P4, Part A: Shop Consultation

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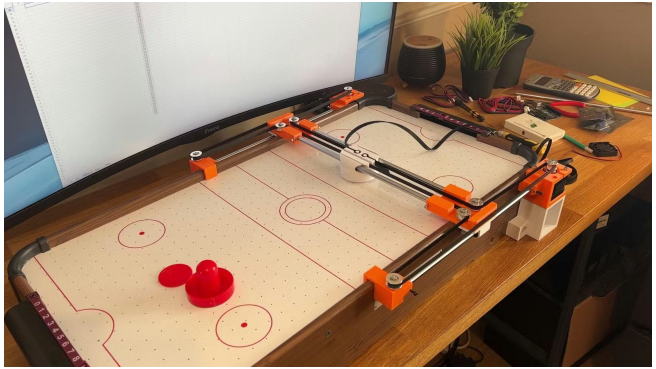
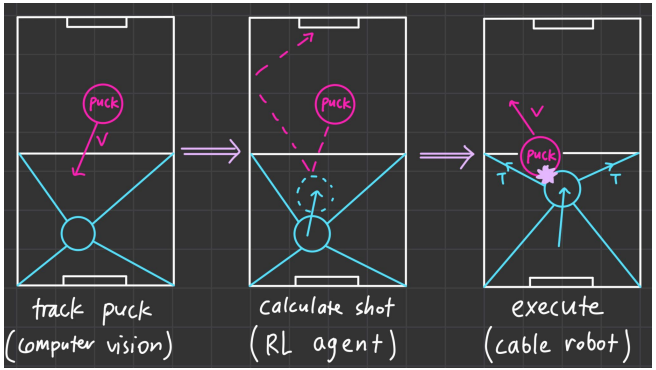
Problem Description

- Current reflex training methods for high-level athletes are highly repetitive or just for recreational use.
    - E.g. catch the falling object, press a button when the light changes color, etc.
- A **high-performance air hockey robot** provides a fun and engaging alternative to existing repetitive tasks, and also doesn't require another human to administer the training.
- Some air hockey robots have been implemented by hobbyists on the internet, but none have the shot velocity or precision to be a worthy opponent for elite athletes.
- We chose this project for the technical challenge (both on the hardware and software sides) and for the fun factor.

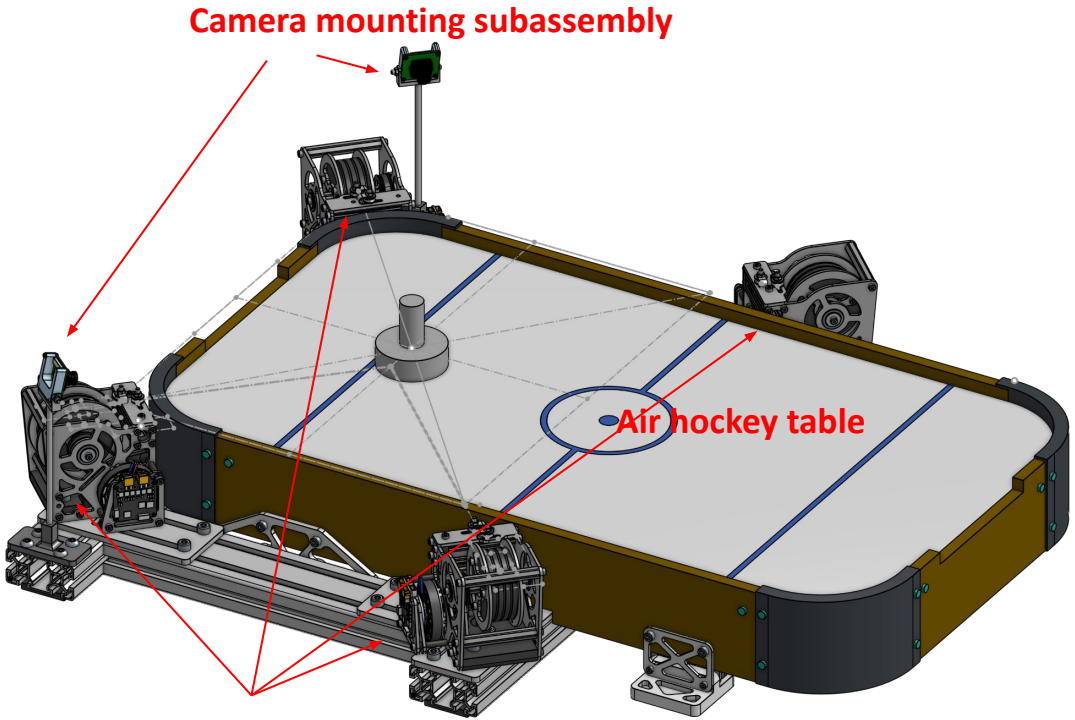


Air hockey bot with CoreXY gantry
(credit: zeroshot)



4-cable robot execution pipeline:
CV ⟶ RL agent ⟶ Actuation

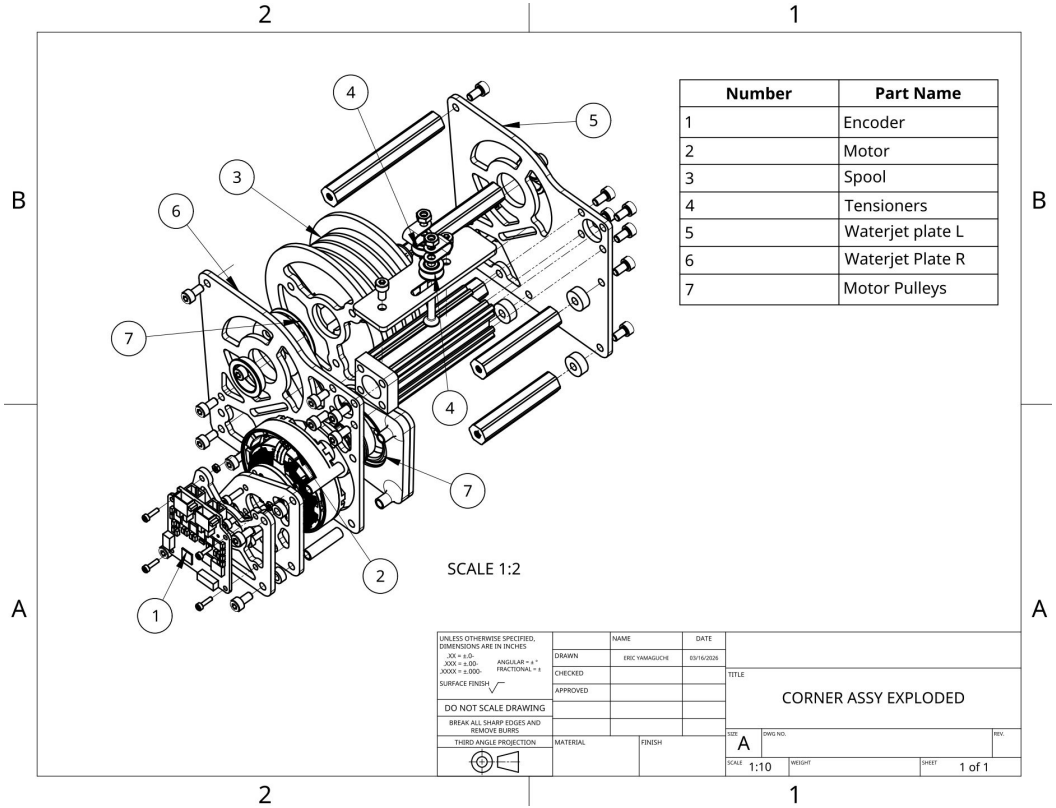
Mechanism and Overall Architecture



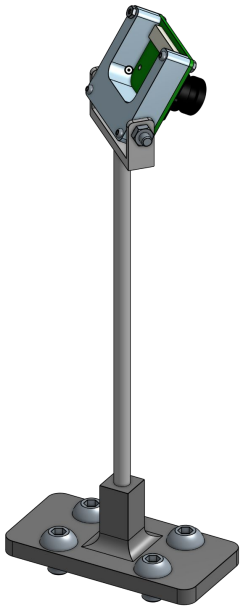
***Question**: Is it necessary to add shielding panels on the sides of the robot for player/spectator protection?*

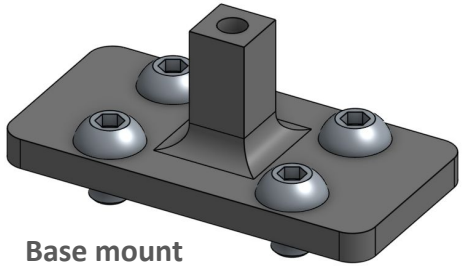
Motor and Transmission Sub-assembly

- **Function-critical components:** The actuation system relies on the BLDC motors paired with a belt reduction transmission, cable spools, and cable tensioners. This assembly must drive the puck across the board in roughly 300 ms (or around 3.5 m/s).
- **Contact Sensing**: limit switch on mallet provides digital input indicating contact with the puck.
  - ***Question***: *How can we cleanly route the sensor wires to the mallet without them snapping from whip or tangling with the tensioned drive cables?*
  - Alternative approach: detect contact by looking at motor current spikes
- **Materials and Manufacturing:** The transmission utilizes helical spools designed with specific diameter, width, and winding specifications. All parts are waterjetted.

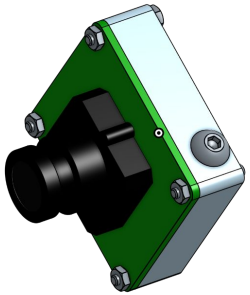


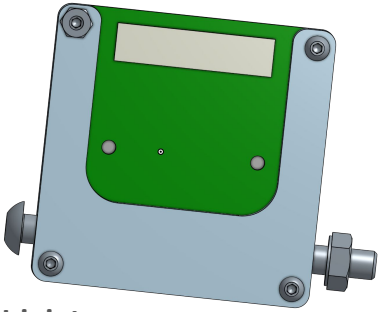
Vision and Control





Base mount





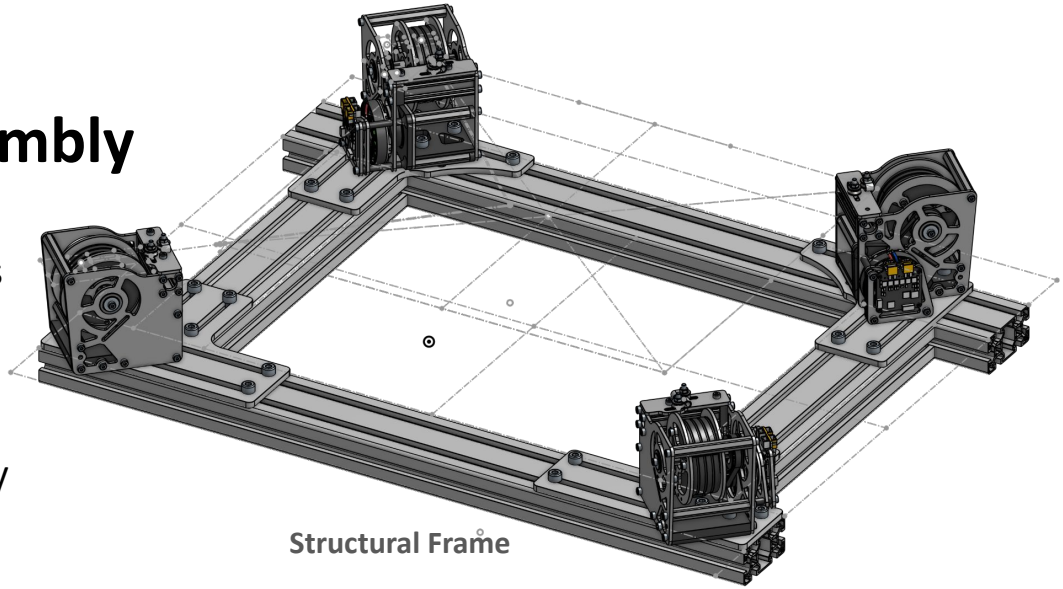
Swivel U-joint

- **CV Tracking:** 2 cameras are mounted above the plane of the table to maintain an unobstructed playing space while tracking the puck in real-time. Processed using NVIDIA Jetson Orin Nano and sent to RL agent for optimal shot calculations.
- **Camera Mount Materials & Fabrication**: Swivel U-joint 3D printed; base mount 3D printed; bracket is sheet metal; everything else is COTS

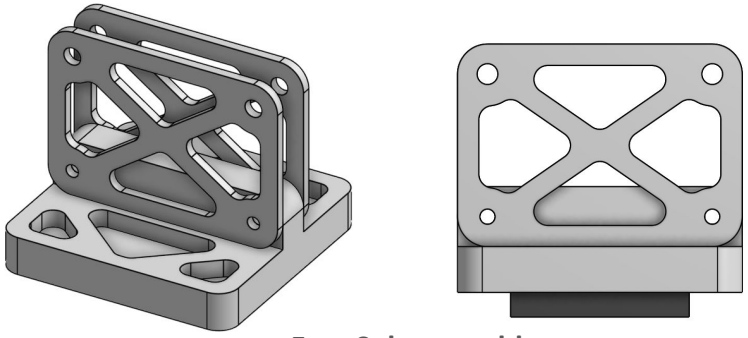
***Question**: Since the camera mounts to a tall and thin dowel, it will be vulnerable to vibrations from high acceleration movements. Should we add dampening between our frame and the table, or should we mount the camera to a decoupled structure?*

Structural Frame Sub-assembly

- **Stability and Integration**: The system is supported by a mounting frame equipped with rubber feet.
- **Enclosures:** The frame houses the electronics enclosure and power supply unit away from the mechanical action, below the table.
- **Materials and Manufacturing:** The structure is built primarily from 80/20 aluminum extrusions. Table is connected to 80/20 via waterjetted support brackets.
- **Feet**: plates are waterjetted, and rubber padding added below for friction against table surface.



Structural Frame



Feet Sub-assembly