# **CMSC477:** Robotics Perception and Planning
# Project 3: Clean Out the Closet!

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Competition Day: Monday, May 19, 2025, 10:30am - 12:30pm (RAL Lab)
Report Due: May 21, 2025
**It is not possible to use late days or extend the due date because the final competition is in the final exam time slot, and the report is due on the last day of finals.**




*1st place team wins a set of trophy plaques*

## Introduction:

In this project, your team's autonomous robot will compete against another team's robot to clean out their closet by moving Legos from one "closet" to the other team's "closet". Each Lego stack is worth a certain number of points. The team with the least number of points on their side of the arena after 5 minutes, wins. Legos dropped outside of the closet, in the "room" zones, have 1/4th of their point value. Dropping a Lego in the "hallway" between rooms results in a penalty equal to the Lego stack's value.

Each team will use one robot to autonomously pick up, pass, and place LEGO stacks, as shown in Figure 1. The Lego stacks will be three blocks high in 4x4 (4 points), 2x4 (8 points), and 2x2 (16 points) configurations. The arena will contain obstacles (fabric boxes) at unknown locations with AprilTags on them. Fabric boxes at known locations will have colored construction paper on them in a randomized order. A blue line on the floor will mark the center of the hallway zone. The closets outlines will be marked with purple tape.

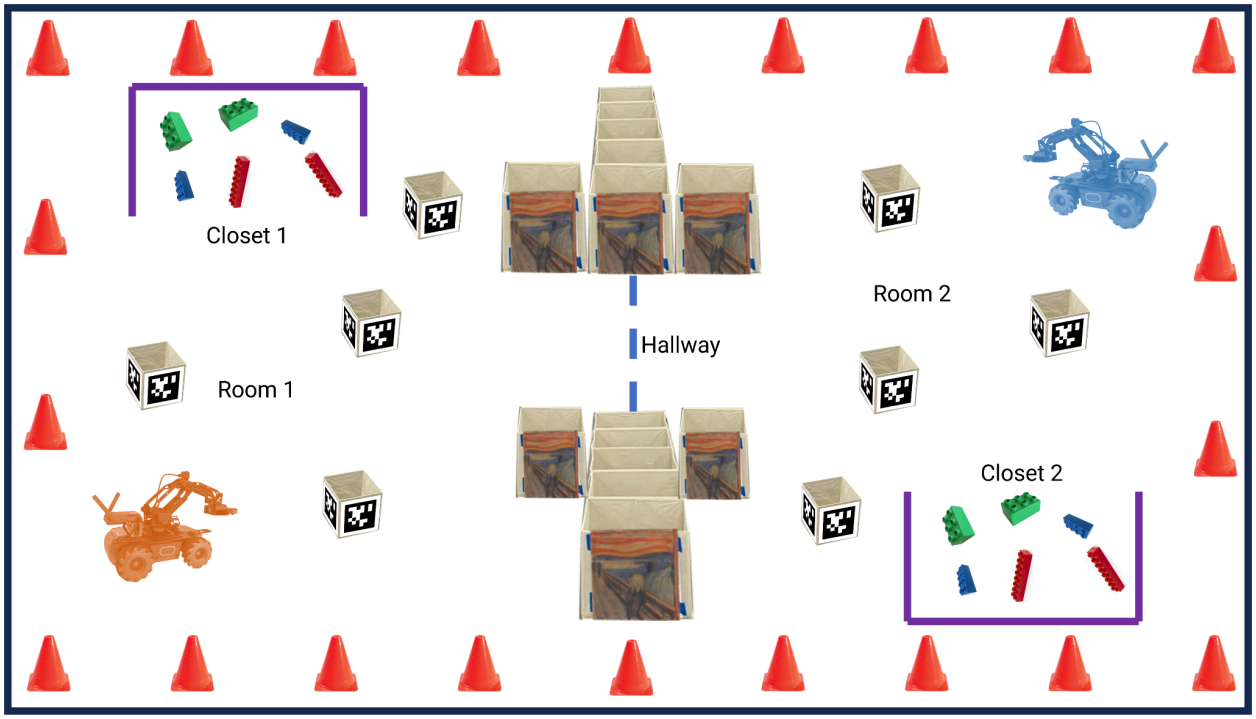
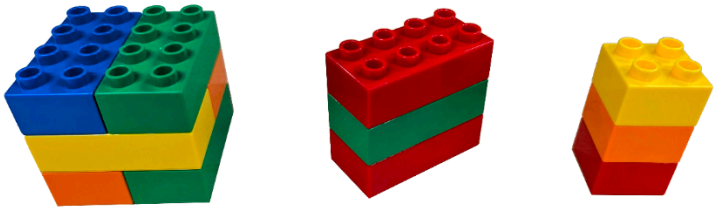



Figure 1: Figure of Project 3 Competition layout. Team 1 scores points by moving Legos from Closet 1 and putting them in Room 1, Room 2, or Closet 2 with more points awarded for Room 2 and Closet 2. The team that gets the most Legos (points) on the opposing team's side, wins.

**Detailed Description:**

1. Two teams will be competing against each other at once.
2. Initially, the Lego stacks will be distributed equally in the two "room" zones
3. The three Lego stacks configurations will be the following with random colors.
    a. You may need more than 100 samples to train YOLO to detect these objects since they will have different colors
    b. The class is encouraged to organize and share their labeled datasets



4. Their point values are:
    a. 4x4 – 4 points
    b. 2x4 – 8 points
    c. 2x2 – 16 points
5. Legos left in a room have one-fourth of their point value.

6. Legos left in the hallway result in a penalty equal their full point value to the team that left the lego in the hallway.
7. The team with the ***least*** points on their side of the arena at the end of 5 minutes wins!
8. Creative strategies are encouraged, for example:
    a. Suppose Team A emptied their closet into their room
    b. Team B could start putting the objects in Team A's back into Team A's closet
9. You may not block the passageway for more than 30 seconds
    a. A penalty of 8 points will be assessed for doing so
10. 4/16/25: An "at fault" crash into another teams robot results in a penalty of 4 points
11. 4/16/25: Crashing into obstacles, the arena walls, or the cones will result in a penalty of 4 points
12. The robots must be autonomous, but if they get stuck, you can reset them and restart their program or tweak a setting (no live coding, please).

**Requirements:**

- The robots must be completely autonomous
- The robots must be able to avoid moving obstacles (other teams robots) and maneuver around static obstacles whose positions are not known beforehand.

## Suggestions:

You are free to accomplish this project in the manner of your choosing. However, we make the following suggestions:

- Reuse concepts and code from Projects 1 and 2.
- Make a concrete plan for your final system early in the project, but be quick to revise the plan as the project proceeds. Talk with your TA about your strategies.
- Make a rough schedule and revise it frequently.
- Plan to build a map to store obstacle locations. You can use them as landmarks later.
- Detect obstacles, walls, legos, and other robots, using YOLO
- Do not separate each team member's work with the intention of "integrating" everything at the end.
- Use simulation to speed software development and test corner cases
- Use recorded videos to test localization and detection
- Consider writing a planning algorithm to achieve the maximum score in the shortest time.
- Consider calibrating the camera, and running it at an increased resolution, to improve the localization results from YOLO bounding boxes and/or AprilTag detection.

## Grading:

- Demonstrate navigation from closet 1 to closet 2 in an environment with static obstacles at unknown locations: 20 points

- Pick, navigate, and place at least 3 LEGO stacks at the goal in 5 minutes: 20 points
- Demonstrate avoidance of the other team's moving robot: 10 points
- Participate in competition: 30 points
- Report: 20 points
- Bonus 1: Use a search-based planner or other sophisticated method to create and update a plan that maximizes points. 10 points
- Bonus 2: Implement a simple SLAM algorithm that keeps track of where previously seen obstacles and Legos are and updates them if they move. 10 points

## Submission Guidelines:

Please submit a video and PDF report. The video should show your team's demonstration and any relevant animated visualizations. The report should have the following sections:

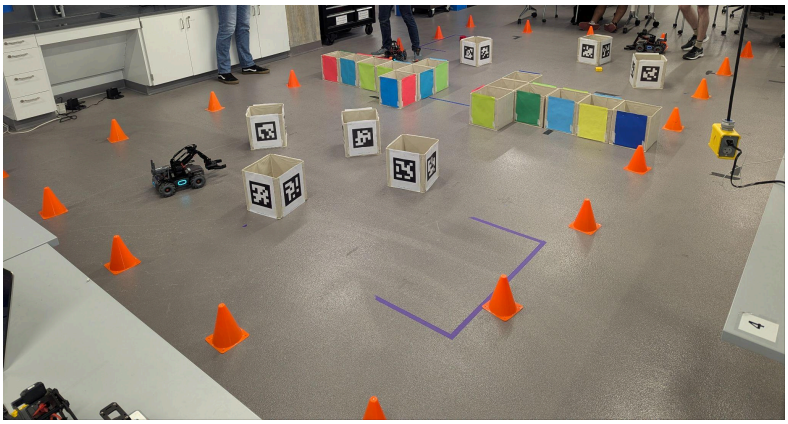
- Introduction
- Block Diagram
- Link to and description of demonstration video (Google Drive or YouTube)
- Methodology
- Results
    - At a minimum, the results section should contain
        - Measurements from vision (time series and/or annotated images),
        - Measured and target variables used by a controller as a time series or phase plot
        - Accuracy scores for Yolo on the validation set (if Yolo was used)
        - Success rate if you ran the experiment multiple times
        - Any additional videos with comments that may be relevant
    - Generally speaking, the results section should allow the reader to understand "how well" the method works through either quantitative measurements or qualitative results presented in figures.
- Conclusion
- Appendix A: Code Listing

## Collaboration Policy:

You can discuss the assignment with any number of people. But the report and code you turn in MUST be original to your team. Plagiarism is strictly prohibited. A plagiarism checker will be used to check your submission. Please make sure to cite any references from papers, websites, or any other student's work you might have referred to.

## FAQ:

- Can we take LEGO's from another teams room, hallway, etc?
    - Yes
- Can we run into the other team's robots?
    - There should be no collisions when you can see the other team's robot.
    - If the crash occurs, the team responsible for the crash will lose 4 points.
- What does the built arena look like?



- What are the arena dimensions?
    - 21 feet long, 12 feet wide
    - Cones are spaced 3 feet apart
    - The fabric cubes are approximately 10.5 inches on each side
    - The closets are placed 2 feet away from the arena boundary
    - The closets are 3 feet wide, 18 inches deep
    - The hallways are approximately 2 feet wide
    - AprilTags are 15.5 cm wide
    - Here is a diagram (will be updated with a nice drawing soon)