Stereoscopic Observation System (SOS)

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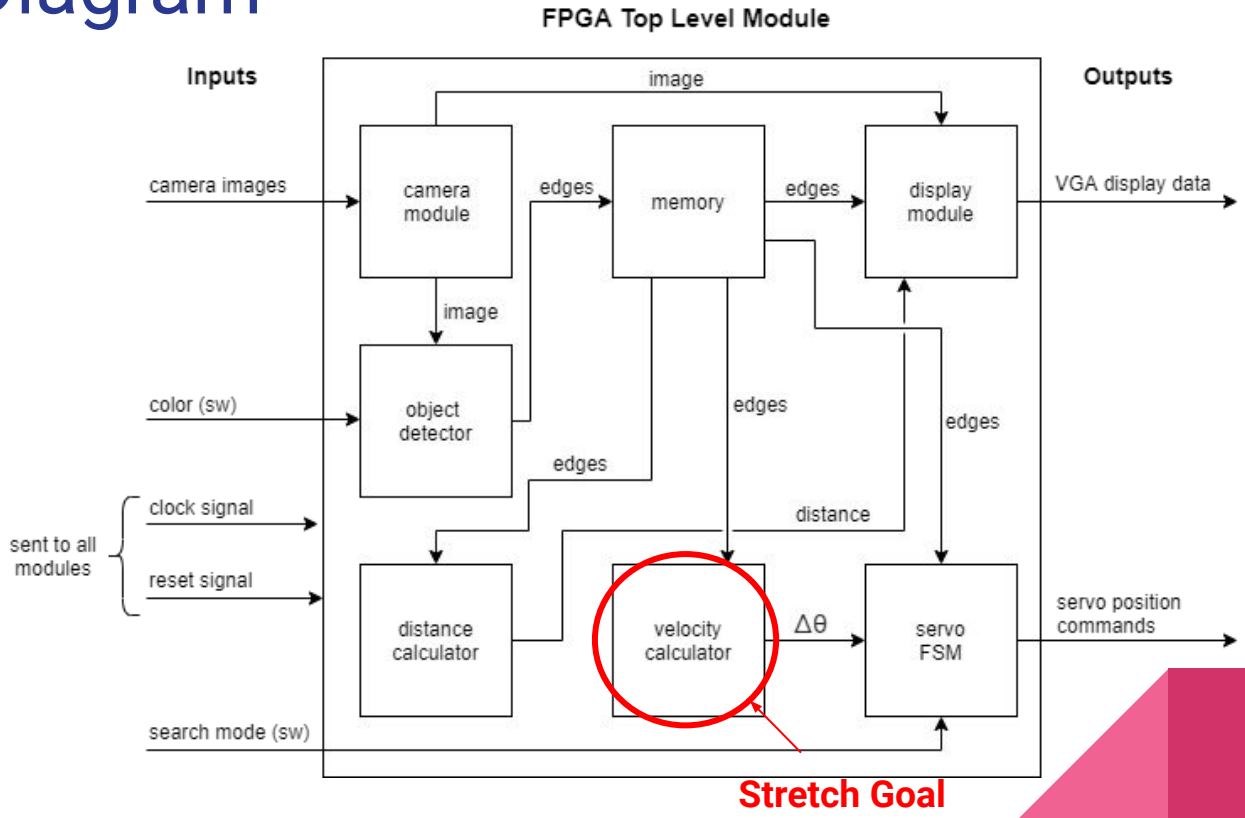
Overview

- **Two calibrated cameras** attached rigidly to a servo, which sweeps the room and sends snapshots to the FPGA
- Take the images to detect the coordinates of target (a known shape and color) using **chroma keying**
- If target detected, we use **projective geometry** to calculate the distance from cameras to the target
- **VGA display** of the overlay of the two camera feeds
- Multiple Features: color detection input, distance calculator, object tracker, background remover, dual axis servo

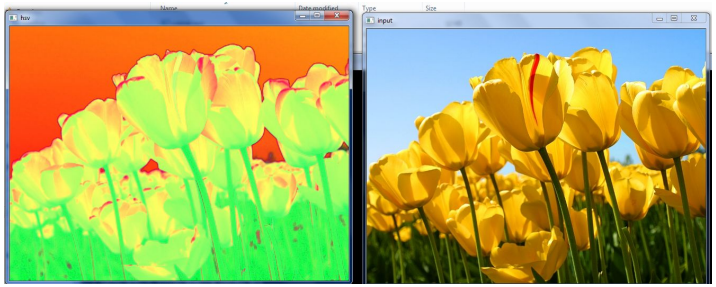
Block Diagram



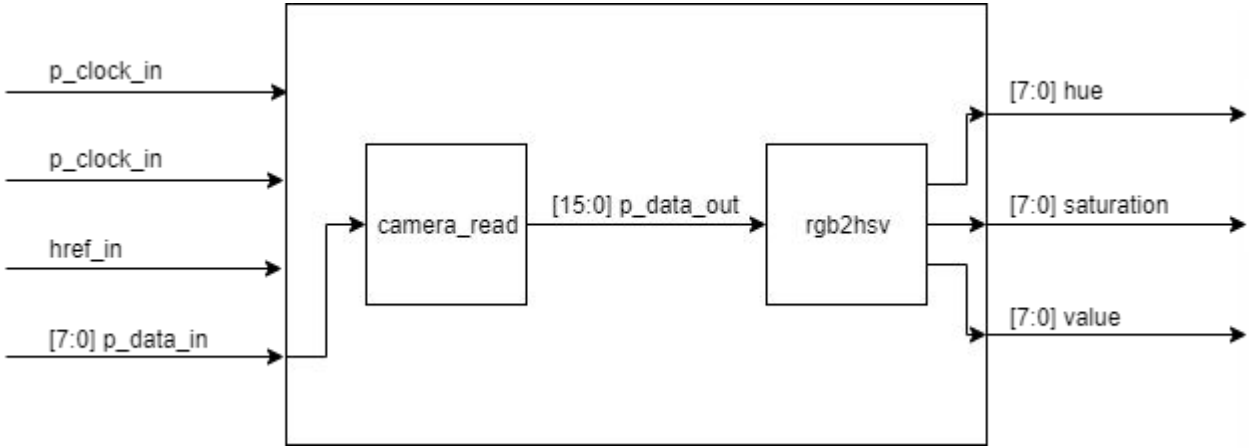
Major Modules

- Camera Module
- Object detector (chroma keying)
- Distance calculator
- BRAM Memory
- Velocity Calculator
- Servo Module
- FSM
- VGA Display module

Camera Module

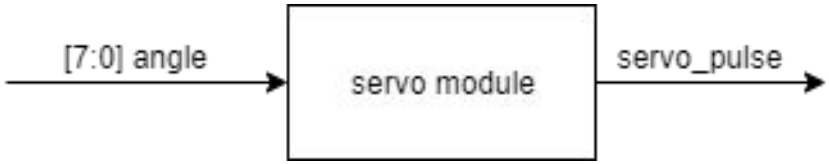


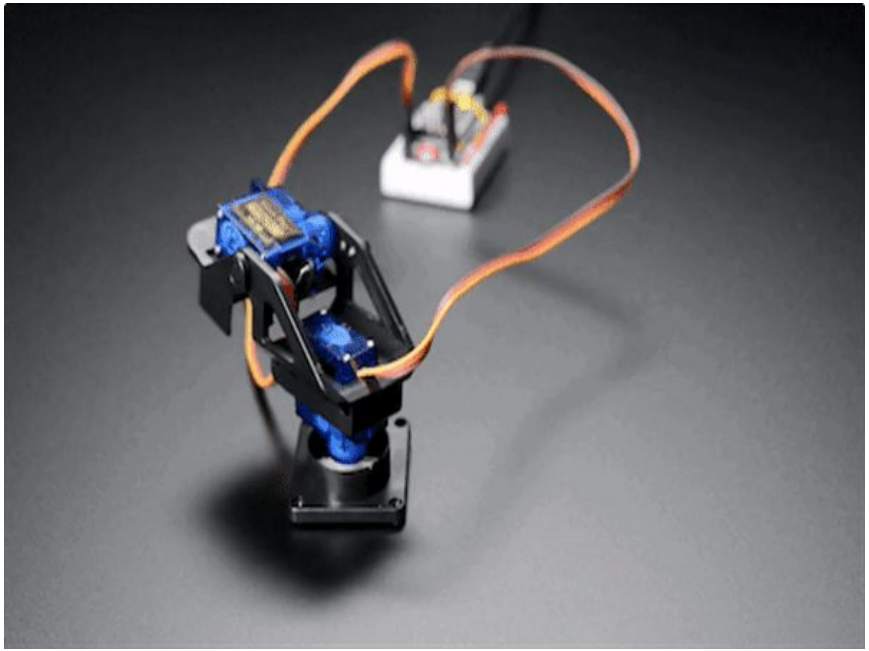
- Convert pixels to HSV (Hue Saturation Value)



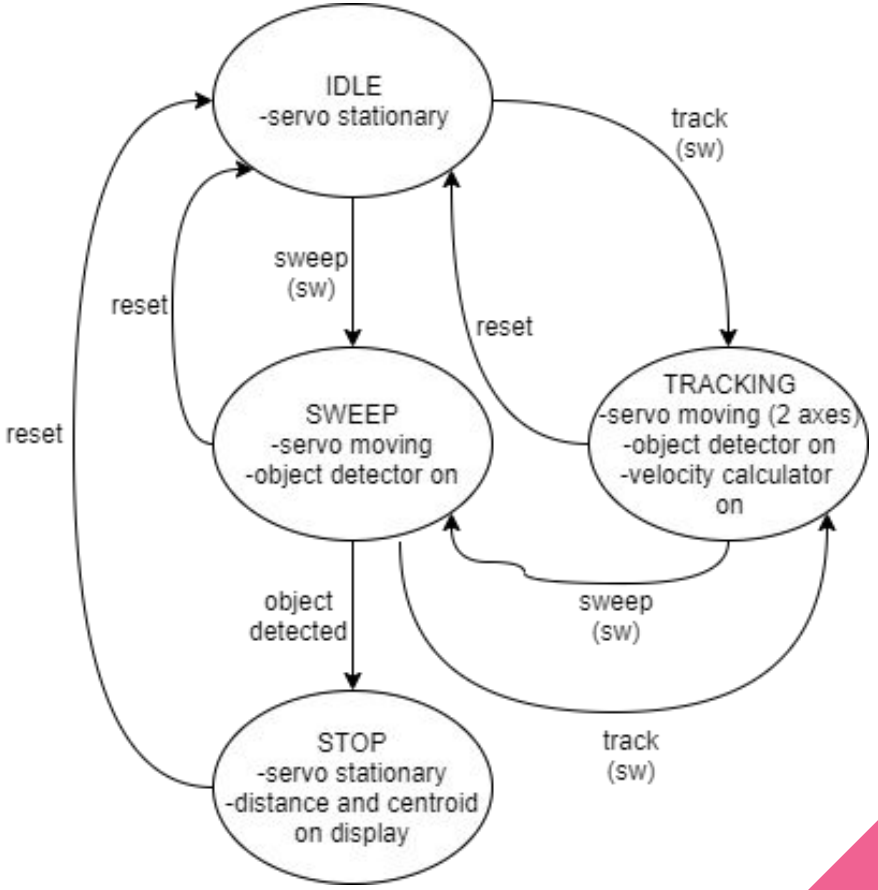
Servo Module

- Stretch goal: 2 axes of rotation
- Pulse Width Modulation (PWM)





System FSM


IDLE
-servo stationary
track
(sw)
sweep
(sw)
reset
reset
reset
SWEEP
-servo moving
-object detector on
TRACKING
-servo moving (2 axes)
-object detector on
-velocity calculator
on
object
detected
sweep
(sw)
track
(sw)
STOP
-servo stationary
-distance and centroid
on display

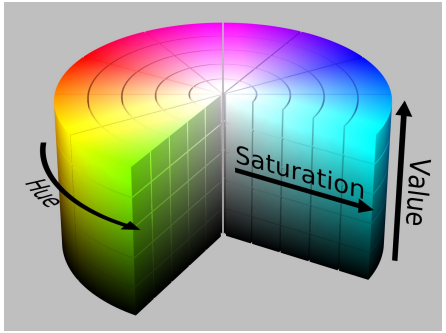
Object Detection Modules

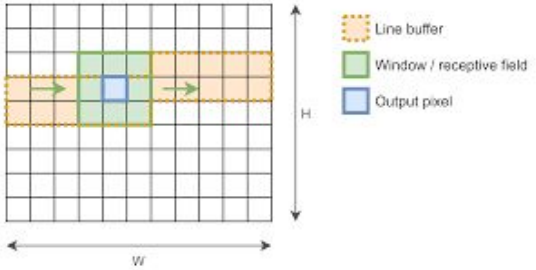
We will detect the edges of objects using chroma keying. This supermodule will consist of three submodules.

In sequence:

1. **Thresholding** (for lighting)

   Pass in to following modules 3 lines at a time (linear buffering)





Object Detection, continued

2. **Erosion:** to eliminate noise. color decided using the FPGA's switches.

3. **Dilation:** restore the eroded object's data by using a dilating kernel.

4. **Object location:** pixel location of object's limits would then be passed on to relevant modules.

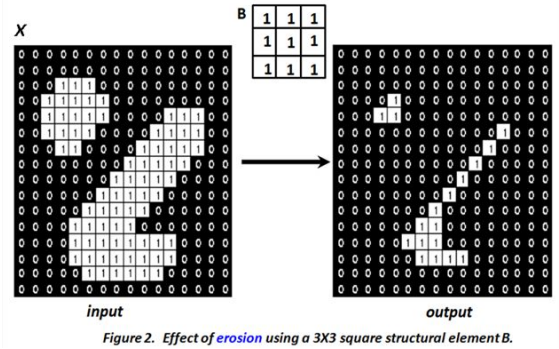
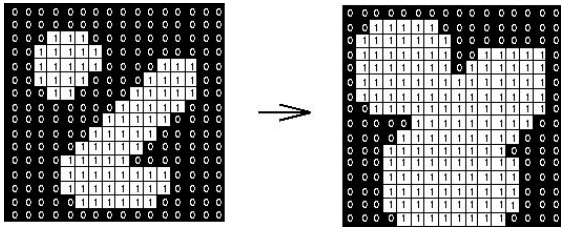
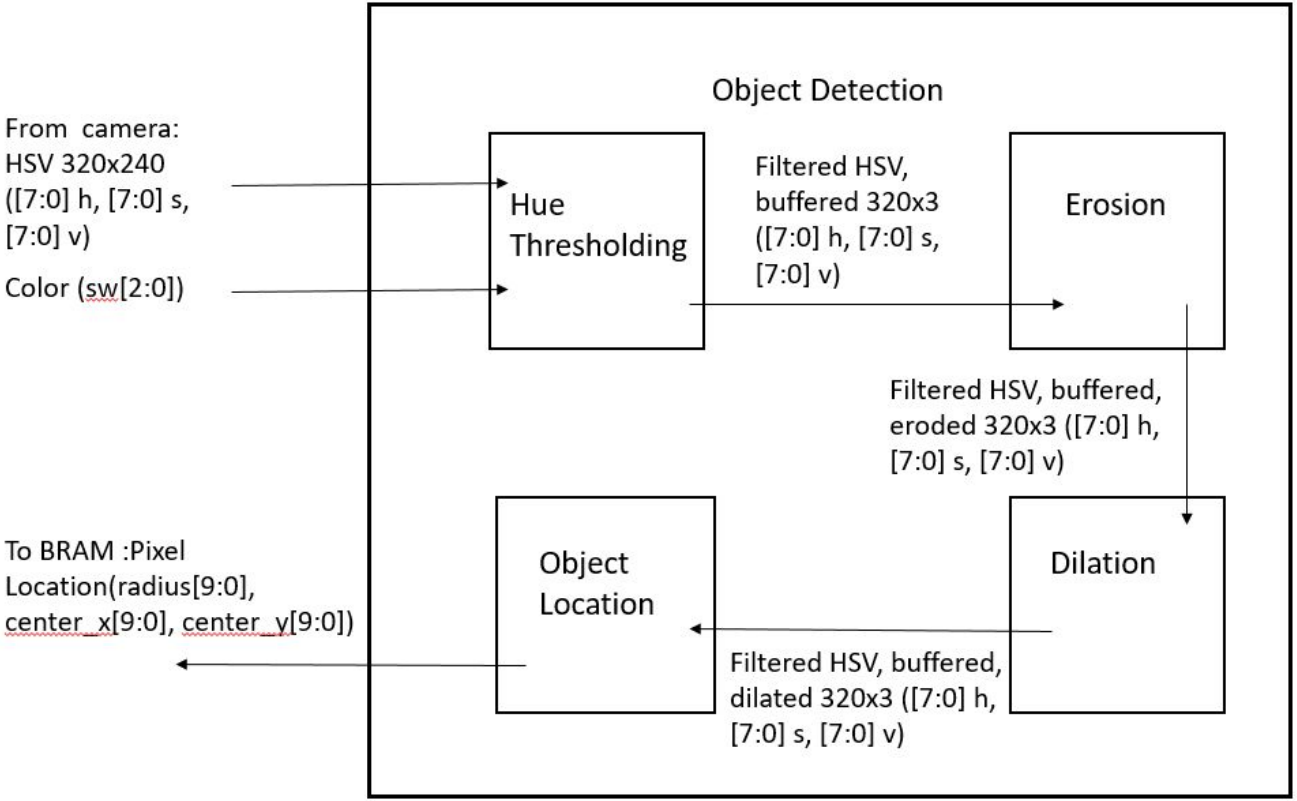


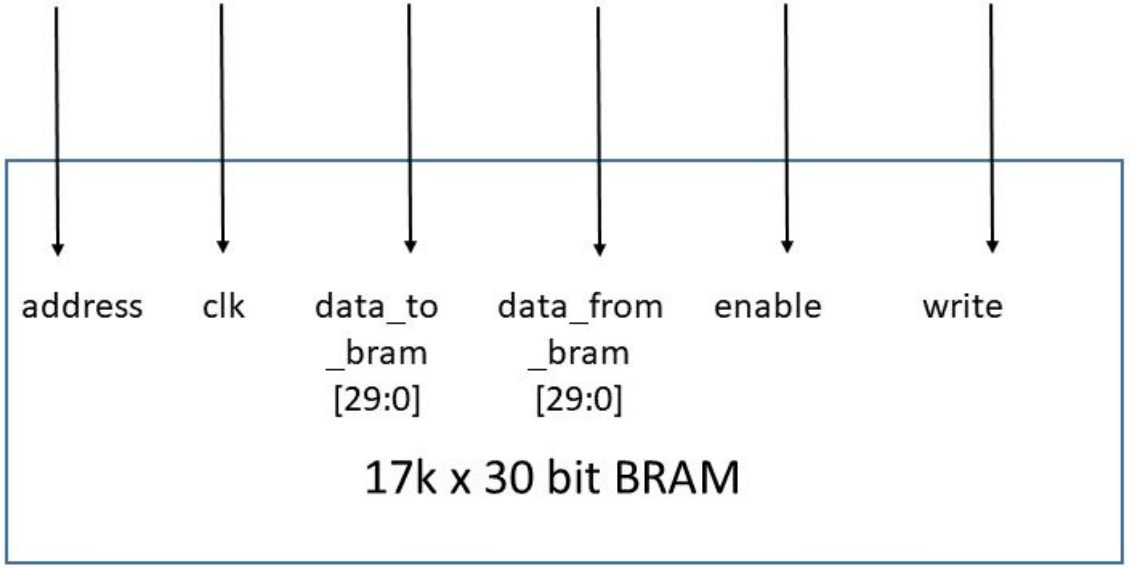
Figure 2. Effect of erosion using a 3X3 square structural element B.



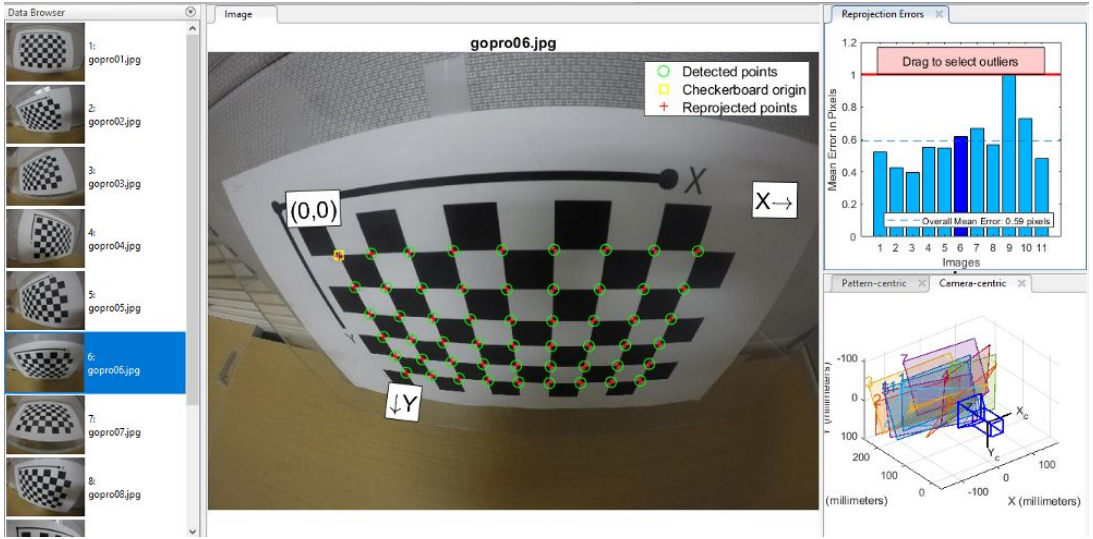
Object Detection Block Diagram



Block Memory



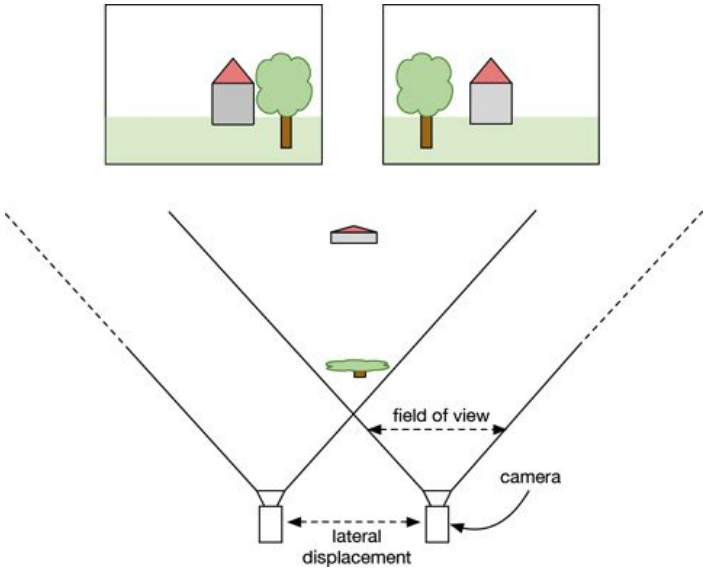
Distance Calculator - Calibration (Off FPGA)



Source: https://www.mathworks.com/help/vision/ug/single-camera-calibrator-app.html

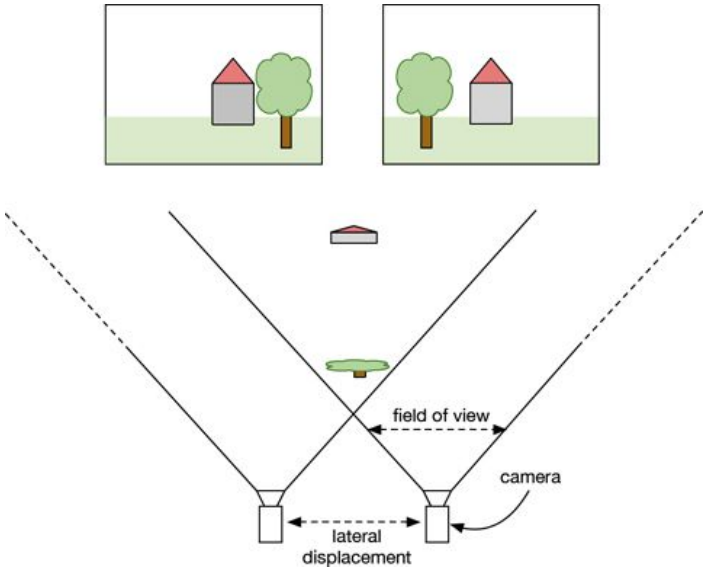
- Zhang's Calibration Method: intrinsic parameters + distortion coefficients → **camera's lens correction**

Camera Orientation Options (On FPGA)

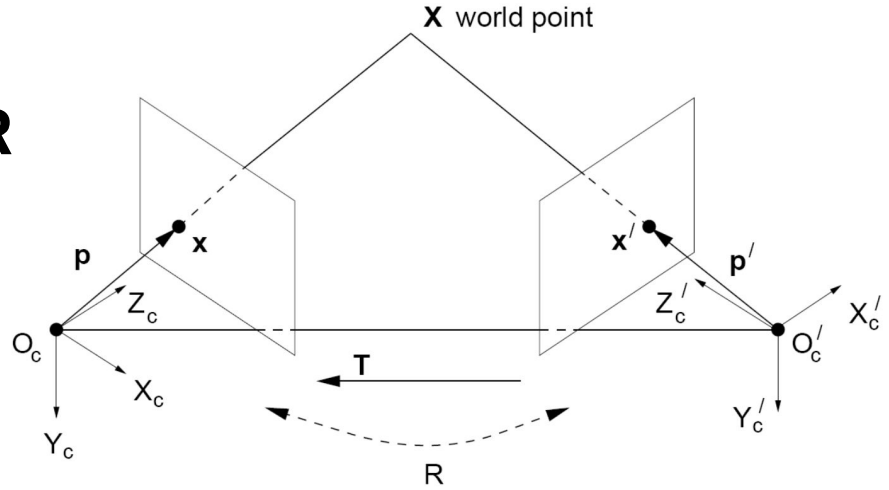


- Set cameras in fixed points then solve for extrinsic parameters T, R with real world references

Camera Orientation Options (On FPGA)



OR



$$\mathbf{X}'_c = \mathbf{R}\mathbf{X}_c + \mathbf{T}$$

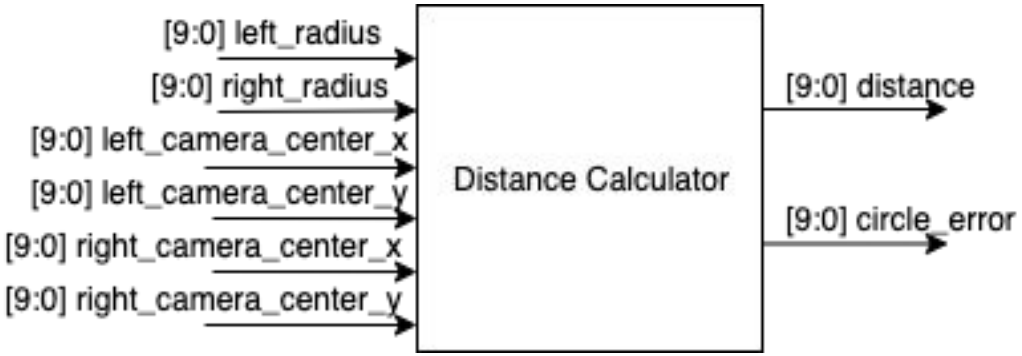
- Set cameras in fixed points then solve for extrinsic parameters T, R with real world references

In our case, the cameras will be rigidly attached to a servo

Distance Calculator - Projective Geometry

- Compute the lines from camera to objects for both cameras

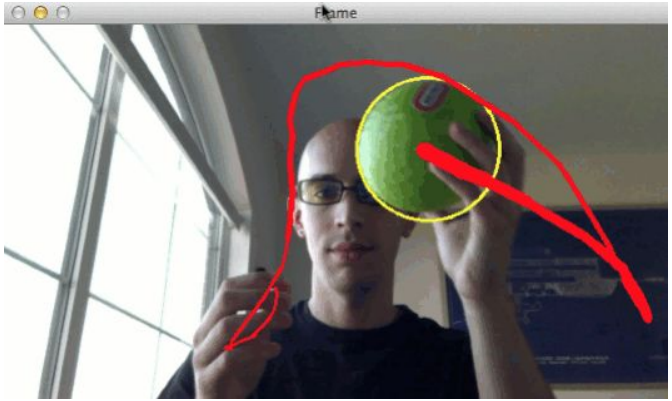
- Pixel location of the center of ball gives a projective line of where it can be. The point at which both lines come closest together is the x, y, z coord of ball.



VGA Display Module

The VGA display will present an assortment of data on object's position and motion, as well as enhance the viewing for the user's benefit.

- ROMs to display the object's distance from the camera, its centroid, velocity, and the predicted path of the object's motion.
- A filter can also be added in order to black out the background



Timeline

	Week 1 (11/4-11/10)	Week 2 (11/11-11/17)	Week 3 (11/18-11/24)	Week 4 (11/25-12/1)	Week 5 (12/2-12/8)	Week 6 (12/9-12/11)
Leilani	Demo servo operation and connect camera	Create top level file, mount cameras to servo	Develop the servo module and FSM	Fix any integration issues	Stretch goal: 2-axis servo motion	Final touches
Jeana	Demo software, parametrize camera calibration	Set extrinsic parameters, calc. distance for still servo	Integrate with servo	Integrate with Ryan's object detection	Stretch: velocity + prediction module	Final touches
Ryan	Demo erosion + dilation, display camera images	Display edges + info on monitor, filter images	Get edges working while servo is in motion	Setup velocity module	Display predictive path on monitor	Final touches