

High-Performance Air Hockey Bot

Project Pitch Slides (Deliverable 4)

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Problem Description

- Current reflex training methods for high-level athletes are highly repetitive
 - 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
 - The robot can also be used recreationally, as we plan to demonstrate at the showcase!
- 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.



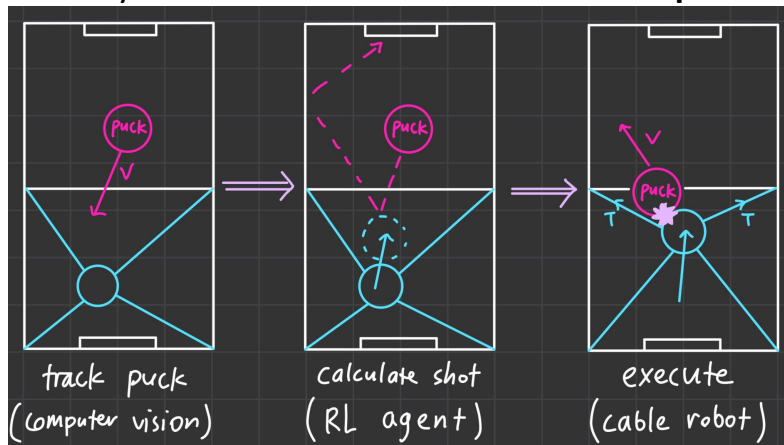
Air hockey bot with CoreXY gantry
(credit: zeroshot)



Air hockey played using robot arms
(credit: Puze Liu et al. arxiv.org/abs/2107.06140)

Strategy of the Air Hockey Bot

- Our robot will be mounted on one half of a standard air hockey table.
- It has **4 high-speed motors** in the corners, each of which controls a tensioned cable; the cables connect in the center to hold the air hockey mallet, which is moved around at very high velocity by rapidly adjusting the cable tensions.
- The robot is controlled by an **RL agent** that determines the optimal mallet placement according to the current puck position and velocity. It obtains that information via **computer vision**.



Low-Fidelity Mockup

- Based on our experience playing air hockey, the required collision impulse needed to accelerate our puck to the desired speed is not very high.
- Our mockup, shown at right, has a “mallet” (thimble) controlled by 4 “cables” (strings). The strings can be pulled in combination in various directions to move the mallet to any desired position in its half of the board.
- **Primary lesson learned:** to precisely control the mallet’s movement, we will have to carefully control the relative cable tensions. This will be accounted for in our motor control program, to come later.



System Design and Performance Metrics

Integration notes (not reflected in drawing):

- Camera will be mounted above plane of table, so playing space is unobstructed.
- Due to system inherently being 2DOF, may switch to 2 or 3 motor system, needs further deliberation.

Project requirements:

- **Analog Input:** Real-time camera feed, motor encoders
- **Digital Input:** Limit switch on mallet for contact sensing
- 4x **BLDC motors** + belt reduction
- Automatically tensioned cable **transmission**

Performance metrics:

- **Shot velocity:** At maximum speed, the puck should traverse the length of the board (40") in ~300 ms, roughly equivalent to a speed of 3.5 m/s.
 - We chose this metric relative to the average human reaction time of 250 ms. Since the robot should be unbeatable, we felt that this was a reasonable target.
- **Shot placement and simulation correlation:** If the RL agent predicts that a given path will score without obstruction, it should score in real life as well.
- **Positional Tolerance:** The mallet should always end within a 3mm radius of the desired position.

