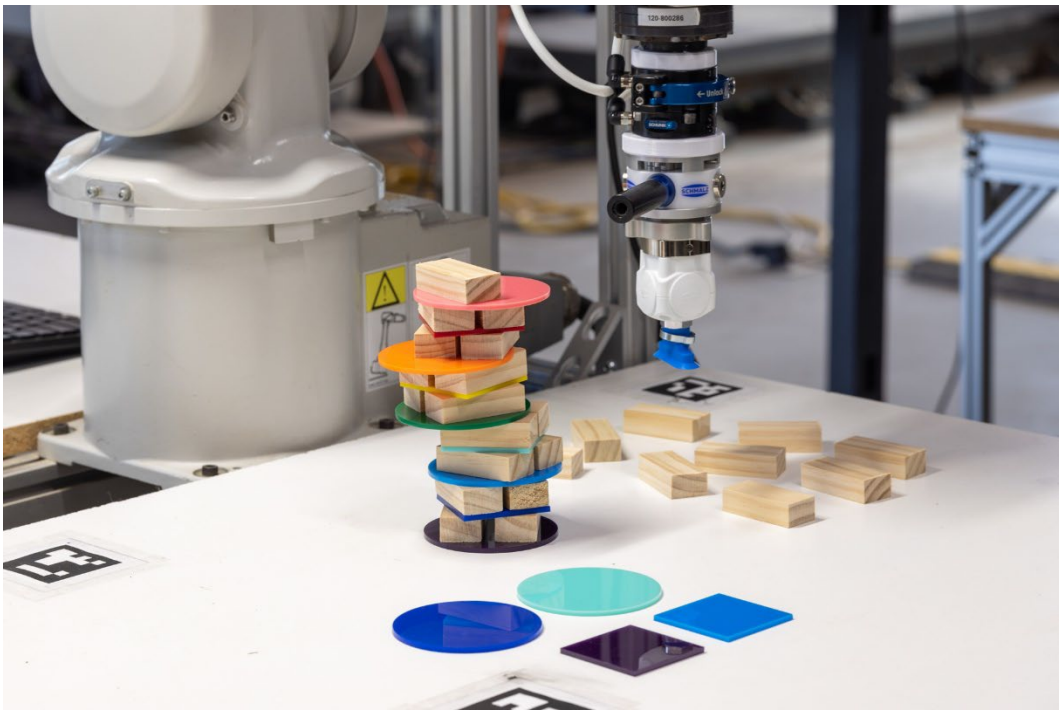
ARC 380 / CEE 380 – Introduction to Robotics for Digital Fabrication
Mondays & Wednesdays 11:00am-12:30pm | Arch Bldg N107 / ECL
Princeton University | School of Architecture | Spring 2024

Professor: Arash Adel | Assistant-in-Instruction: Daniel Ruan



Final Project: Tower Assembly

Schedule & Due Dates: The final project is a four-week-long assignment. (See page 3 for weekly tasks.)

Week 1 Tasks: Due April 16, 2024, 11:59 p.m.
Week 2 Tasks: Due April 23, 2024, 11:59 p.m. (Internal Review on April 24)
Week 3 Tasks: Due April 30, 2024, 6:00 p.m. (Final presentation submission)
→ *Course Final Review with External Guests: Wednesday, May 1, 2:00 p.m. (to be confirmed)*
Week 4 Tasks: Due May 7, 2024, 11:59 p.m. (Final project and paper submission)

Instructions:

The goal of the final project is to combine all of the topics we have covered this semester into a comprehensive workflow for robotically assembling a tower from a collection of objects. This workflow utilizes both 2D and 3D perception to characterize objects in the task area, then automatically controls the robot to pick and place these objects into specified designed structures. The focus of the final project is on robotic fabrication and its potential for automated and flexible design. The final project is a group project (teams of three, same groups as the assignments) and includes eight main parts:

***Part 1 – Design the tower structures* (5 pts)**

Using the available kit of parts, including both colored disks (in various shapes and sizes) and wooden blocks, design two different tower structures (maximum 250 mm tall, each) in Rhino. The design should follow some sort of logic and demonstrate a structure that would be difficult for a human to build precisely without robotic aid.

Generate simple renderings of the tower designs for the presentation and project submission. Include a short description (maximum 150 words) of the design logic for your towers in the final paper.

***Part 2 – Develop the perception framework* (10 pts)**

Develop the 2D and 3D perception required to precisely determine the pose of each object to pick and place them. You will need to utilize the ArUco markers to calibrate the frame of the camera, then process the RGB image and point cloud data to extract the relevant features. Feel free to explore other code libraries and techniques for perception.

***Part 3 – Develop the task and motion planning framework* (10 pts)**

Develop the task sequencing so that your tower structure is buildable and structural during each step of the assembly process. Utilize COMPAS_FAB and COMPAS_RRC to develop the motion planning, keeping in mind that the path of the robot should always avoid collision with the tower.

***Part 4 – Correspond geometry objects* (5 pts)**

In the Session 21 workshop, we go over how to export the Rhino tower structure from Part 1 into a JSON file. Develop code that can match perceived objects to their corresponding location in the tower structure using the object features.

***Part 5 – Execute the assembly process (with the physical setup)* (20 pts)**

Execute your code for assembling each of the two towers on the physical ABB IRB 120 robot. The components of each tower should start in a random configuration spread across the task area. Additional objects can be added to the task area by hand during the assembly process if there is not enough space to fit all the components initially. Record each assembly process and include an edited, sped-up video in the presentation and project submission.

***Part 6 – Final Review Presentation* (25 pts)**

Prepare a presentation for the final review of the project (maximum 10 minutes per group). We will provide a PowerPoint template. Submit your presentation before the deadline, Tuesday, April 30, 6:00 p.m.

***Part 7 – Final Paper Write-Up* (25 pts)**

Write a paper (max 1500 words) detailing your group's experience with the final project, including the methods/algorithms utilized, specific challenges and how your group debugged/solved them, areas for potential future improvement, and any responses to feedback received during the final review.

Part 8 – Final Submission

Follow the instructions below and submit your project and paper before the deadline, Tuesday, May 7, 11:59 p.m.

Weekly Tasks

Week 1 Tasks: Due April 16, 2024, 11:59 p.m.

- Complete Parts 1 and 2.

Week 2 Tasks: Due April 23, 2024, 11:59 p.m. (Internal Review on April 24)

- Revise Parts 1 and 2 based on feedback (if necessary).
- Complete Parts 3 and 4.
- Prepare your final presentation draft (Part 6) for internal review (PowerPoint).

Week 3 Tasks: Due April 30, 2024, 6:00 p.m. (Final presentation submission)

- Revise Parts 1-4 based on feedback (if necessary).
- Complete Part 5.
- Revise and finalize your final presentation (Part 6).
- Submit your final presentation and practice your presentation.
- → *Course Final Review with External Guests: Wednesday, May 1, 2:00 p.m. (to be confirmed)*

Week 4 Tasks: Due May 7, 2024, 11:59 p.m. (Final project and paper submission)

- Submit your project and final paper (Part 7) based on the submission guidelines.

Submission guidelines:

Create a folder titled ARC380_FinalProject_YourTeamLastNames (e.g., ARC380_FinalProject_AdelRuan). For the final submission, upload all of your code under a sub-folder under the main assignment folder. Besides your code, include your tower design renderings, assembly videos, and any photos (in high quality) under the main folder. Zip the main folder (including sub-folders and files) and upload it to Canvas. Upload your final presentation and final paper separately to their respective assignments on Canvas. For the weekly submissions, upload your current progress for the files above to the weekly task assignments on Canvas.

Only one member per group needs to submit the weekly tasks, project, presentation, and paper on Canvas.