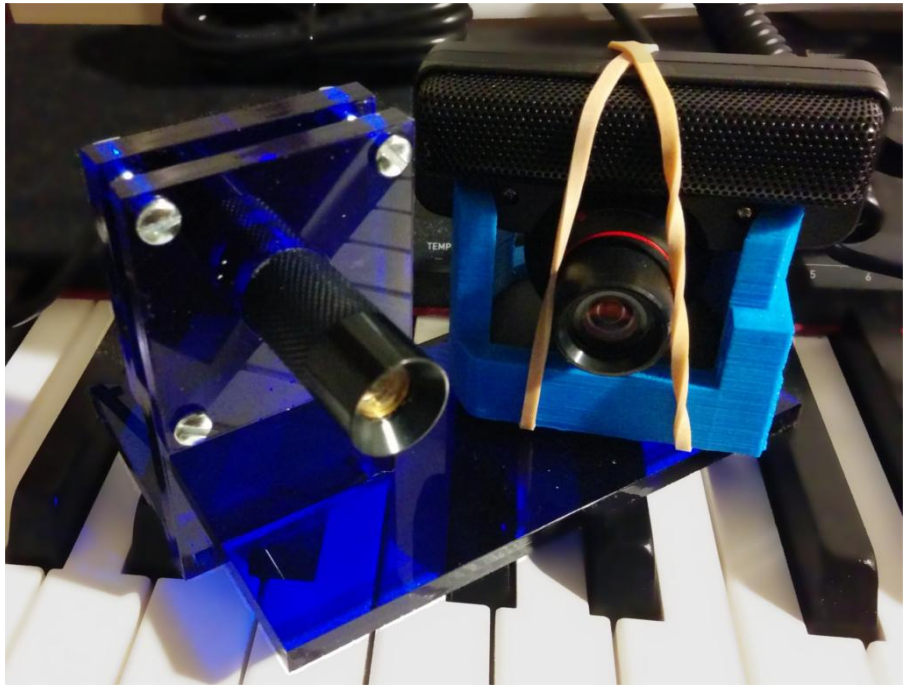
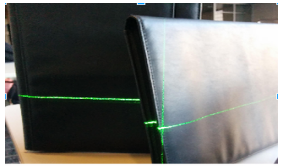
What is it?

A low-cost laser rangefinder consisting of PS3 Eye camera + line laser diode

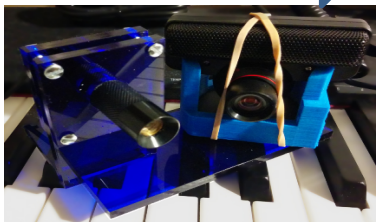


Algorithm

1. RGB -> Greyscale
2. Noise elimination: Gaussian convolution
3. Finds the index which has the maximum convolved peak
4. Find distance from the peak index using pre-calibrated settings



Image



-Calibrating the relationship between laser distance and image pixel

SOFTWARE Userland

-Get image
-RGB -> Grayscale
-Make a group of 32 pixel horizontally for the convolution later

-Calibrating laser distance given max pixel image

SOFTWARE INTERFACE

-Driver kernel to communicate between the software and the hardware.
-Use ioread32/ iowrite32

HARDWARE FPGA

Eliminate noise and find max value pixel index using 16x1 Gaussian convolution

Hardware

- a 60-byte addressable memory device implemented using unpacked byte array
- A single read-only 32-bit word is used to hold the results
- 32 convolutions done in parallel within a single clock cycle, using Altera IP-based 16-way parallel adder and multiplier units

Hardware-software Interface

A large contiguous shared memory with the following layout:

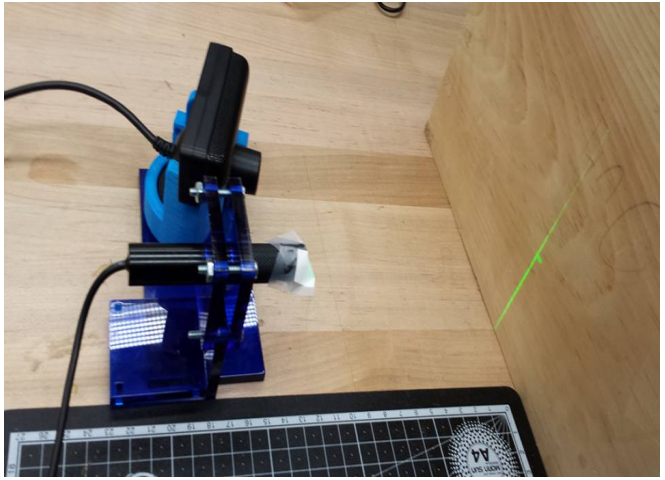
initial fill	8 bytes
data	32 bytes
end fill	8 bytes
convolution vector	8 bytes
max value	2 bytes
max position	1 byte

Software

- Kernel driver: uses ioread32/iowrite32 to transfer data between software and hardware
- Userland: reads in an image, converts it to grayscale, sends pixels in groups 32 to hardware for convolution, and calculate distance from convolved peaks and pre-calibrated settings

Distance Calibration

- Take image of the laser project onto the wall as it shows in the image below.
- Keep the angle between laser and camera constant, increase the laser distance from the wall



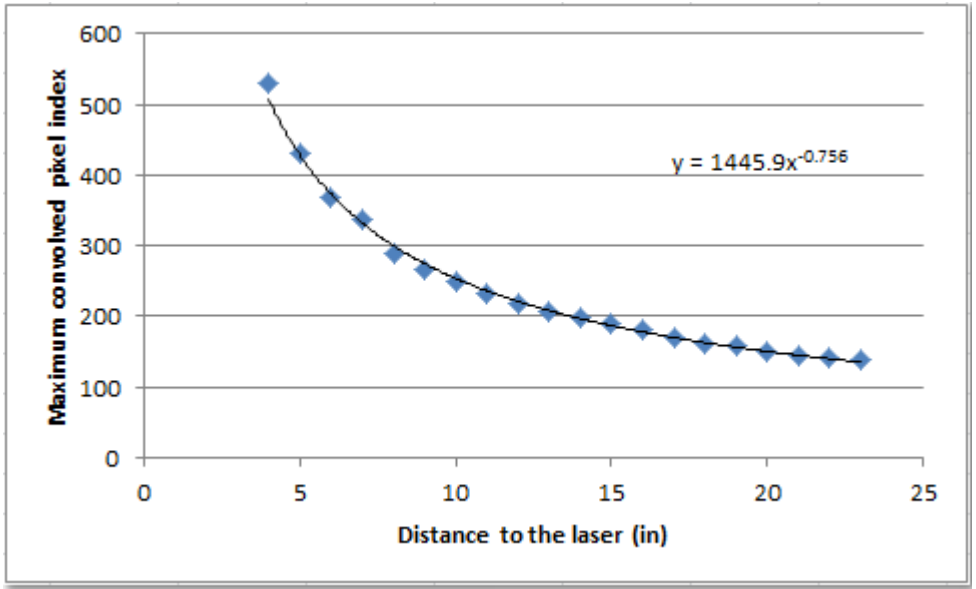
- To calculate the pixel corresponding to each distance, we just manually measure the horizontal distance of the laser line from the image

Calibration (2)

- Plot the relationship between the laser distance and pixel image, do a best fit line

$$x = \left(\frac{1445.9}{y}\right)^{0.244}$$

where x is the distance from the laser, and y is the pixel location of the laser point



Conclusion

- Challenges:
  - USB Bus Bandwidth
  - PCI-E Communication
  - Avalon bus width
- Lessons learned
  - software and hardware connection
  - interface available