ME 5493 Robotics @ UTSA

Mini-project #2
LARPA Robotics Challenge
(LARPA = LEGO, Automated, Reliable, Powered, Agents)
Due on May 2, 2019 at 10 AM in BSE atrium

1 Motivation

On March 11, 2011 a powerful earthquake and tsunami hit Japan due to which the Fukushima Daiichi nuclear reactor suffered damage. The reactor had to be shutdown but it was clearly not possible to send humans inside the reactor site (to shut it down and for damage assessement) due to safety concerns. Although robots would have been the ideal choice, there were no robots that were mission-ready for such a task.

This incident prompted the United States Defense Advanced Research Projects Agency (DARPA) to initiate the DARPA robotics challenge. The challenge consists of the robot executing a series of challenges that a nuclear disaster response-ready robot would have to face. Here is a sped-up video of one of the robots executing all the 8 tasks: https://youtu.be/7urLgdzHS2U.

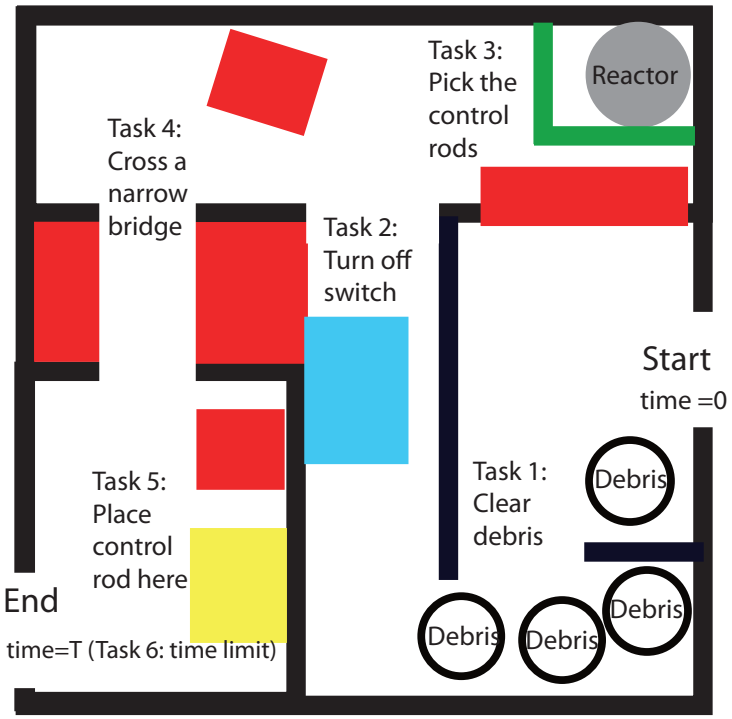

Figure 1: An overview of the map and a list of tasks (1 through 6) in the LARPA robotics challenge.

2 Goal

The overall goal is to create an autonomous (not tele-operated) robotic system using LEGO Mindstorms EV3 that is mission-ready for nuclear disaster response events; the LEGO, Automated, Reliable, Powered, Agents robotics challenge (LARPA robotics challenge). Figure 1 shows an overview of the map of a prototype nuclear reactor and list of tasks. The robot will start from the right side at time, t=0. It will then move to clear debris (Task 1). Then the robot will park itself for a prescribed time on the blue patch to shutdown the operation of the nuclear plant (Task 2). Then the robot will go on to pick up control rods to shutdown ongoing nuclear fission processes (Task 3). Then the robot will navigate through a narrow bridge (Task 4). Then the robot will place the control rod on the yellow patch (Task 5). Finally, the robot will exit the disaster site within a specified time limit (Task 6). During the course of the mission, there are series of hazards and/or places that the robot should not cross in order to remain safe.

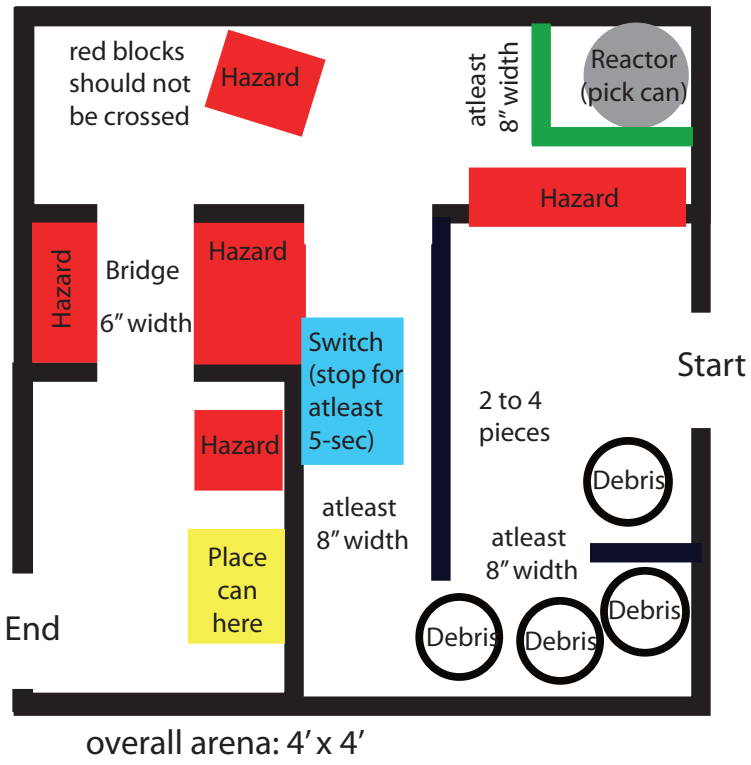

Figure 2: Specifics on the map and tasks are detailed in the write up with reference to this figure.

3 Setting up the disaster site

Figure 2 lays down the specifics of the nuclear disaster site. With the instructions given below you should be able to construct the prototype nuclear disaster site by yourself for practice.

1. You will need a tiled white or off-white floor (similar to the one in the BSE atrium), which is at least 48" x 48" or 4'x4'.
2. The black lines are most easily created using either black electrical or duct tape (e.g., Dollar store sell inexpensive tape).
3. A series of colors (red, yellow, green, blue) that can be downloaded as a zip file from here: http://aux.coe.utsa.edu/ pab/info/lego/LARPA_colors.zip. Please download these cut-outs and print them on colored paper, 3 of red and 1 each for others.
4. The debris (white circles with black outline) are created by rolling letter size paper into balls, one paper per ball. Note that the circles will not be shown on the ground as shown in the map for the actual project demonstration but you can use the ultrasonic sensor to localize the debris.
5. The control rod to be placed on the reactor (gray circle on the top right corner) is an empty soda can (approximately 3.5" x 2") such as those sold in vending machines. The soda can will be placed on pedestal of height between 0.5" and 1" so that after your robot grips it, the can will not be grazing the ground. Note that the grey circle on the ground will not be shown during actual project demonstration but you can use the green line to localize the robot.

4 Details about the tasks

1. **Task1 - Clear debris (20 points):** The robot needs to localize to the debris and push them outside the outermost black lines to consider that the task is achieved successfully. There will be between 2 to 4 pieces of debris approximately in the area shown. No partial points are given for pushing some of the debris, all debris needs to be pushed out to get full points for this task. The number and location of debris will change across trials.
2. **Task2 - Turn Switch OFF (10 points):** The robot will have to find the blue patch and come to complete stop on the patch for at least 5 seconds. The robot will have to have atleast 50% of its body (measured by the body projection) on the blue patch to consider it be on the patch successfully. The blue patch maybe anywhere on the passage way where the patch is currently shown. The blue patch will be at least 8" x 8".
3. **Task3 - Pick control rod (20 points):** The robot will have to use the green lines to locate the empty soda can that serves as the control rod. Then a gripper will have to be used to grip the can (see instructions below on creating a gripper robot) and then transport the can. The can should be gripped and moved out of the area marked by the green lines to be considered successful. The green lines and the can may be placed in any area between the switch and the bridge, so please prepare accordingly. The width of the green lines will be 2". Your robot should not crush the can. The can is considered crushed if it losses it shape and cannot be used for future trials. If the can is crushed your attempt will end the moment the can is crushed.

4. **Task4 - Navigate the bridge (10 points):** The robot has to move along the narrow bridge (marked by white patch with red hazard blocks) successfully. Note that the white patch will not be explicitly placed as shown in the disaster site map, only the red patches. The robot has to cross the entire bridge (enclosed between the red patches) to be counted successful.

5. **Task 5 - Place the control rod (20 points):** The robot will have to place the control rod (the can) held by the gripper on the yellow patch. The entire base of the can should be on the yellow patch for the task to be counted successful. The can has to stand on its circular base, it should not fall down on its side. The blue patch will be at least 8" x 8".

6. **Task 6 - Exit (20 points):** The robot should exit from the white patch on the left as shown. The time will be stopped the moment the robots exits the white line at the end, i.e., the robot should continue moving such that its entire body is outside the arena. If the total time from start to end is T, then T should be less than 120 secs or 2 min for success on Task 6.

7. **Red and black lines:** The red and black lines should never be crossed. After encountering the red or black lines if the robot keeps moving, then the mission is terminated at the very instance. That is, the team cannot earn any more points after that point. The black lines will not change from the above course. However, the red patch size and locations might change. This excludes the 2 red patches used to create the bridge.

8. **Green, blue, yellow patches:** The green, blue, and yellow lines/patches are helpful markings to help the robot to localize. These can be touched/crossed as needed.

9. **Creating a gripper robot:** Feel free to use your imagination or designs from the internet. You could also add a gripper to the line following robot your built in Lab 1, 2, and 3. Here are instructions to create a gripper. http://www.instructables.com/id/Simplest-EV3-Robot-ClawGripper/ OR watch this YouTube video https://youtu.be/VEsLKZAAoSc. You will also need to use the ultrasonic sensor to detect the soda can. LEGO Mindstorms has instruction on making a gripper robot. Here is a video of the robot: https://youtu.be/I4i5VNcibJg. The instruction to build the robot are here:
http://aux.coe.utsa.edu/ pab/info/lego/lego_gripper.pdf (57 MB). You can build this robot. But I am not sure if your kit has all parts necessary to make it. For example, I suspect it needs four motors but your kits has only three motors. But you might be able to modify the design a bit. Another idea is to build the gripper using the instructions on the above pdf (see page 4 to 23). Next, you can attach the gripper to the mobile robot you built in the earlier lab. However, you will have extend the size of the gripper by adding a few LEGO technic elements because the gripper size is not big enough to grasp a soda can.

5 Grading specifics

NOTE: The project is a team effort, all team members have to contribute to the project (brainstorm, build, program, and test the robot). If a project member has not contributed to the project, then he/she may see a grade penalization.

1. Each team gets 3 trials to improve their score. The maximum score is 100 points as noted in the section above.

2. Although 2 minutes is the cut-off for exiting the arena to win points for Task 6, a maximum of 2 min 30 second is allowed (e.g., for a robot that is going slow). After 2 min 30 seconds, we will count your score irrespective of anything and you will be told to stop the robot thus ending the particular trial.

3. After 3 trials, if your score is less than 50 points, then you can avail the time trial to score 50 points. In the time trial, you have to go from start to end in 45 seconds or less, still avoiding crossing the red and black lines. You do not need to do any tasks (debris, grip etc).

4. The instructor/TA have the right to reduce the difficulty of the tasks as needed (e.g., increase time limit, reduce debris). However, we will try our best to ensure that the change is fair to all (i.e., everybody gets the same choice). Thus, we require that all teams complete trial 1 in sequence so that we get a chance to reduce the difficulty (if needed) for trial 2, and so on.