Pong.iRL

Play pong in the real world

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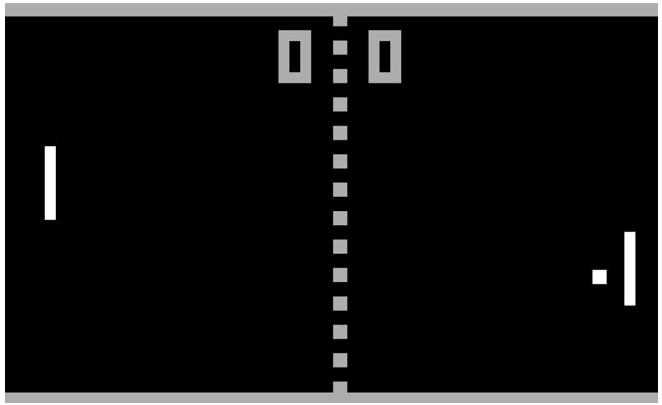
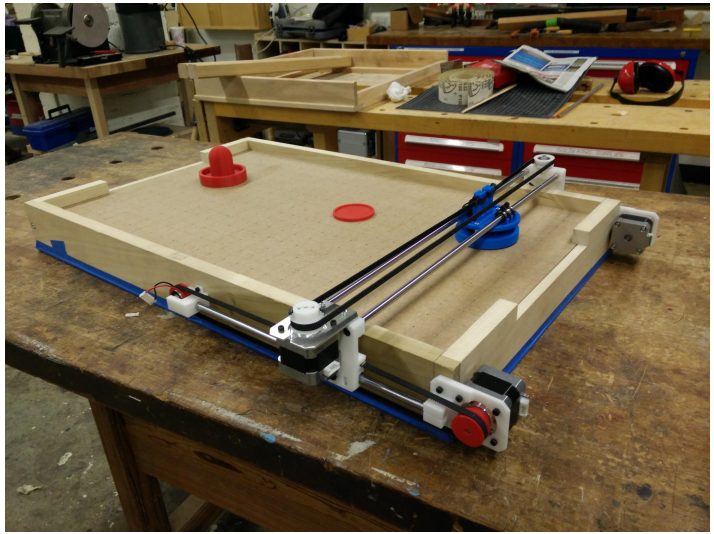
Project Overview

- A human vs robot physical air hockey system with the use of machine vision
- Wanted to expand our favorite lab of the semester onto a new dimension



Hardware

- 2D movement, actuated by steppers
  - Stepper drivers
- 2 PC fans under table generating air stream
  - Reduced friction puck
- Camera

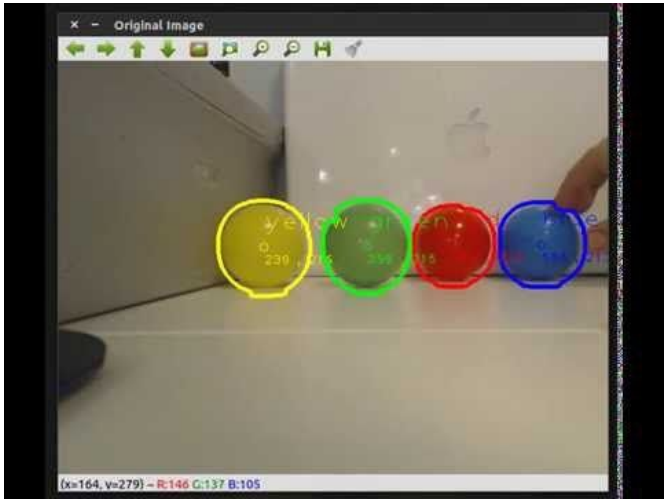


Subsystems

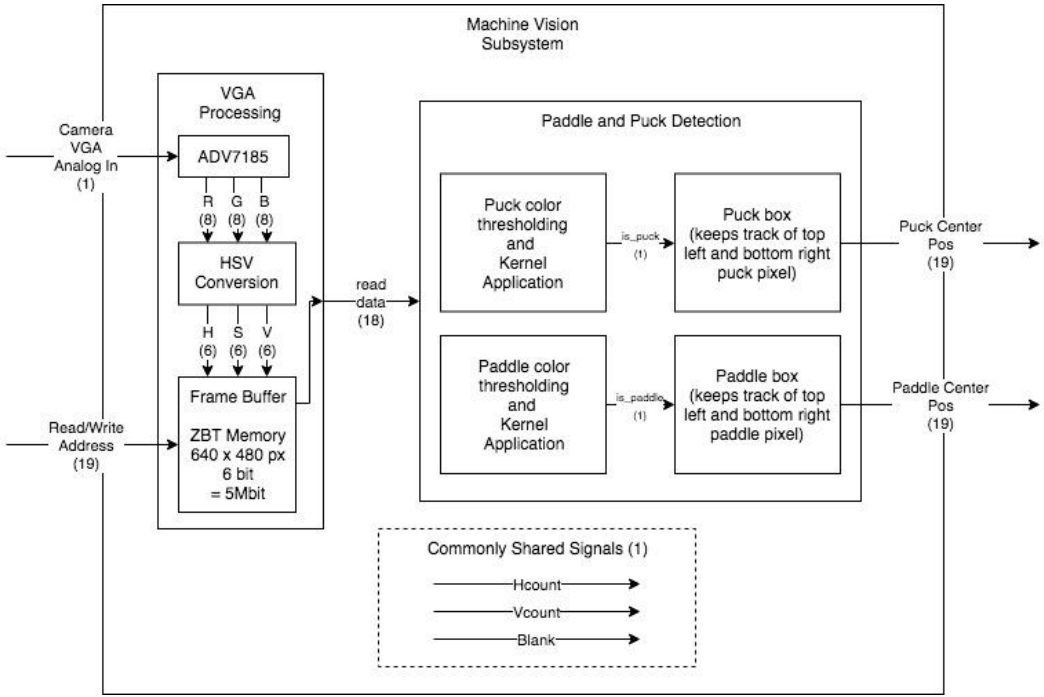
- **Machine Vision subsystem**
  Alex Huang
- **Robot Logic subsystem**
  Kathy Camenzind
- **Motion Control subsystem**
  Xavier Zapien

Sensing for Pong.iRL

- Analog camera 640 x 480
- Chroma keying



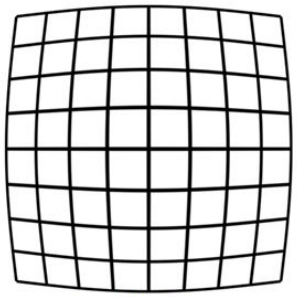
Machine Vision Subsystem



- Needs to determine where the puck and paddle are

Challenges

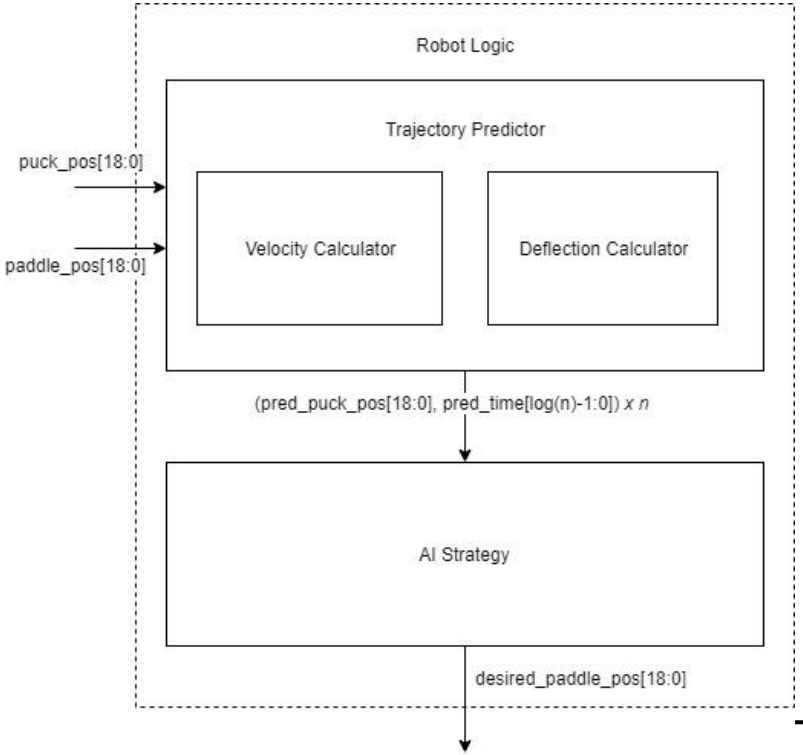
- Image noise
- Vibration
- Distortion



Barrel Distortion

- Provide light source
- Use temporal filtering
- Construct camera frame to be rigid
- Filter out by using fixed reference
- Construct a lookup table mapping camera location -> real table location

Robot Logic Subsystem

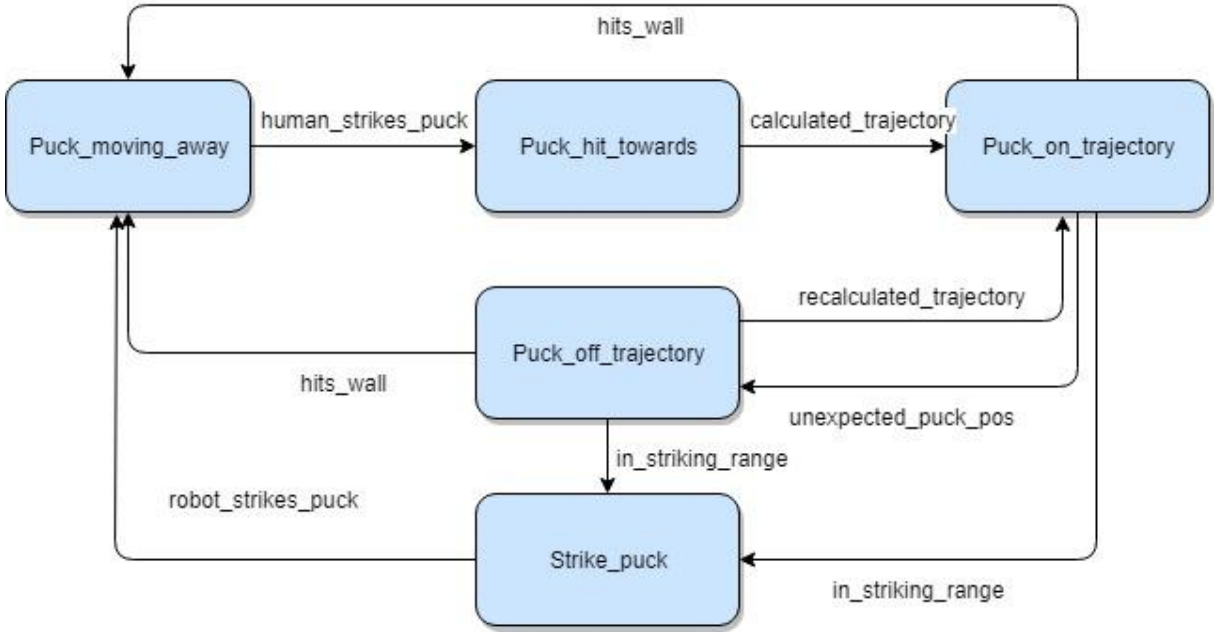


- Trajectory predictor: outputs the y coordinate and time that the puck will score. Continuously self-corrects based on newest input values.
  - Velocity calculator: Calculates speed and direction of puck based on two previous timesteps. Significant change in direction = bounced off wall.
  - Deflection calculator: Calculates the y deflection when the predicted trajectory bounces off of walls
  - Outputs an array of the next *n* positions
- AI Strategy: Implemented as an FSM
  - Basic strategy is only y paddle movement (defensive)
  - Stretch goal is more advanced AI: offensive strategy, hitting puck forwards, choosing move based on heuristics

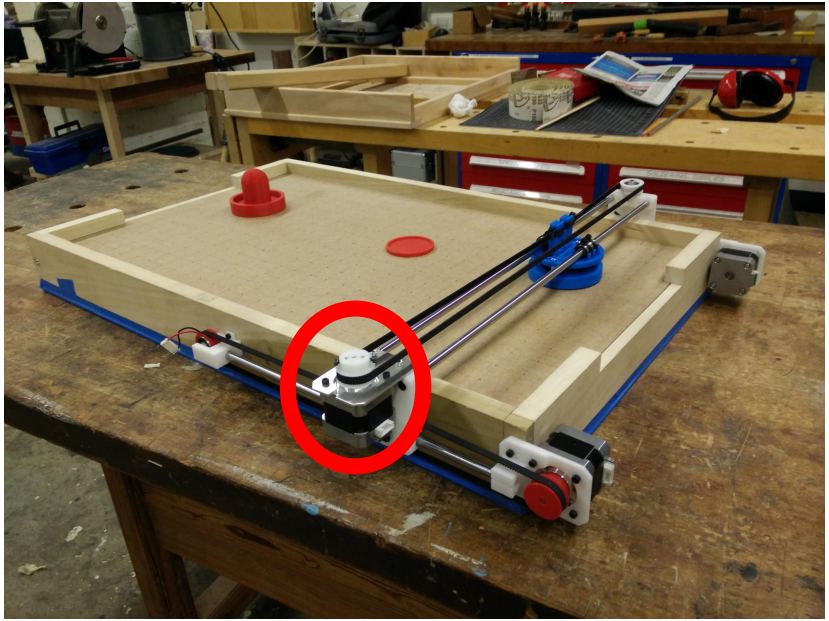
Robot AI FSM

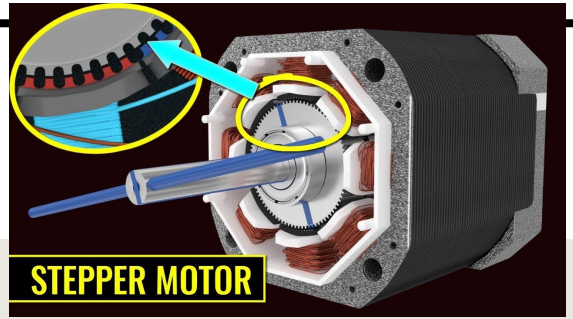
Challenges:

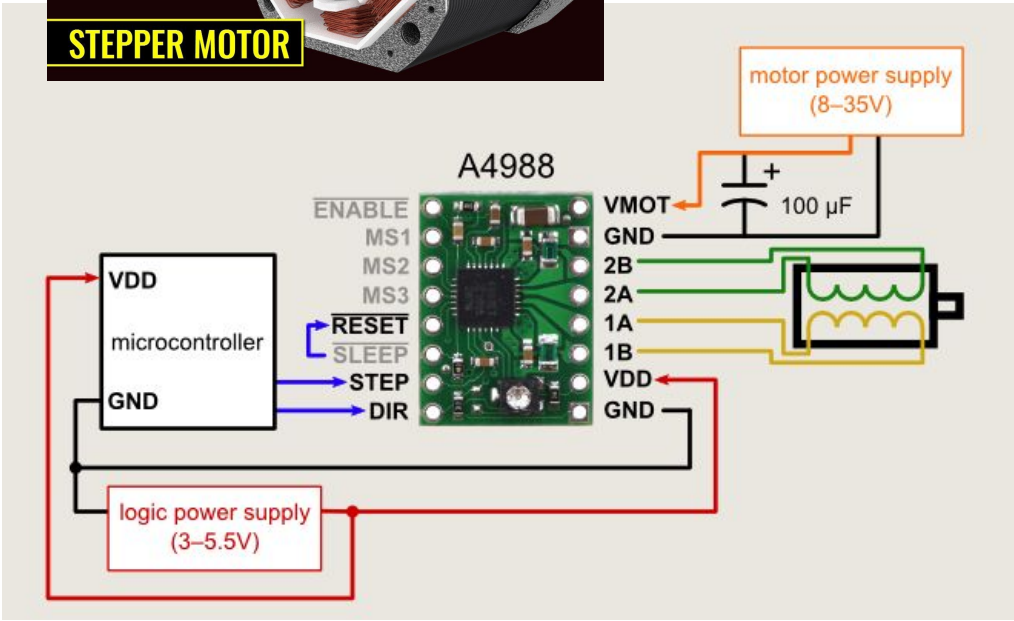
- Not over correcting for noise
- Developing a good heuristic for where and how to hit the puck to score
- Not getting in the way of the puck



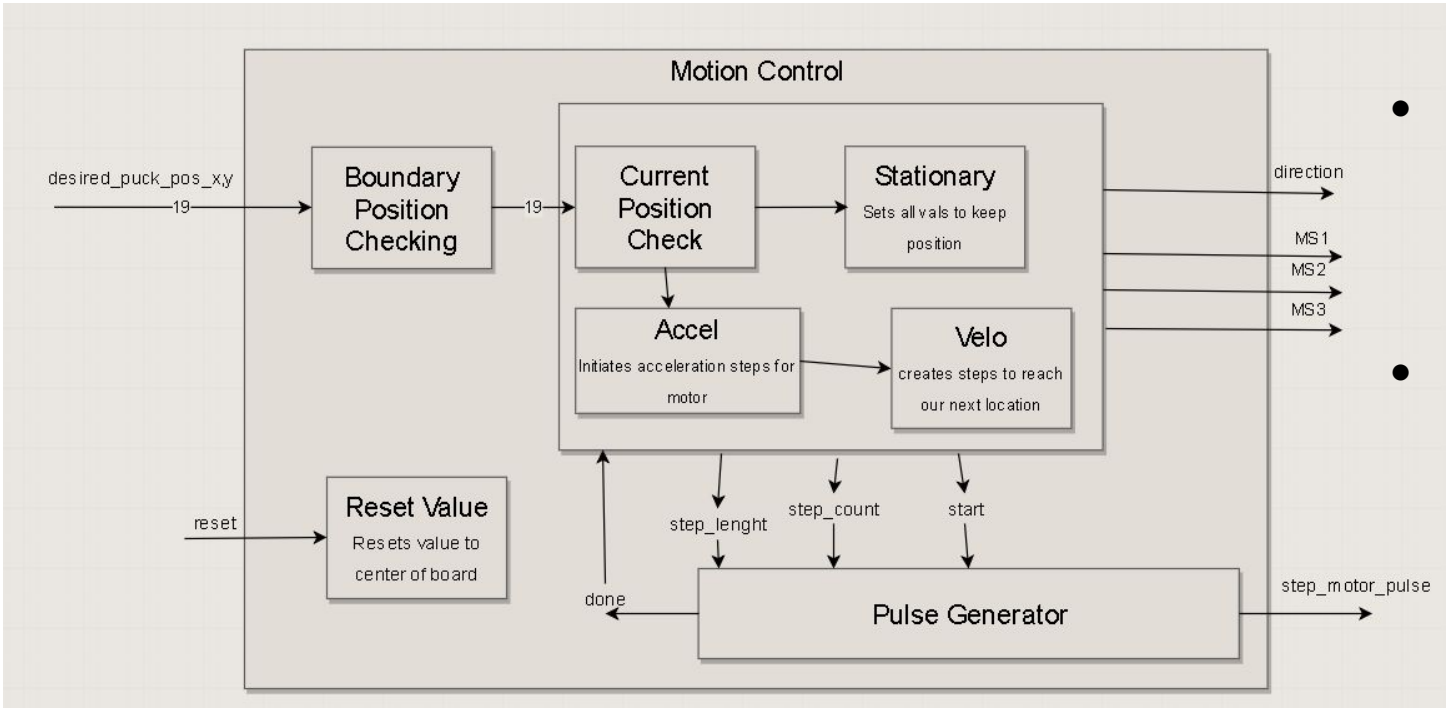
Mechanics of Pong





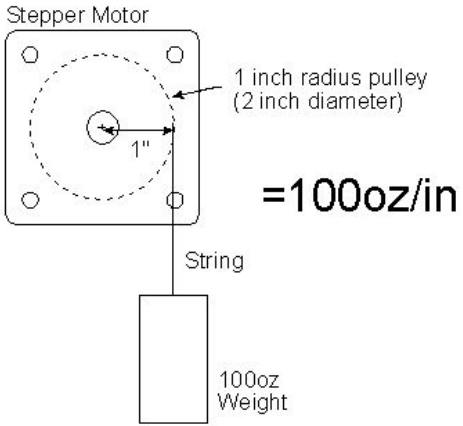


Motion Control Subsystem



- Given the desired paddle x and y values, we will be shifting the paddle to the desired position as fast as possible
- Need to consider acceleration and stalling

Challenges



Motor Stall

- Testing methods

Moving and Timing

- Need to be able to react fast enough to not lose to human

Reach Goal

- Allow the paddle to move in the X axis
- Add the attack mode

Timeline

Module	11/5	11/12	11/19	11/26	12/3	12/10
Machine Vision	Camera communicating with FPGA Output to computer screen	Research chroma-keying image processing Implement machine vision algorithm	Test and fine tune algorithm on monitor	Assist stall detection		
Robot AI	Develop detailed plan for AI strategy	Implement trajectory predictor submodules	Implement AI submodules with varying levels of aggression			
Motion Control	FPGA communicating with motors Test motor speeds	Implement smooth ramp up speed	Stall detection	Integrate subsystems	Testing	
Hardware	Mount camera	3D print pucks and paddles	Fine tune for durability and minimizing vibrations	Maintenance		Final project checkoff