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
-Calibrating the relationship between laser distance and image pixel

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

-Calibrating laser distance given max pixel image

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

-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:

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial fill</td>
<td>8 bytes</td>
</tr>
<tr>
<td>data</td>
<td>32 bytes</td>
</tr>
<tr>
<td>end fill</td>
<td>8 bytes</td>
</tr>
<tr>
<td>convolution vector</td>
<td>8 bytes</td>
</tr>
<tr>
<td>max value</td>
<td>2 bytes</td>
</tr>
<tr>
<td>max position</td>
<td>1 byte</td>
</tr>
</tbody>
</table>
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.

![Graph showing the relationship between distance and pixel index](image)
Conclusion

- Challenges:
  - USB Bus Bandwidth
  - PCI-E Communication
  - Avalon bus width

- Lessons learned
  - software and hardware connection
  - interface available