Robot Olympics
Project

Just like humans, robots have their version of the Olympics, known as the "Robot Olympics". Our Robot Olympics will take place in the final meeting of this course and will consist of two events:

1. Curling
2. Search and Rescue

Your goal is to implement three programs, one for each of the two events. Once the competition begins, you will not be able to modify your programs.

Your robot will participate in each of the events in the competition and your grade will depend in part on the robot's performance in the competition. Your robot will earn points based on its performance in the competition. The winner of the competition will be the robot with the greatest number of points summed over all three events.

The project description is divided into five parts. The first section describes the general rules of the competition and provides some general hints. The second section describes the two events, their rules, and hints for building the programs. The next section provides lab report questions. The last section describes the project report requirements and the deliverables.

1 General Rules

1.1 Programming

Before an event, a robot must contain the program for the event. Once an event begins, no reprogramming of robots is allowed. Rule violation will result in disqualification from the event.

1.2 Starting

Robots will be started in an event by pressing their **Forward Button**. The starter will say "Ready!", "Set!", "Go!", and will start the clock while one of your team members pressed the **Forward Button**. If is recommended that the **Backward Button** be used to stop the robot, in the event of a false start or some other irregularity.

1.3 Scoring

For each event in the competition the top three robots will be awarded gold, silver, and bronze medals. A gold is worth three points, a silver is worth two points, and a bronze is worth 1 point. The robot with the largest point value over all three events will win of the Olympic games.

1.4 Interference

Once a robot begins an event it cannot be touched or interfered with in any way. If the robot is touched or interfered with in any way then the robot's attempt is disqualified.

1.5 Battery Charging

Robot batteries should be fully charged prior to the start of the competition.

2 Grading

Your robot will be graded using the following general grading scheme:

F	No show or robot does absolutely nothing.
D	robot attempts the event but does not complete any of the expected requirements.
C	robot completes some of the expected requirements.
B	robot completes the expected requirements.
A-	robot completes the expected requirements and comes in 3rd in the event.
A	robot completes the expected requirements and comes in 2nd in the event.
A+	robot completes the expected requirements and comes in 1st in the event.

Refer to each event section for specific grading. Fifty percent of your project mark will be the **sum** of the two grades received for the events. **The Curling event has 40% of the mark and the Search and Rescue event has 60% of the mark.**

2.1 Hints and Suggestions

Remember that you have a limited amount of time to implement your programs. Start with the easier events and work your way up to the harder ones. You will have many opportunities to test and fine-tune your programs prior to the competitions. Be sure to take advantage of it!

In general, you will know that your Olympics programs are effective if they not only run correctly on your robot but on one of the spare robots as well. In the past, some students found that on the day of the Robot Olympics their solutions did not work as they expected. Testing on other robots is a way to guard against this. Another general recommendation is to ask a Teaching Assistant to watch the operation of your programs *before the day of the Olympics* to confirm that they correctly complete the events.

3 The Events

3.1 Curling

This is an event of medium difficulty. Traditional curling takes place on a sheet of ice, like hockey, and involves, players taking turns "throwing" rocks (blocks of granite) down the ice by giving a rock a push at one end of the sheet and letting it slide down the ice to the other end. The goal is to get the rocks as close as possible to the center of the rings at the other end of the sheet. As the rocks slide, they may bump into other rocks, changing their position and altering its own course.

In robotic curling, two robots compete to get to the center of the rings in a limited time frame, called an "end". The robots start at one end of the sheet (see Figure 1) and attempt to get to the center of the rings. The robots may bump into each other, get into each other's way, and try to dislodge each other. After a fixed amount of time, both robots must stop and the robot that is closer to the center of the rings is deemed the winner of this end.
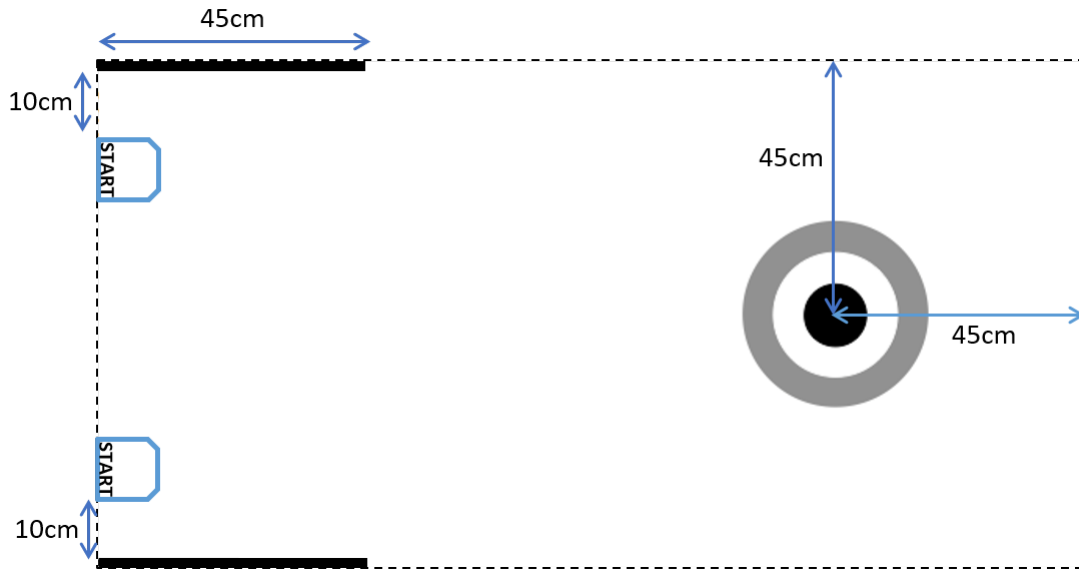

Figure 1: The robot curling sheet.

3.1.1 Rules

1. This event will take place in a $1.8m \times 0.9m$ arena (one of the large tables in the lab).
2. There is no boundary for the curling sheet. There are two 45cm black electrical tapes on the edges of the table located on the **START** side of the sheet.
3. The rings will be placed inside the sheet (table), at one of the ends, centered, 45cm from each of the three table edges.
4. The robots start (after pressing the **Forward Button**) at one end of the sheet (10cm from black electrical tapes), in opposite corners, with their wheels on the line (edge of the table). The starting positions are determined by a coin toss.
5. The robots **must stop** 60 seconds after they start. If they do not, they automatically lose the match. Thus, each end takes 60 seconds.
6. If the robot moves outside of the sheet (falls off the table), it is deemed to have lost this end.
7. After the robots stop, the robot that is closest to the center is deemed the winner of the end.
8. **Each match will comprise three (3) ends of 60 seconds each. The winner of two of three ends is deemed the winner of the match**.
9. A robot **must** first qualify to compete in the curling tournament.

   Qualifier #1 :
      (a) The robot is placed on the sheet on its own.
      (b) The robot is started, the robot should start moving and **turn off** the circle LEDs.

(c) The robot **must** stop after 60 seconds and **light up** its circle LEDs.

Qualifier #2 :

    (a) The robot is placed on the sheet on its own.

    (b) The robot is started.

    (c) The robot **must** stop within the outer ring once the 60 seconds.

    (d) The robot passes the qualifier with honors if it ends up on the inner-most ring.

10. The robot will have two attempts at each qualifier.
11. **The qualifying robots shall participate in a double elimination tournament.**
12. The robots will be graded on how well they perform in the qualifiers and how well they compete in the tournament.

3.1.2 Grading Scheme

F	No show or robot does absolutely nothing.
D	robot passes Qualifier #1.
C	robot passes Qualifier #2.
B	robot passes Qualifier #2 with honours.
B+	robot passes Qualifier #2 with honours and wins at least one match in the tournament.
A-	robot comes in 3rd in the tournament.
A	robot comes in 2nd in the tournament.
A+	robot comes in 1st in the tournament.

3.1.3 Hints and Suggestions

The robot needs to work in two (or three) phases. In the first phase, the robot needs to find the rings because they are not guaranteed to be in the same place each time and because the robot is not starting from exactly the same position (it has to be able to start on both sides of the sheet). Once the robot locates the rings, it will need to orient itself towards the center and move forward. It can use the different shades of gray of the rings to determine its position and identify when it reaches the center (see Figure 2). Once it is in the center, it may decide to enter the third phase. In the third phase, the robot stops and waits. If it is tapped (check out the **tap** sensor) it determines whether it has been pushed off center, and attempts to correct its position. Hence, you can implement your program in these corresponding phases. You should also think about your strategy: do you let the other robot find the center first and then push it off? Or, do try to find the center first and remain on it? In real curling, having last rock (going last) is a significant advantage. **Warning:** Be careful to thoroughly test your solution and ensure that it can routinely accomplish the qualifiers. You only get one attempt at each qualifier, so you will not want to rely on chance as a strategy.

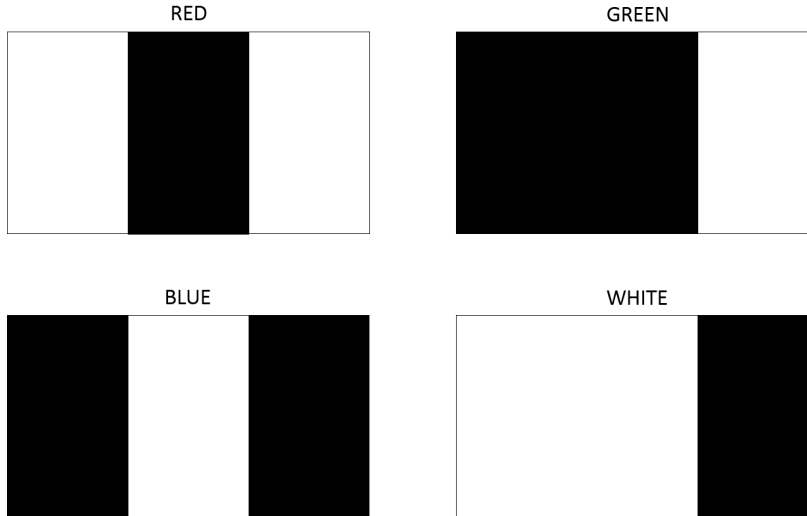Figure 2: The approximate gray-settings for the rings.

Figure 3: Patterns for the search and rescue mission.

3.2 Search and Rescue

This is probably the hardest event. In this event, robots compete to find specific patterns in a known environment and inform the position of them in the fastest time possible. Your robot first captures one of the patterns shown in Figure 3 when you place the robot in front of the pattern and press the **Right Button**. Then your robot is placed by the TA at a random position and started by pressing the **Forward Button**, moves around the environment (see Figure 4), locates the position of the specific pattern on the wall on a random location, returns to the **FINISH** area, and informs the location of the pattern using circle LEDs and top RGB LED.

3.2.1 Rules

1. This event will take place in a $1.8m \times 0.9m$ table (one of the large tables in the lab).
2. The search and rescue arena with size $77cm \times 77cm$ is printed on a poster size paper. The boundary of the arena will be demarcated by green Duplo blocks that will be at least 6cm high. There are three dark gray and five light gray areas with size $23.5cm \times 23.5cm$ in the arena. There are $2cm$ white areas between gray areas as well as $1cm$ white areas between gray areas and walls.
3. There are four different patterns with size $13cm \times 6cm$ shown in Figure 3. We named these pattern based on different color codes (RED, GREEN, BLUE, and WHITE). For each pattern, your robot **must** show the color code on top RGB LED. There are also four dummy patterns (all black and all white).
4. We randomly place the patterns (color coded and dummies) on the walls (see Figure 4). There are $2cm \times 9cm$ black strips on the gray areas to guide your robot to the center of the patterns.
5. At the start the competition, your TA will ask you to put your robot in $1cm$ distance from the middle of a random pattern on the wall to capture it by pressing the **Right Button**.
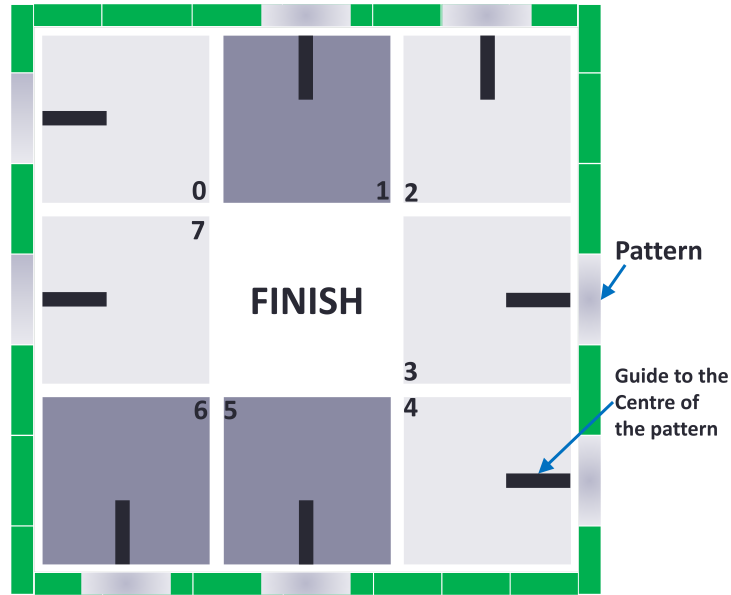
Figure 4: The search and rescue arena.

Your robot **must** show the color of the pattern on the top RGB LED.

6. Your TA will place your robot at the center of a random gray area such that it can move clockwise.
7. To complete the event the robot must move around the arena without touching any blocks (walls) and **must** stop on the finish area (center of the arena). Your robot **must** turn off all LEDs when it starts moving. When it finds the pattern, it **must** show its color on the top RGB LED and it **must** also show the location on the circle LEDs.
8. The robot will be allowed two 4-minute attempts (two different patterns).
9. A 10-second penalty will be added if your robot touches the wall.
10. The best attempt will be graded.

3.2.2 Grading Scheme

F	No show or robot does absolutely nothing.
D	Robot can not complete the mission, but shows the color code on top RGB LED at the start.
C	Robot can not complete the mission, but shows its current location.
C+	Robot can not complete the mission, but detects some patterns.
B-	Robot completes the mission, finds the pattern but report the wrong position, Or Robot completes the mission, detects wrong pattern but report the position.
B	Robot finds the location of the pattern but does not stop on the FINISH area.
B+	Robot completes the mission and finds the location of the pattern.
A-	Robot completes the mission, finds the location of the pattern and has the 3rd fastest time.
A	Robot completes the mission, finds the location of the pattern and has the 2nd fastest time.
A+	Robot completes the mission, finds the location of the pattern and has the fastest time.

3.2.3 Hints and Suggestions

If you want the robot travels straight, you need to calibrate the speed of the motors. You can calibrate the motor speed using this link: `https://www.thymio.org/en:thymiomotorcalibration`. You will have many opportunities to test and fine-tune your program prior to the competition and to have it evaluated by the TA (The B grade would be guaranteed if robot completes the mission and finds the location of the pattern). Moreover, if your robot completes the Search and Rescue mission on the simulator environment, the B+ grade would be guaranteed. **Be sure to take advantage of them!**

4 Lab Period Questions

For the eight lab reports that you will need to fill out while working on your large project please answer the corresponding questions.

Period 1 :

1. Describe briefly your strategy and tactics for each of the two events—you can reuse this in the final report.
2. Include a preliminary state-transition diagram of your program design for each of the two events.
3. Provide a timeline with deliverables. It should include all your group members as resources. Note, some work may need to be done outside of lab time.

Periods 2 to 7 :

1. Describe in detail your strategy and tactics for the event(s) that you are working on—you can reuse this in the final report.
2. What changes did you have to make to your strategies and tactics as you built and tested your program(s)?
3. Include a revised state-transition diagram of your program design for the event(s).
4. Did you manage to complete most of your program(s)? Why or why not?
5. Describe what has been accomplished so far and what remains to be done.
6. Is your progress in-line with your project plan? If not, provide a plan update.
7. Did you test your program on the event(s)? If so, what was the score and why?

5 Report Guidelines

You must submit a technical report as one of the deliverables. The purpose of this report is to describe the three programs that your group implemented for the robotics competition. For each of the two events the report should describe the program's design, the reasons for the design, and the strengths and weaknesses of the design.

The audience for your report are your class peers, the teaching assistants for the course, and the course instructor. Consequently, your report must contain a sufficiently detailed description of your project, but must not be overly long because we will need to read many of them in order to perform the evaluations. Put another way, another student in the course should be able to reproduce your project from the description you provide. Your report should comprise the following sections:

Title and Author Information is the first part of the report containing:

- the report title,
- the authors' (your) names, and
- the authors' affiliation (Faculty of Computer Science, Dalhousie University, Canada).

The title itself should be a meaningful phrase giving the reader a succinct description of what the report is about. "Our Project" is *not* a good title.

Abstract is a brief summary of the entire report, briefly stating the purpose of the project, what was done during the project and what the results were. The abstract is limited to 100 words.

Introduction sets the stage for the report. It should introduce the topic(s) and problem(s) at hand, state the purpose of the project (what is being solved), outline what was done in greater detail than the abstract, and possibly discuss the results of the project. A student, having read the introduction, should have a clear picture of the problem(s) and what was done.

For example, your introduction should briefly describe the area of robotics, then give an overview of your project, including: the robot system that was used, the events in the robotics competition, the major problems encountered during the project and the resulting solutions.

Background sets the context for the report. It describes previous work and concepts that were used in the project and discusses common assumptions made in the course of the project. This section will typically have quite a few citations because it discusses work, ideas, and concepts that preceded your project report.

For example, your background section should thoroughly describe the robot platform that was used, including its basic structures, the sensor capabilities, its mobility, and also the platform's limitations. This section should also describe features that are common to the three events. Lastly, you should discuss (and cite) any related work that you encountered while working on the project.

The content in this section typically comprises material compiled from other sources. Be sure to properly cite all material that you reference in your report.

The Curling Program explains how the problem was solved and why was this solution chosen. Thus, the report must describe the event and the particular challenges that it entails.

The report must then describe your solution to the problem including **state transition diagram**. It should describe the basic strategy of your solution and the tactics used to achieve it.

Lastly, and **most important**, your solution must be justified. **You need to justify both your strategy and your tactics.** I.e., Why did you decide on a particular strategy to solve the problem and why did you use the tactics your report describes. Your justification should also describe the strengths and weaknesses of your solution.

The Search and Rescue Program section describes your program for the Search and Rescue event and, has the same format and addresses the same issues as the previous section.

Results describes and analyzes the quality of your solutions. This section will be based on the competition that will take place at the end of the module and should describe how well your programs performed, why the programs performed as well or as poorly as they did, and how well your programs performed relative to other programs.

Conclusion and Future Work After a final synopsis, you should describe what else you would have liked to do with your project, how the project could be improved or extended, etc. Important ideas that were part of the solutions should be recapped here. Lastly, this section describes what should be done if more time to improve the programs was available.

References contains a complete citation listing of any other works that you referred to or used for preparing this includes Wikipedia. Citations in computer science are typically done using end-notes[4]. However, using other styles such as the APA [1], Chicago Manual of Style [3], ACM [2], etc, are all acceptable as long as they are used consistently.

The project report should use 11-point font and be no more than eight (8) pages in length, except for the program code. This means that the title, all figures, and references must all fit within the eight page limit.

Standard conventions for grammar, word use, spelling, citations, headings, paragraphs, figures, and tables are expected. A template is provided on the course website so you know how they should be formatted. The report will be marked using the following rubric[1].

	Exceptional: A	Acceptable: B	Substandard: C-D	Unacceptable: F
Content and Structure (50%)	Contains all required information. Ideas well organized and logically laid out always or almost always.	Contains most of the required information. Ideas well organized and logically laid out with competence.	Contains some of the required information. Minimal organization and logical progression of ideas.	Is missing most of the required information. Little or no organization or logical flow of ideas.
Analysis and Depth (30%)	Identifies and explains all issues and design decisions. Considers the issues from multiple points of view. Shows superior understanding of subject.	Identifies and explains most of the issues and design decisions. Shows commonplace understanding of subject.	Identifies and explains some of the issues and design decisions. Shows partial or limited understanding of the subject.	Identifies and explains few of the issues and design decisions. Shows a great deal of misunderstanding about the subject.
Presentation, Style & Tone (20%) Standard conventions for grammar, word use, spelling, citations, headings, paragraphs, figures, and tables. Word choices set appropriate style and tone.	Always uses standard conventions. The document looks professional. Shows exceptional use of tone and style. Speaks to the reader with precise, concise, appropriate language, and choice of words.	Mostly uses standard conventions. The document could use some editing. Shows competent use of tone and style. Makes good word choices.	Does not consistently use standard conventions. The document requires significant editing. Shows minimal attention to tone and style. Shows poor usage or ineffective word variation.	Standard conventions are flouted. Document is unreadable. Shows little or no understanding of appropriate tone. Uses inappropriate language and word choice.

6 Deliverables

The deliverables for this project are:

Two programs loaded on your robot to compete in the Robot Olympics.
Technical report in PDF or Word format.
Code for the program provided in appendices in your report.

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[1]Based in part on Fleming, "Grading Rubric for Written Assignments", CSCI 2100, 2011

The *two programs* should be ready to go for the competition at the start of the presentation period. The technical report is due on December 7, 2017, at 8 AM. Students must include their programs as part of their reports. These can be generated by copying and pasting the programs into an appendix at the end of your report. Be sure to format this nicely. Create a folder and put all the files (two programs and the technical report) inside the folder. Compress this folder and submit it via `csci1108@gmail.com`. **The subject of the email must include your team number as well as the lab section number (B01, B02, B03, or B04)**.

References

[1] American Psychological Association. *Publication Manual of the American Psychological Association*. American Psychological Association, Washington, DC, USA, 6th edition, 2009.

[2] Association for Computing Machinery. `http://www.acm.org/publications/submissions`. Accessed August 17, 2012.

[3] University of Chicago Press Staff, editor. *The Chicago Manual of Style*. University of Chicago Press, 15th edition, 2003.

[4] Mary-Claire van Leunen. *A Handbook for Scholars*. Oxford University Press, New York, revised edition, 1992.