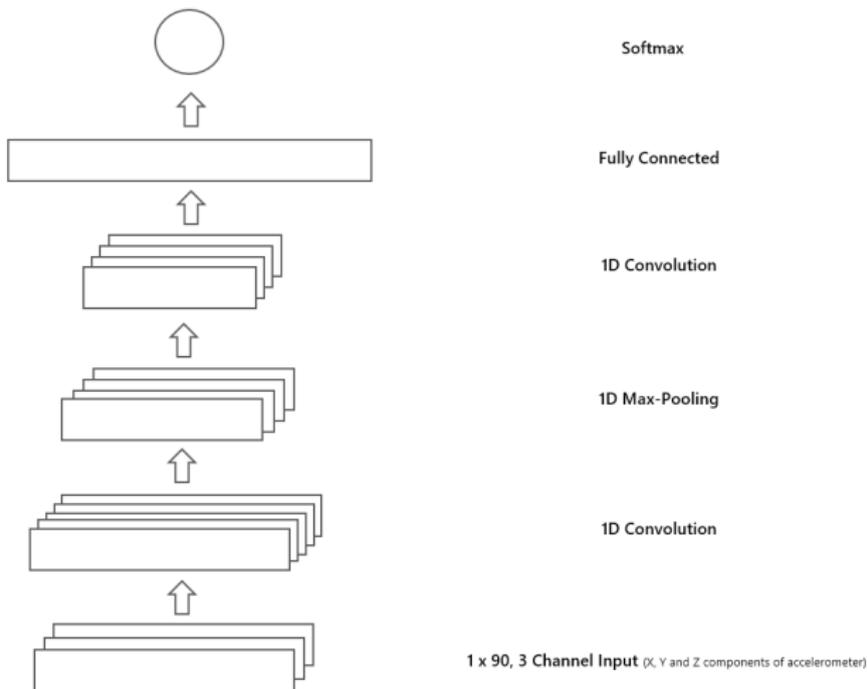
What about... Temporal Differencing?



Good for removing constant bias in parts of the image.

More Ideas!

- ▶ Difference of Gaussians (Bandpass- not just Lowpass)
- ▶ Cross Correlation with known signal
- ▶ Convolutional Neural Networks??



Potential Issues?

- ▶ What to do if there are multiple track crossings?
- ▶ Can't find the line
- ▶ Other Issues?

Solutions!

- ▶ Maintain a history (previous line pos, camera scan, etc.)
- ▶ Ignore the problem(s) and go fast!
- ▶ Anything else?

Demo showing example camera outputs
with the oscilloscope!

Summary

- ▶ Many ways to do line detection (max, differencing, gaussian smoothing, temporal differencing, etc.)
- ▶ Camera calibration
- ▶ Demo!