Pokemon Robotics Challenge: Gotta Catch'em All
2.12: Introduction to Robotics Project Rules
Fall 2016

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Note

1. **Website is on http://robot2016.mit.edu.**
2. **Staff denotes instructors and TAs.**
3. **Staff may refine the rules in the future and will release new versions every Wednesday on Website.**
4. **If you are not sure whether certain approach is permitted, ask it on Piazza before proceeding. Staff may not respond immediately but should clarify it in a new release of the rules.**

1 Story

In the beginning there were Pokemon. They lived in other dimensions and concealed themselves from human beings. With the invention of "Pokemon Go", the portal to the human world is opened. To gain the trust and make friends with Pokemon, we have to work hard and catch them first. As brilliant engineers at MIT, we want to do this more efficiently with an army of robots! Your mission is to build a robot using the lab robot platform to participate in the Pokemon Robotics Challenge (PRC).

2 Calendar

Sept 26, midnight	Submit initial concept report.
Oct 12, midnight	Submit report for design review.
Oct 13/14, in lab	Design review.
~~Oct 31, midnight~~	~~Submit report and demo video for technical review.~~
Nov 3/4, in lab	Technical review.
Dec 1, 7-9pm	Competition; submit video, summary slides.
Dec 9, 23:59pm	2-page individual report.

Note that reports and videos are summary of your current progress. They will help staff understand your situation and provide proper guidance.

3 Equipment

3.1 Robot Equipment

Staff will provide a mobile robot platform, a Kinect v1, and 2 Dynamixel motors for each team in Lab 6. The robot platform should stay in the lab space during preparation. You are allowed to program the robot remotely through SSH. To do so, you will need to use a power adapter and make sure all the actuators are not connected.

Lab 1 to 5 are designed to familiarize yourself with the equipment and build the system.

1. In Lab 1 and 2, we introduce the mobile platform.
2. In Lab 3, we introduce ROS (Robot Operating System) to help organize your software, and give an example of using AprilTag for visual navigation.
3. In Lab 4, we introduce camera calibration, HSV color space, and Kinect depth sensing.
4. In Lab 5, we will introduce the Dynamixel motors and arms. You will need to design and fabricate a robot arm and end effector for this project.

3.2 Financial support

Each team will have $300 budget this semester. There are two ways to use this budget.

Through staff (preferred): list all the items that you want to buy with URL links. During lab sections, staff will help you order them online. We will limit to Amazon, McMaster, ServoCity and DigiKey to simplify reimbursement.

Purchase by yourself: purchase items with the MIT Tax exempt ID. Then put the receipts in an envelop, label clearly of the person who paid and the amount. Give it to staff during lab sections. You will be responsible for the tax if you fail to tell the vendor about tax exemption.

3.3 Practice Equipment

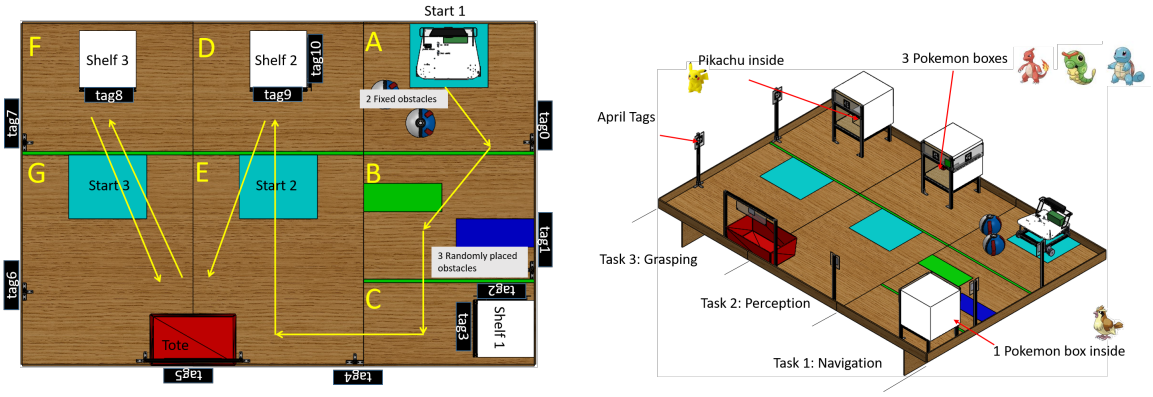
In room 5-007, staff will provide 1 complete arena that includes the 3 tasks, and 3 individual shelves. They are expected to finish before October 6.

4 Arena Overview

The arena is 12 ft (3.66m) by 8 ft (2.44m), which will be lifted off the ground by 1 ft (0.3m) with support structure. A 3D CAD of the arena will be posted on Website. A top view of the arena is shown in Figure 1. **For safety concern, only 1 person can be on the arena at the same time**. Detailed dimensions of the arena and objects are shown in Figure 2.

5 Task Description and Scoring

The goal of the PRC is to build and program your robot to autonomously pick 3 Pokemon and put them in the red tote. The PRC can be divided into 3 separate tasks for testing but you should attempt all 3 in a single run for the final competition. The time limit for this run is 6 minutes. Teams will be ranked first by score. If there is a tie in score, then teams will be further ranked by the time they score their final points. Here is a list of the three tasks.



(a) Top view. Yellow arrows show an example trajectory of the robot completing all 3 tasks.

(b) Isometric view

Figure 1: Overview of the PRC arena.

1. Navigation: robot needs to navigate through obstacles to pick up Pokemon box pasted with Pidgey's picture.

2. Perception: robot needs to detect and pick the desired Pokemon box out of three based on vision. All the Pokemon will be located a set distance into the shelf, and 3 cm away from the side, evenly spaced, but randomly ordered.

3. Grasping: robot needs to grasp an irregularly-shaped Pokemon Pikachu.

5.1 Task 1: Navigation

This task is on the right side of the arena shown in Figure 1. The robot should navigate from Start 1 position to in front of Shelf 1 and pick up a metallic box in which Pidgey lives. The metallic box will be pasted with Pidgey's picture.

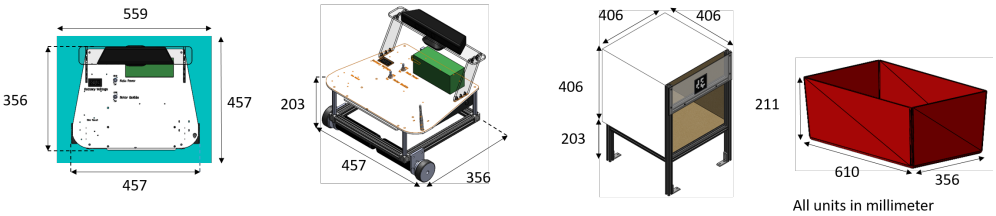
There are 5 obstacles in total on the path that are shown as Pokeballs in Figure 1. In actual PRC, they will be 5 Pokemon characters of no larger than a 20-cm cube as shown in Figure 3. Note that the arena is separated by green lines with labeled sections. The obstacles in section A are fixed, and the ones in section B will be in a random configuration that allow the robot to go through.

Scoring

Here is a table of rewards and penalties. Each item can only be scored once. Maximum score in Task 1 is 5. In this document "in the air" means the object is in robot's possession without touching the arena or shelf. Navigating to a new section (i.e. Section B to Section C) is defined as having one wheel cross the plane defined by the section line. Moving an obxtacle is defined as having any one of the obstacles in that section touch the plywood surface outside their placement zone. Pidgey being on the ground is defined as the object touching the plywood playing surface in any manner (this goes for all objective objects). Putting Pidgey into the tote is defined as having the box touching only the tote (this goes for all objective objects).

(a) Vertical dimensions

(b) Horizontal dimensions.



(c) Dimensions of objects on the arena.

Figure 2: Arena dimensions

Navigate from Start 1 to Section B	+1
Navigate from Section B to Section C	+1
Pick up and hold the Pidgey box in the air for > 5 sec	+1
Put the Pidgey box into the tote	+1
Finish this task in 2 mins from the start of the challenge	+1
Move obstacle in section A	−2
Move obstacle in section B	−2
Leave the Pidgey box on the ground	−1

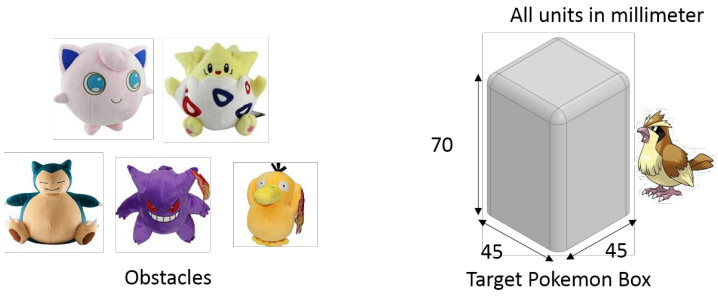


Figure 3: Task 1 objects

5.2 Task 2: Perception

This task is in the middle of the PRC board as shown in Figure 1. Before the run starts, the team leader will draw lots to decide which Pokemon box is the desired one for Task 2. Staff will Velcro a picture of the Pokemon to the shelf accordingly. The task is to pick the Pokemon box that matches this picture.

The robot should identify the picture on the corner as shown in Figure 4. The Pokemon box will be covered with Pokemon stickers that have distinctive colors.

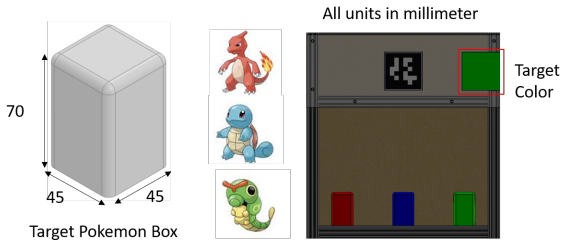


Figure 4: Task 2 objects. Left: the metal Pokemon box. Middle: the 3 Pokemon whose picture will be pasted on the 3 Pokemon boxes. Right: location of the desired Pokemon picture on the shelf.

Scoring

Here is a table of rewards and penalties. Each item can only be scored once. Maximum score in Task 2 is 5. Note that picking up and placing the desired Pokemon in the tote effectively doubles the points gained; it is not required to pick up and place two Pokemon to earn all points. You will only receive one deduction for a Pokemon box on the ground (you can only have a maximum of -1 in this category). Putting a Pokemon box into the tote is defined as having the box touching only the tote.

Navigate from outside into Section D	+1
Pick up and hold one and only one of the Pokemon box in the air > 5 sec	+1
The Pokemon box picked up is the desired one	+1 (additional to the above)
Put any Pokemon box into the tote	+1
The Pokemon box dropped into the tote is the desired Pokemon	+1 (additional to the above)
Leave a Pokemon box on the ground	−1

Note that holding two or more boxes in this task at the same time does not count to the 5 sec.

5.3 Task 3: Grasping

This task is about grasping and is on the left side of the arena. The robot needs to use its arm and end-effector to pick up a plastic Pikachu placed at the center of a 6-inch (15.2-cm) cube box as shown in Figure 5. The box will not be fixed to the shelf.

Scoring

Here is a table of rewards and penalties. Each item can only be scored once. Maximum score in Task 3 is 5.

Navigate from outside into Section F	+1
Pick up and hold Pokemon Pikachu in the air for > 5 sec	+2
Put the Pokemon Pikachu into the tote	+2
Leave Pokemon Pikachu on the ground	−1

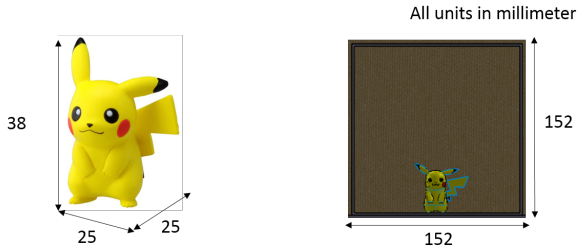


Figure 5: Task 3 objects. Left: the dimension of the Pikachu. Right: Pikachu inside its shelf.

5.4 Starting

Before timer starts, the team will setup their robot at Start 1, and there will be a large cardboard blocking the front view of the robot. After the team is done with the setup, staff will count down from 3 to remove the cardboard. On the removal, the timer will start and the robot needs to start autonomously to do the tasks. A false start will result in the reset of your robot to the starting box, upon which the code can be reset/restarted and the cardboard will be placed in front of the robot again. The exact placement of the cardboard can vary based upon the robots size, as it will need to sit in front of any grasper mechanisms. Do remember that there is an obstacle directly in front of the starting region, so the cardboard start can occupy the region in front of that or behind it, but not inside it.

5.5 Human intervention

Team leaders can call for human intervention to have one team member put the robot to one of the starting point in any pose. The 3 starting points are labeled in blue in Figure 1. Every human intervention will cause a penalty of −1. The timer for the run will continue during intervention. That is, the intervention time will be counted into the time limit of 6 minutes. You are allowed as many human interventions during the round as you desire. For each human intervention, you will have the option of resetting the board (placing obstacles back into their starting locations if they have been moved) and/or resetting any Pokemon boxes/objectives to their starting locations. The other option is to leave the obstacles as they are, and to leave any Pokemon objectives as they are, be it on the playing field or on the robot. You cannot touch the objectives if they are to remain on the robot, nor release them from any grasper during this intervention. To restart the robot, you will be able to use a keyboard and a mouse to reset or restart code as needed. The white cardboard will not be used. The definition of being in a starting point is that all three wheels are contained in the region.

6 Hand in

Before the PRC on Dec 1. Please submit

1. a 2-page individual report. There should be at least one page describing your individual contribution;
2. a 3-min video describing your robot;
3. a powerpoint (∼4 page) that you want to show during your session of competition.

6.1 Team organization

Each team will elect a team leader through whom staff will contact the teams. For work distribution, we suggest you have clear roles assigned to each team members, such as manager, software integrator, computer vision specialist, navigation specialist, gripper designer, and arm designer.

7 Fabrication

Due to the natural of the course, certain degrees of fabrication will be necessary to complete the final project. For machine shop access, a number of on-campus resources can be utilized. For example, course 2 students can go to MakerWorks and course 6 students can go to the CSAIL machine shop. Please download and install the "MIT Mobius" application on your smart phone to look for available resources and shop time. You may also visit the following website: `https://project-manus.mit.edu/mobius`.

Most shops require that the users complete training to gain access to the shop. We highly recommend that you start early with those trainings within the teams by assigning different tasks to different people, e.g. A in charge of milling, B in charge of 3D printing, and C in charge of laser cutting.

8 FAQ

Q Do we have to return the pokemon to the Tote Box after every task, or can we keep them in a basket on our robot?

A No, robot does not need to put them in the Tote after each task. The robot can hold them until it wants to drop them.

9 Change Log

09/28 Clarified the scoring of Task 2. Clarified the term "in the air" in Task 1. Converted all units to metric. Confirmed financial support and purchasing protocol. Added Fabrication section. Added AprilTag location in Figure 1.

10/5 Removed the requirement of video for design review. In Section 3.1, changed 4 Dynamixels to 2 Dynamixels per team but increase budget to $300 to give teams freedom to buy your own motors. Raised the vertical position of AprilTags as shown in Figure 2.

10/12 Clarified Task 2 that you can only pick up and hold one and only one to score the point of "in the air." Added an FAQ section. Added allowing to program the robot remotely in Section 3.1. Added the smaller box in Task 3 is not fixed to the shelf Section 5.3.

10/27 Removed the need for technical review report submission. You'll present it during the lab sections.

11/29 Changed section 5, item 2: Perception: robot needs to detect and pick the desired Pokemon box out of three based on vision. All the Pokemon will be **located a set distance into** the shelf, and 3 cm away from the side, **evenly spaced, but randomly ordered.**

Added the definitions for scoring of Task one. Added: Navigating to a new section (i.e. Section B to Section C) is defined as having one wheel cross the plane defined by the section line. Moving an obstacle is defined as having any one of the obstacles in that section touch the plywood surface outside their placement zone. Pidgey being on the ground is defined as the object touching the plywood playing surface in any manner (this goes for all objective objects). Putting Pidgey into the tote is defined as having the box touching only the tote (this goes for all objective objects).

Added to the definitions for scoring of Task two. Added: You will only receive one deduction for a Pokemon box on the ground (you can only have a maximum of -1 in this category).

Added to the starting section: A false start will result in the reset of your robot to the starting box, upon which the code can be reset/restarted and the cardboard will be placed in front of the robot again. The exact placement of the cardboard can vary based upon the robots size, as it will need to sit in front of any grasper mechanisms. Do remember that there is an obstacle directly in front of the starting region, so the cardboard start can occupy the region in front of that or behind it, but not inside it.

Added to human intervention section: You are allowed as many human interventions during the round as you desire. For each human intervention, you will have the option of resetting the board (placing obstacles back into their starting locations if they have been moved) and/or resetting any Pokemon boxes/objectives to their starting locations. The other option is to leave the obstacles as they are, and to leave any Pokemon objectives as they are, be it on the playing field or on the robot. You cannot touch the objectives if they are to remain on the robot, nor release them from any grasper during this intervention. To restart the robot, you will be able to use a keyboard and a mouse to reset or restart code as needed. The white cardboard will not be used. The definition of being in a starting point is that all three wheels are contained in the region.

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