Robot Olympics Project

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

1. The Bulldozer Rally
2. The Obstacle Course
3. Touch Wrestling

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

Your Tribot will participate in each of the events in the competition and your grade will depend in part on the Tribot's performance in the competition. Your Tribot will also earn points based on its performance in the competition. The winner of the competition will be the Tribot 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 next section describes the three events, their rules, and hints for building the programs. The last two sections describes the project report requirements and the deliverables.

1 General Rules

1.1 Programming

All Tribots must contain the three programs for the three events prior to the start of the competition. Once the competition begins, no reprogramming of Tribots may take place. Violation of this rule could result in disqualification from the event for which the program was changed during the competition. Each Tribot may contain at most one program per event. I.e., multiple programs for the same event are not allowed.

1.2 Scoring

For each event in the competition the top three Tribots 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 Tribot with the largest point value over all three events will be declared the winner of the Olympic games.

1.3 Interference

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

1.4 Battery Charging

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

2 Grading

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

F	No show or Tribot does absolutely nothing.
D	Tribot attempts the event but does not complete any of the expected requirements.
C	Tribot completes few of the expected requirements.
B	Tribot completes most expected requirements.
A-	Tribot completes the expected requirements.
A	Tribot completes the expected requirements and comes in 2nd and 3rd in the event.
A+	Tribot 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 average of the three grades received for the events.

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!

3 The Events

3.1 The Bulldozer Rally

In today's day and age, bulldozing an area is something that can get a little tedious, and can best be accomplished by machines. That's why Tribots are perfectly suited for this endeavor. In this event your Tribot must locate and remove as many objects from a bounded area, without leaving the area itself. The area boundary is demarcated by black electrical tape, and the objects to be removed are Duplo[1] blocks that are 23cm high, 9cm wide, and 8cm deep. The objects will be randomly scattered throughout the bounded area. This is the simplest of the three events.

3.1.1 Rules

1. This event will take place in a $2m \times 1m$ arena (one of the large tables in the lab).
2. The boundary will be marked on the table using black electrical tape. The boundary will be 10cm from the edge of the table.
3. The arena will contain a fixed number of "objects" that measure 9cm $\times$ 8cm $\times$ 23cm. The blocks are tall enough to be detected by the ultrasonic sensor and are light enough to be bulldozed by the Tribot.
4. The Tribot will be placed, facing the center, in one corner of the arena.
5. To complete the event the Tribot must remove as many "objects" as possible in 2 minutes.

[1] Duplo is a registered trademark of Lego.

6. An object is considered removed if it is not in contact with the area *inside* the boundary.
7. The Tribot will be allowed two 2-minute attempts.
8. If the Tribot leaves the area, such that no part of it is overhanging the boundary or inside the boundary, the attempt will be deemed over.
9. If the Tribot topples, the attempt will be deemed over.
10. The best attempt, in which most "objects" were removed, will be graded.
11. If the Tribot manages to remove all the objects from the arena within two minutes, then the time that it took will be recorded.
12. The Tribot will graded according to the number of objects it removes and how quickly it removes them.

3.1.2 Grading Scheme

F	No show or Tribot does absolutely nothing.
D	Tribot removes at least one (1) "object" from the arena *or* remains within the arena.
C-	Tribot removes at least one (1) "object" from the arena *and* remains within the arena.
C	Tribot removes at least two (2) "objects" from the arena.
C+	Tribot removes at least three (3) "objects" from the arena.
B	Tribot removes at least four (4) "objects" from the arena.
B+	Tribot removes at least five (5) "objects" from the arena.
A-	Tribot removes at least seven (7) "objects" from the arena.
A	Tribot removes at least eight (8) "objects" *or* comes in 2nd or 3rd in the event.
A+	Tribot removes all the "objects" *or* comes in first in the event.

3.1.3 Hints and Suggestions

A boundary avoiding program should form the core of your program. A simple approach is just to randomly traverse the arena, bulldozing objects if they are encountered. More advance programs can implement specific search patterns to systematically cover the entire arena and/or use the ultrasonic sensor to locate "objects" and push them out.

3.2 The Obstacle Course

This is an event of medium difficulty. Having a robot negotiate an obstacle course is a traditional challenge. The obstacle course represents a world that the robot does not know a priori, and must explore it in order to traverse it. In this event your Tribot must negotiate an obstacle course comprising towers, walls, and gates to reach the exit. For example, the figure below illustrates the general structure of the obstacle course.

3.2.1 Rules

1. This event will take place in a $2m \times 1m$ maze (one of the large tables in the lab).
2. The boundary will be marked on the table using black electrical tape. The boundary will be 10cm from the edge of the table.
3. The arena will contain a wall 23cm high, 1m wide, and 7cm deep, which bisects the table widthwise into two equal halves.
4. The wall will contain a gate that is 22cm wide, somewhere in the wall.

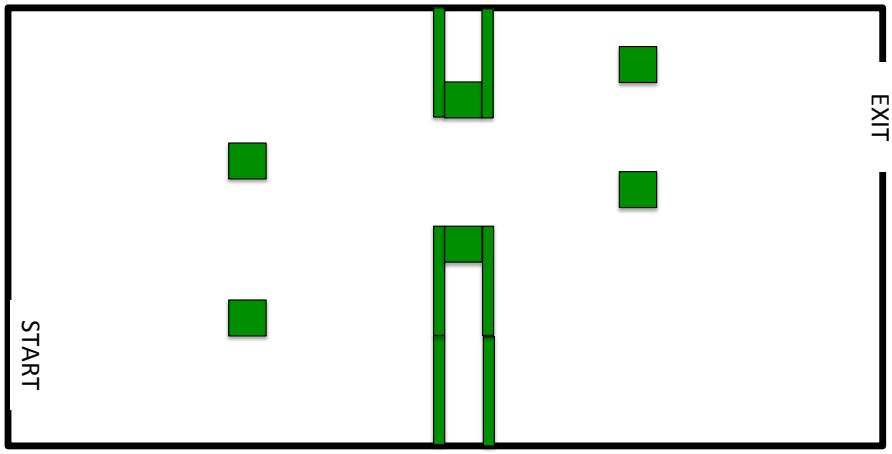

Figure 1: A sample obstacle course.

5. Each half will contain two randomly placed towers, measuring 8cm × 9cm × 23cm.
6. The towers will be at minimum 20cm away from the boundary or the wall.
7. One half will contain the **EXIT** gate, parallel to the wall, which will measure 20cm in width.
8. The other half will contain the **START** gate, in right corner (facing the wall). The Tribot will face the wall when starting.
9. To complete the event the Tribot must reach the **EXIT** without dislodging the towers or walls, and without leaving the arena.
10. The Tribot will be allowed three 2-minute attempts.
11. If the Tribot dislodges a tower or a wall by more than 5cm, the attempt will be deemed over.
12. If the Tribot leaves the area, such that no part of it is overhanging the boundary or inside the boundary, the attempt will be deemed over.
13. If the Tribot topples, the attempt will be deemed over.
14. The Tribots will graded according to how quickly it reaches the **EXIT** or how close to the **EXIT** during the attempt.
15. The best attempt will be graded.
16. The three fastest times for completing the event will be awarded 1st, 2nd, and 3rd place.
17. You may remove the *Touch Sensor* for this event.

3.2.2 Grading Scheme

F	No show or Tribot does absolutely nothing.
D	Tribot reaches the wall.
C	Tribot reaches the gate.
B-	Tribot enters the gate.
B	Tribot exits the gate.
B+	Tribot exits the gate and passes the towers.
A-	Tribot negotiates the obstacle course.
A	Tribot negotiates the obstacle course has the 2nd or 3rd fastest time.
A+	Tribot negotiates the obstacle course and has the fastest time.

3.2.3 Hints and Suggestions

You already know a lot about the obstacle course: the location of the wall and the four possible locations of the gate. You also know that the towers will not be too close to walls or boundary. You can use the boundary to find the wall and then negotiate the wall. You can then use the wall to find the boundary on the other side, and use the boundary to find the exit gate.

3.3 Touch Wrestling

This is probably the hardest event. In traditional wrestling, a wrestler loses if he or she is flipped on their back. In robot touch wrestling, a Tribot loses if its rear touch sensor is activated. In this event your Tribot will compete in wrestling matches against other Tribots. To win your Tribot will need skill and ingenuity rather than brute force.

3.3.1 Rules

1. This event will take place in a 2m x 1m arena (one of the large tables in the lab).
2. A ring will be marked on the table using black electrical tape. The ring will be 10cm from the edge of the table.
3. The Tribots will start at opposite ends of the ring, facing each other.
4. If the Tribot's rear touch sensor is pressed, it must stop, and signify that it has lost by displaying an appropriate picture and sound.
5. If the Tribot starts falling off the table or topples over, it is deemed to have lost as well.
6. Each match will take 2 minutes.
7. If no winner is determined after 2 minutes:
   (a) The contestants can either choose to restart the match, or let the current match continue.
   (b) If after two more minutes there is no winner, (regardless of whether the match was restarted or not) the match shall be determined by flip of a coin.
8. The Tribot must first qualify to compete in the tournament.

   Qualifier #1 :
   (a) The Tribot is placed in a ring with a stationary opponent in the center of the ring.
   (b) The Tribot is started.
   (c) The judge will press the Tribot's touch sensor at some point (shortly) into the match.
   (d) The Tribot should stop and notify the judge that it has lost (as described above).

   Qualifier #2 :
   (a) The Tribot is placed in a ring with a stationary opponent in the center of the ring.
   (b) The Tribot is started.
   (c) The Tribot must win the match. I.e., it must beat its stationary opponent as described above.
9. The Tribot will have 2 attempts at qualifying.
10. The qualifying Tribots shall participate in a double elimination tournament.

3.3.2 Grading Scheme

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

3.3.3 Hints and Suggestions

In theory, the Tribot needs to keep track of at least two sensors: the touch sensor and the light sensor (to detect the edge of the ring). However, your code will become very complicated if it is always checking the touch sensor. Instead, your code should use a separate thread (girder) to wait for the touch sensor to be pressed, and then emit a sound and stop (using the Stop block). The main thread can just deal with the wrestling part of the program.

Your Tribot will likely need to use the ultrasound sensor to detect its opponent. However, it is not known which side of the opposing Tribot is facing you. Hence, your Tribot may need bump its opponent on multiple sides in order to eventually activate the opponent's touch sensor.

Begin by creating the two thread program, and implement the touch sensor monitoring thread first. This should be a very short (3 block) thread. Then implement the wrestling code on the main thread.

There are essentially two stages: find the opponent, using the ultrasound sensor, and then press its touch sensor by circling the opponent and bumping it on all sides.

4 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 three 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. I.e., "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 Bulldozer Rally Program section answers the following three questions about your program for the Bulldozer Rally event. Namely, what is the problem being solved? How was the problem 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. It should describe the basic strategy of your solution and the tactics used to achieve it. For example, actively searching for objects to be bulldozed, which can be accomplished by using the ultrasonic sensor.

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 Obstacle Course Program section describes your program for the Obstacle Course event and, has the same format and addresses the same issues as the previous section.

The Touch Wrestling Program section describes your program for the Touch Wrestling 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. For example, your Bulldozer Rally program may have cleared five objects from the arena, but this does not mean anything until you mention that only two programs managed to remove more objects, indicating that your program was one of the better ones.

Use of tables and graphs to present your results is strongly encouraged.

Conclusion and Future Work is a summary of the report with particular emphasis of the results of the project. Along with a summary of the results, you can also describe what else you would have liked to do with your project, how the project could be improved or extended, etc. This section provides the closing bracket to the report and complements the introduction.

For example, the report should briefly state the purpose of the project, i.e., "We did ...", The report should then summarize your results, with focus on how well your programs did and any major difficulties that your programs encountered. 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, which you really should not use as an official source for anything. 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 (`http://moodle.cs.dal.ca`) so you know how they should be formatted. The report will be marked using the following rubric[2].

	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.

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

5 Deliverables

The deliverables for this project are:

> **Three Programs** loaded on your Tribot to compete in the Robot Olympics.
> **Technical Report** in PDF or Word format.

The *three programs* should be loaded onto your Tribot and be ready to go for the competition at the start of the presentation period for this module. The technical report is due at the start of class following the presentation period (see syllabus). Students must provide printouts of their programs as part of their reports. These can be generated by using the print function of the programming environment to create the corresponding HTML files, which can then be incorporated into your report. The reports must be submitted electronically, via `moodle.cs.dal.ca` and in hard-copy to the instructor as well.

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.