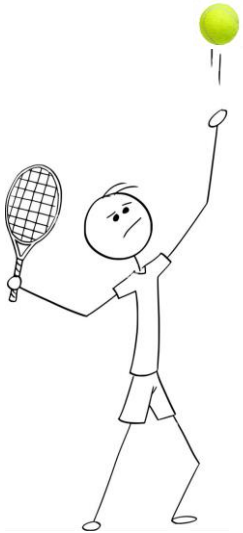

ServeBot

Final Presentation

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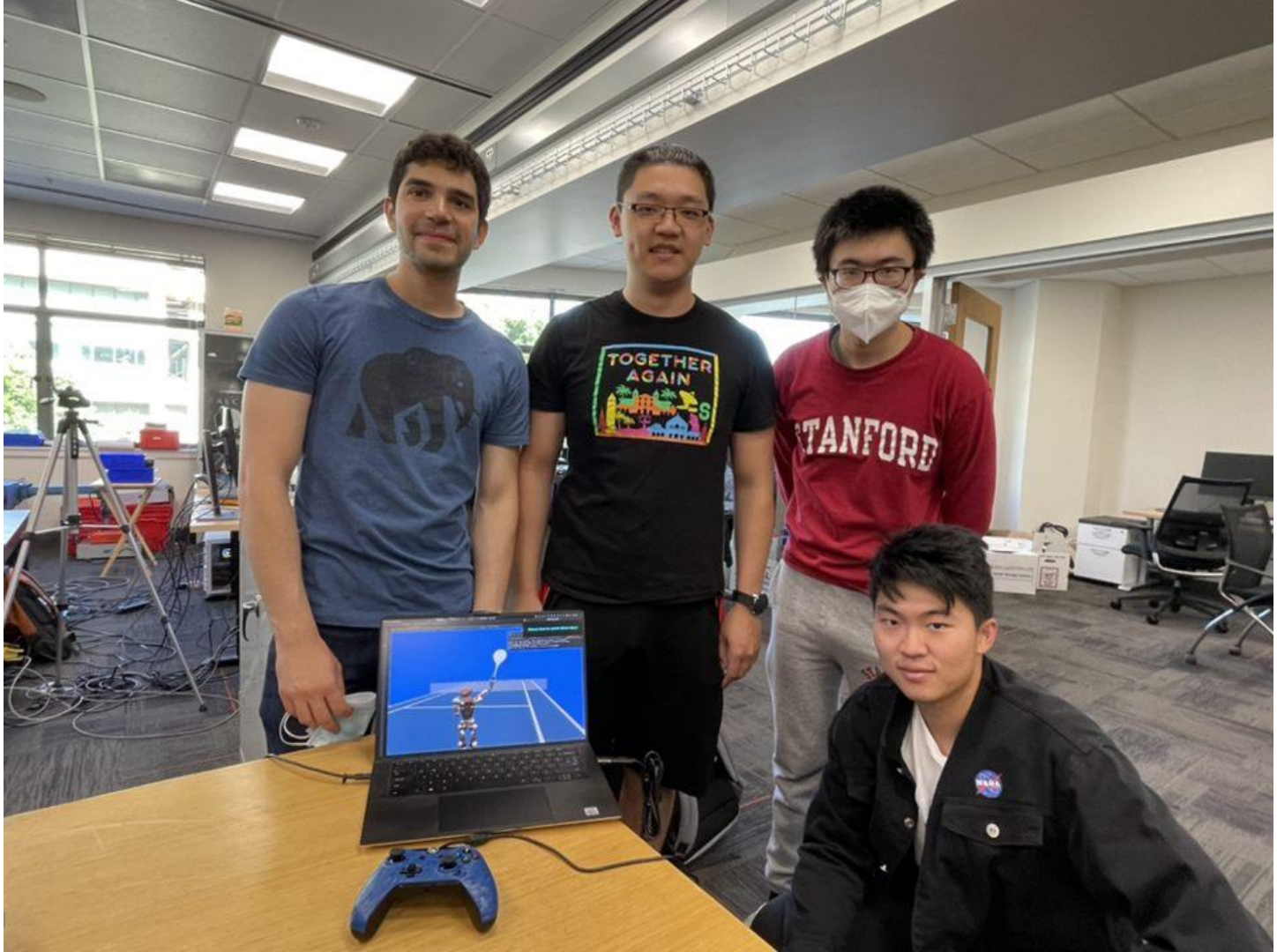
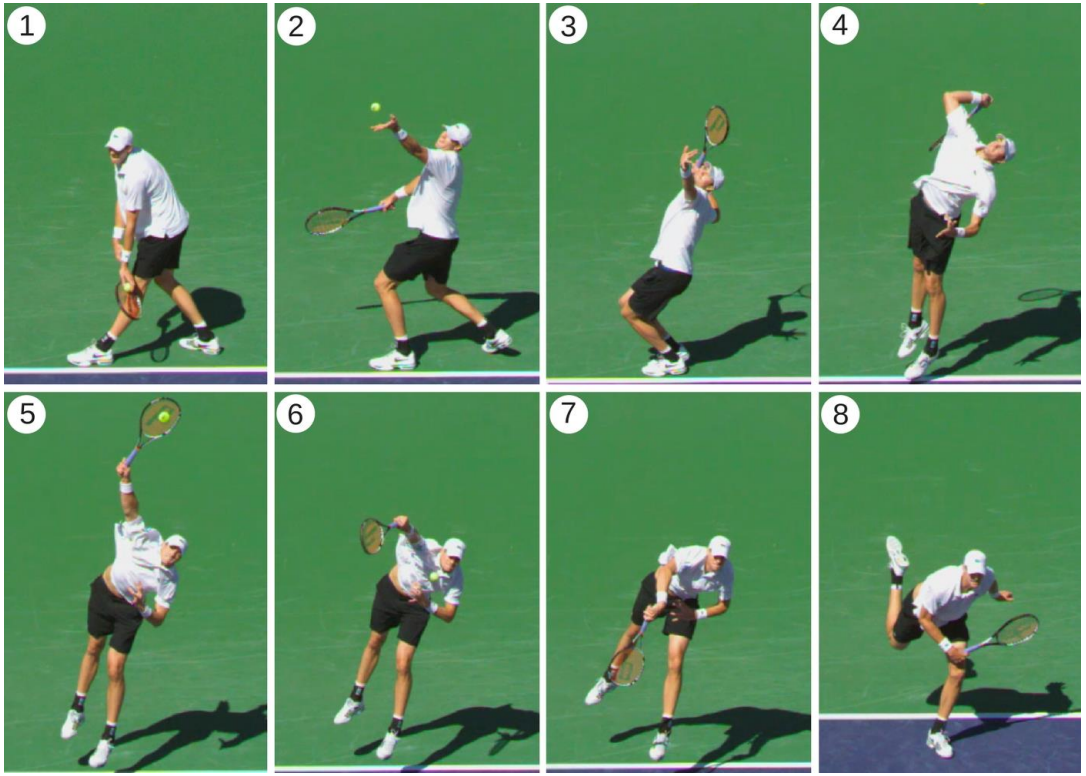
Chongxun Wang
Anil Yildiz
Junnan Yu

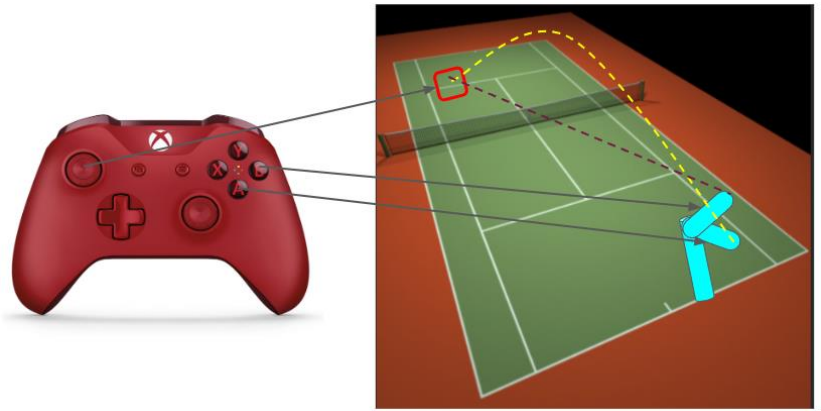

TOGETHER
AGAIN
STANFORD

Motivation

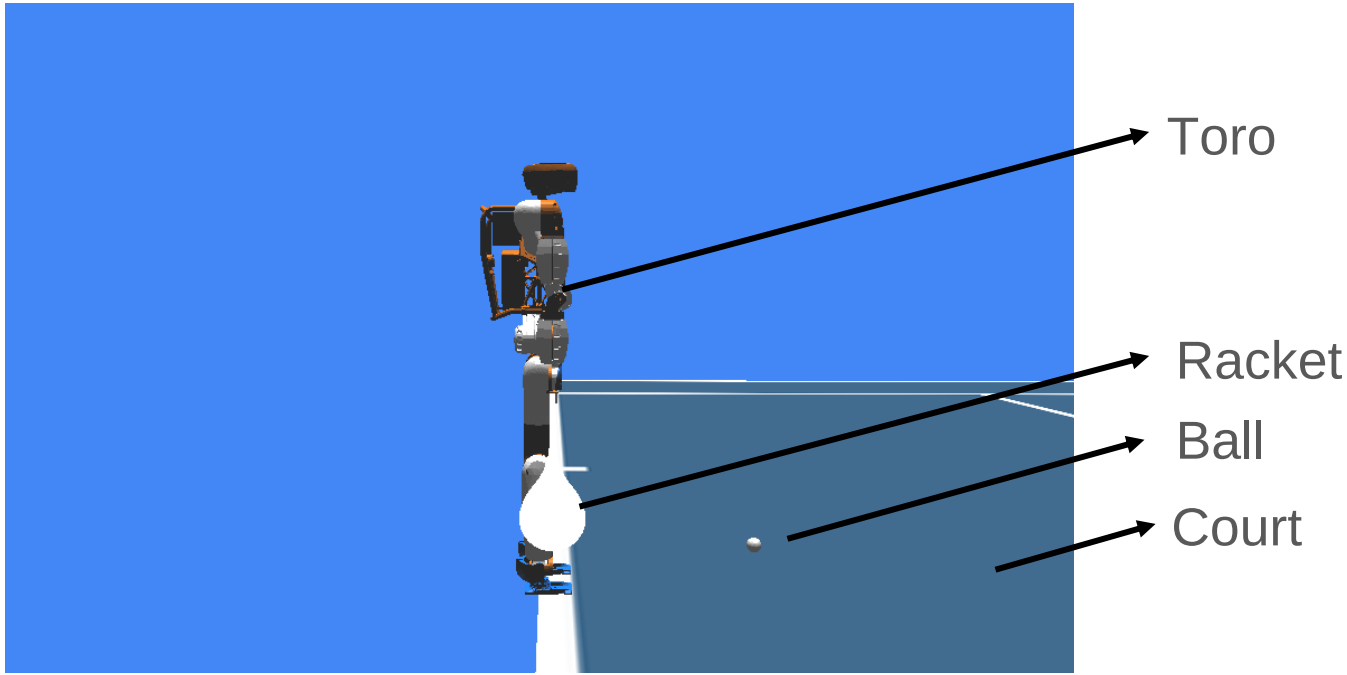


Description and Objectives

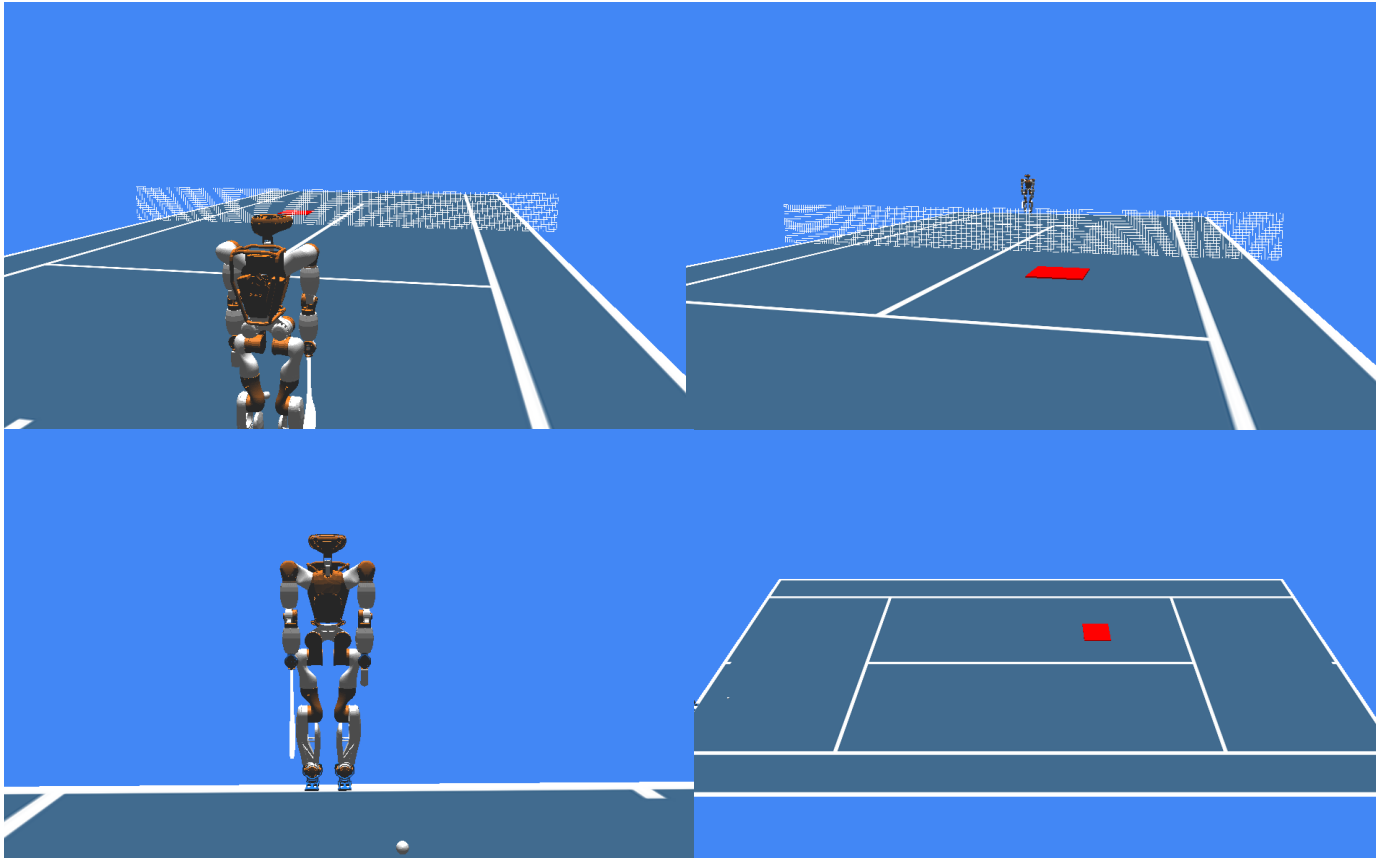
- Design a robot that serves a tennis ball at a certain height to a desired landing position.
- Create an interface that
  - customizes the target ball landing location
  - changes camera angles
  - guides user through different steps in a serving process
- Switch between different serving techniques (upper-hand or under-hand)



Environmental Modeling

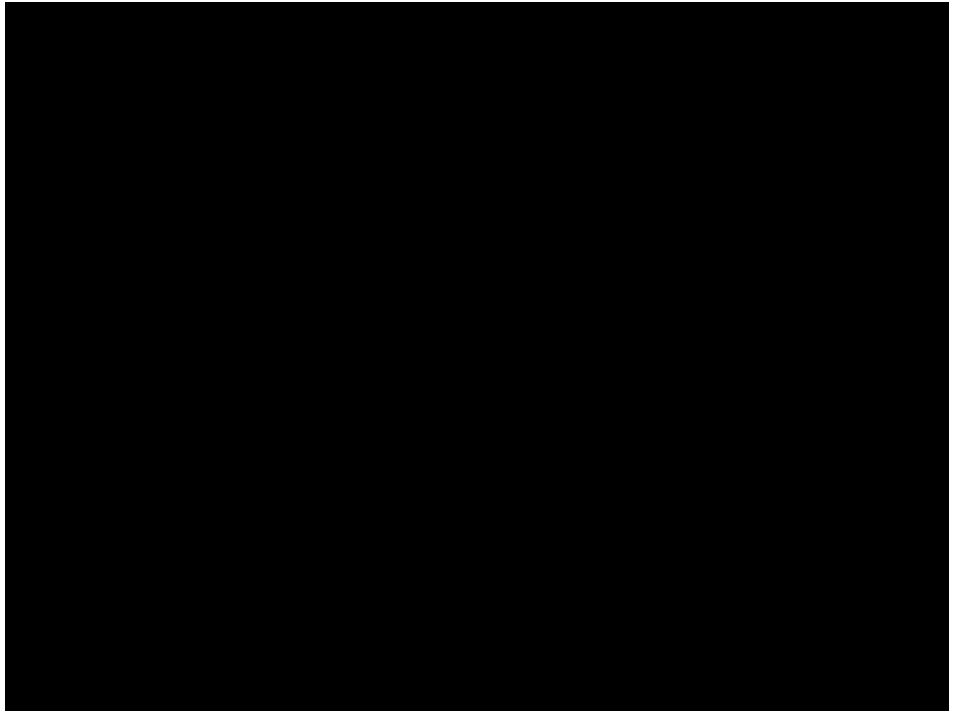


Different Camera Angles

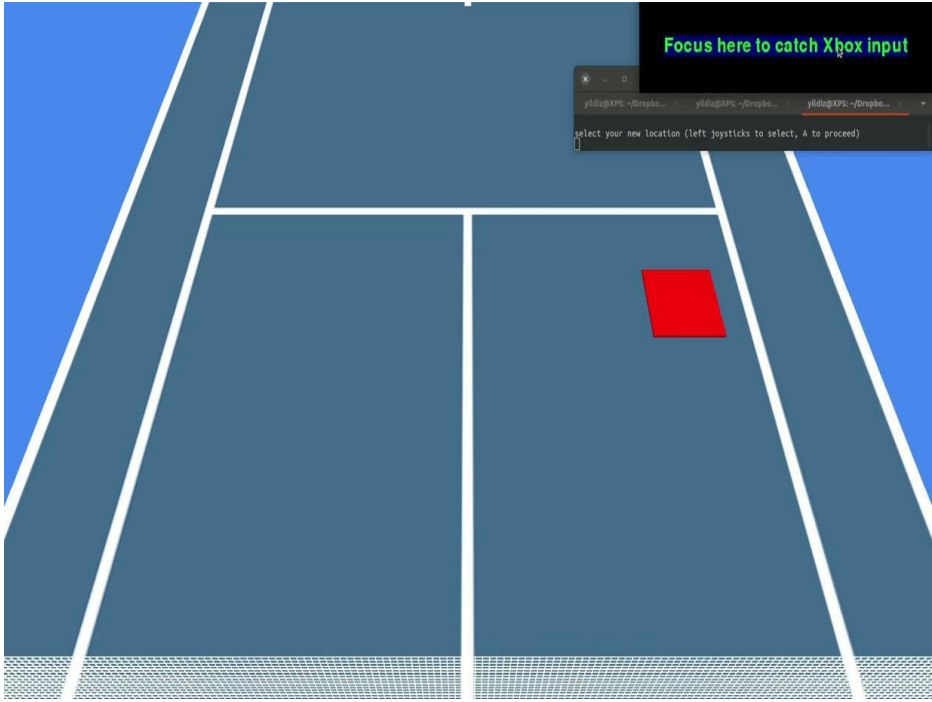


Controller Input to the Environment

Let’s See it in Action!

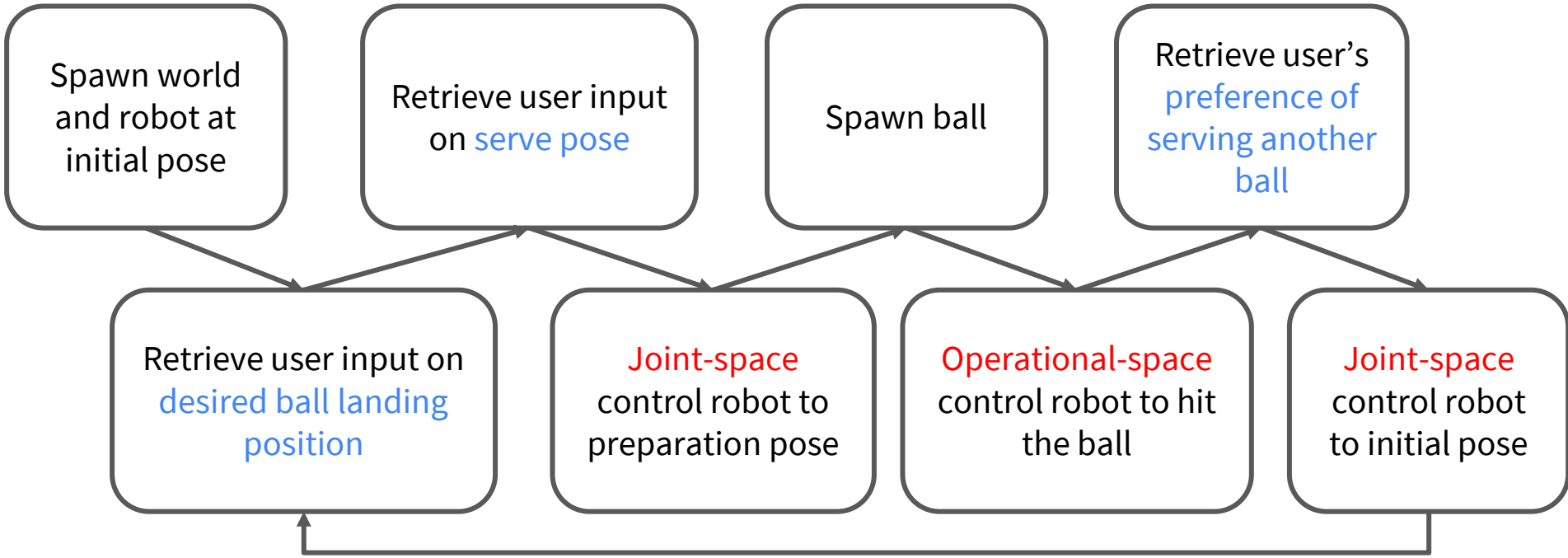


Upper Hand Serve



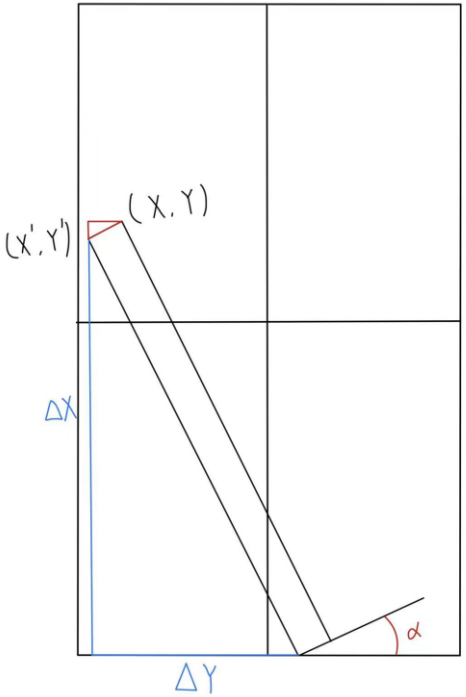
Lower Hand Serve

State Machine



Ball Trajectory Planning

STEP 1



STEP 2

$$V_z t - \frac{1}{2} g t^2 = \Delta h$$

$$V_x t = \Delta x$$

$$V_y t = \Delta y$$

$$V_x{}^2 + V_y{}^2 = \tan^2(\gamma) V_z{}^2$$

upper hand serve: $\Delta h = 2.505\ m,\ \gamma = 0^\circ$

under hand serve: $\Delta h = 0.733\ m,\ \gamma = 60^\circ$

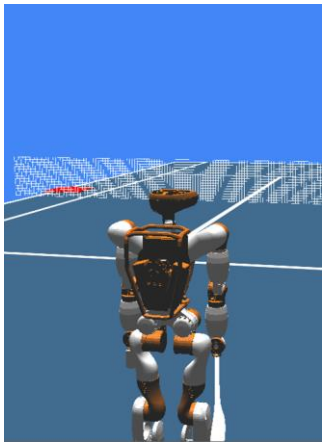
STEP 3

$$e = \frac{V_{ball}{}' - V_{racket}{}'}{V_{racket} - V_{ball}}$$

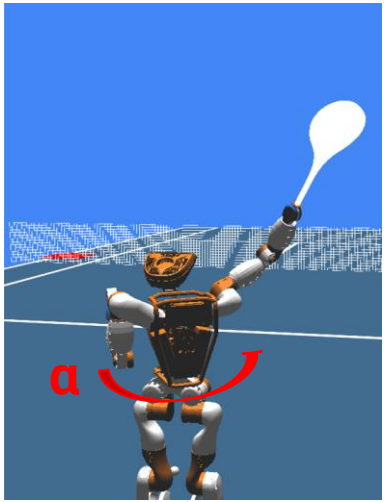
$$V_{ball}{}' = \frac{(1+e)\, m_{racket}}{m_{racket} + m_{ball}} V_{racket}$$

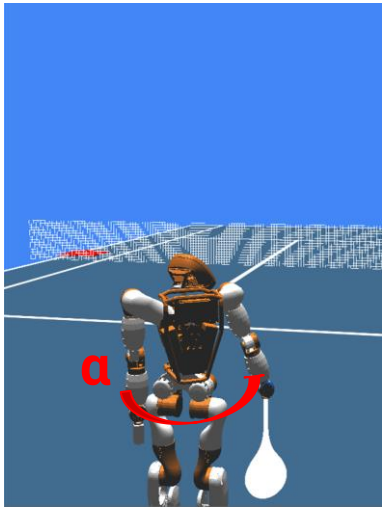
$$= m_{racket} V_{racket}{}' + m_{ball} V_{ball}{}'$$

Control Strategy

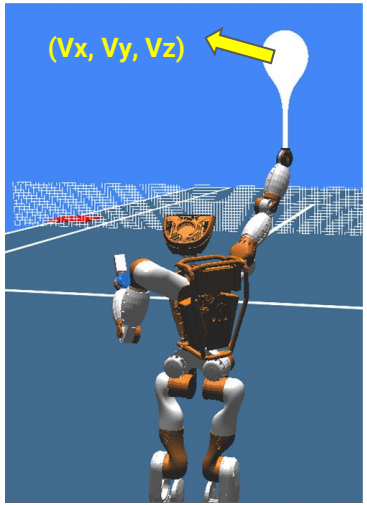


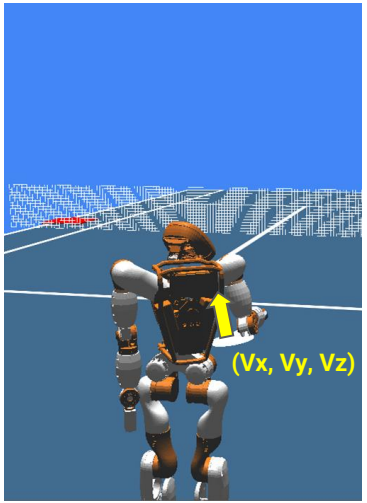
joint space control



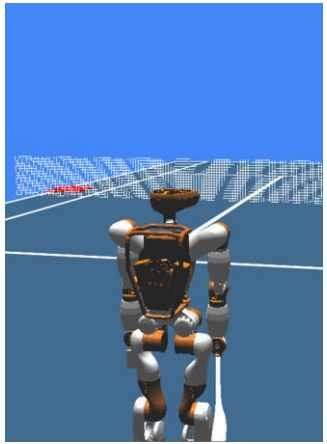


operational space control





joint space control



Challenges

- By specifying desired position, velocity, and orientation at operational-space control, it is hard for the controller to satisfy all these three conditions at the same time. We end up scaling the desired velocity and coefficient of restitution to ensure the final landing position is correct.
- Modelling under-hand serve is more complicated as the desired velocity on the robot includes a non-zero z-dimensional term.
- Simulation error causes inconsistent final landing position in each trial.

Future Work

- Add the motion of throwing up the ball by the left hand of the robot, and hit the ball at a desired time frame.
- Include aero effects in the simulation (Drag force and Magnus effect).
- Fine-tuning operational space controller to balance between the desired position and velocity terms so that a desired trajectory could be reached more consistently.

Questions?