Robotics
Week 7 Practical: Path Planning Challenge

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1   Introduction

The final practical of term consists of a challenge and competition. You should use what you have learned in the previous practicals to design robots and algorithms which you believe will be most effective, and I will give you ideas about which methods to use, but you are free to choose other methods if you think they will be better. In this challenge, accuracy and speed are both important. Importantly, we will give marks this week purely depending on the performance of your robot in the challenge, and following our generosity in previous weeks *the marking scheme will be tough!*

We will test and assess this practical in the final session of term, on **Thursday November 30th**, in competition form. **The competition will start promptly at 11:00am**. Groups will be called up one by one in box/locker number order for their first attempt, then when all groups have had a turn there will be a second round where every group will have another attempt.

In each round, you must be ready to go when I call your team number or you will miss your turn! We will score both of your attempts, but only the better of the two will count for the competition and your group's assessment marks. The team which achieves the highest number of marks, with the shortest time being used to resolve a tie, will be judged the winner and a small prize will be awarded.

This practical, like others this term, will be ASSESSED. There are **10 marks** to be gained based on your performance in the challenge out of a total of 100 for the term. These accumulated marks form the only assessed coursework component of Robotics.

We are only awarding 10 marks this week to emphasize the competition element, and with knowledge that many students are busy with other courses and activities at this time of term.

2   IMPORTANT: CATE SUBMISSION

In the Robotics course we have been providing regular and immediate feedback on your work via the in-lab assessments and I am glad to see that this has encouraged all of you to work hard and the standard of achievement on the exercises has been excellent. This work will set you in good stead for the final exam, the content of which is closely linked to the understanding you will have gained through the practical exercises.

I have explained that the coursework marks for Robotics have been accumulated week by week throughout term. Once this final practical is assessed, each team will have obtained a total number of marks out of 100. I will award each member of a group the same total unless there are any exceptional cases where we believe that the effort put in by some group members was much less than the others.

In order that I can enter the marks officially into CATE, I have set up a dummy 'Cumulative Practicals' coursework exercise for Robotics. Please log onto CATE, and enter the details about the members of

your group into the system. The exercise asks for a text file dummy.txt to be submitted but this is just to keep CATE happy and it just needs a couple of characters I think so that CATE will accept it. I won't look at it. I DO NOT WANT YOU TO SUBMIT REPORTS OR ANY OTHER MATERIALS.

The deadline I have set for submitting the dummy exercise is the end of term. However, since it is so easy to do please go ahead and so it straight away so I can make sure you get your marks immediately after the end of term. 1

3 The Goal

The aim of the challenge this year is to navigate across an area filled with obstacles. Your robot will start with no knowledge of the positions of the bottles and will have to locate them with its sonar and plan a path to advance as far and as quickly as possible.
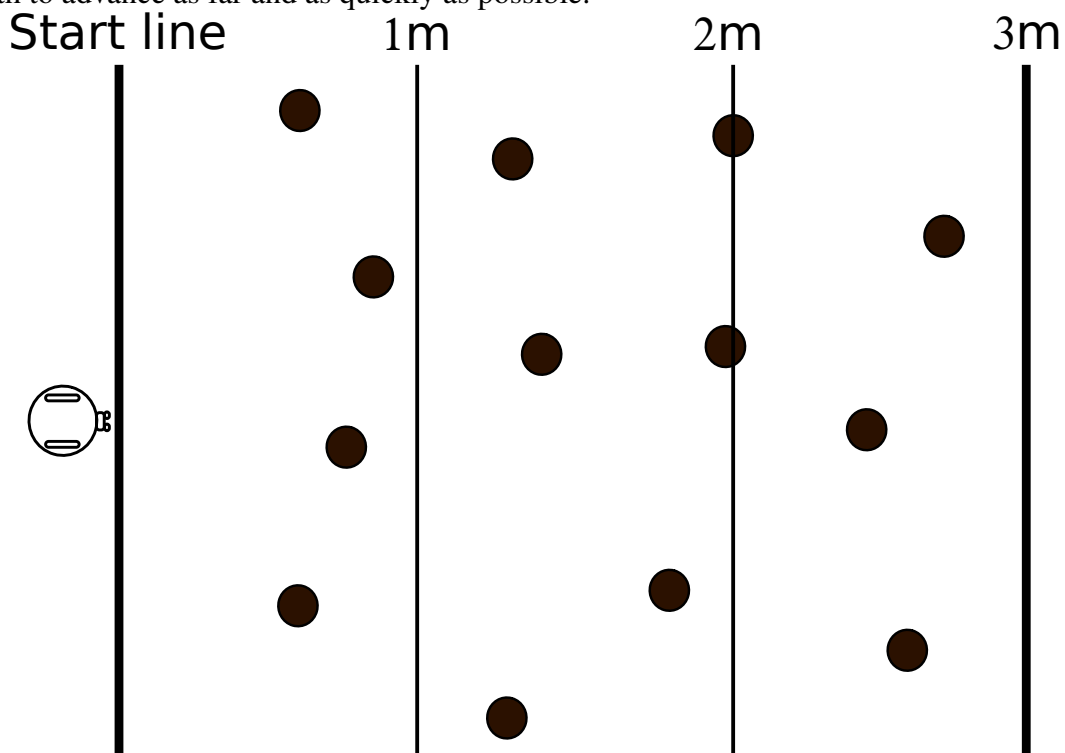
The robot will start behind a start line marked on the floor, facing forwards, and there will be a parallel goal line 3m ahead. We will mark intermediate lines at 1m and 2m which will be used for judging. The course will be at least 3m wide and the robot should not attempt to deliberately outside of this width. To get maximum marks the robot needs to advance all the way across the course without hitting any obstacles, and ideally by maintaining smooth and continous motion throughout. There will be time points for robots that make it all the way to the 3m line, depending on how fast this is achieved (we will start a timer as soon as your program is run).

The obstacles we will use are soda bottles, which you can consider as heavy vertical cylinders with radius 6cm. On each run, a number of bottles will be placed by us randomly in the space in front of the robot. You can assume that the closest obstacle in front of the robot at the start will be at least 0.5m away. There will be fairly wide gaps between the bottles, with at least 0.5m between any pair.

4 Methods

As I said in the introduction, we will be judging purely the performance of the robots against the criteria in Section 5 and the choice of robot design and algorithms is up to you. However, here are some ideas for how you can approach the task.

Most obviously, a purely local planning approach similar to the Dynamic Window Approach will be suitable. I have provided the code for the implementation of this method in Python in a simulated environment in:

`http://www.doc.ic.ac.uk/~ajd/Robotics/RoboticsResources/planning.py`

This simulation is relatively close to the competition setup, and simulates the robot having a forward looking sensor such that it only becomes aware of obstacles when they are in front of it and within a cone shaped sonar beam, and then plans local motions to move towards a target location while avoiding obstacles. The robot moves by controlling its v_L and v_R left and right wheel velocities, so your real robot should also use velocity control and on each timestep adjust the velocity demands it sends to the two wheels. You should use `MAXVELOCITY` and `MAXACCELERATION` values which fit the range within which you think you robot can move smoothly.

One difference between that simulation and the challenge setup is that in the simulation the robot is trying to reach a specific (x, y) goal location, whereas in the challenge we have just asked the robot to move forward as far as possible. If the x coordinate of your frame is the initial forward direction, then the robot's 'benefit' term should try to maximise x increasing and you can modify the program to reflect this.

The other obvious difference is sensing, which must now become real rather than simulated. I expect that a forward looking sonar alone makes it mostly possible to see an obstacle in front of the robot well enough to ensure avoidance. Once an object has been observed once, its global coordinates can be estimated based on the sonar measurement and the robot's position, and added to an obstacle list stored by the robot. You may decide to require at least two consistent measurements of an obstacle to confirm its location.

It may be that a sonar which is able to horizontally scan from side to side to some extent will help with reliably finding obstacles and some of you have built robots which have this capability already using the third motor. However I think that before trying this you should test a fixed forward-looking sonar.

The robot needs to keep moving forward, and will not have a known map of the area to localise against, so I would assume that you will rely on odometry to keep a running estimate of the robot's location. Since the challenge is to keep moving forward, and the sideways position of the robot doesn't matter in the challenge, the need for accurate odometry is reduced, and the main aspect is to keep an accurate orientation so that the robot knows which direction is forwards.

Note that according to the scoring scheme below, we will take off marks if some of the obstacles are touched by the robot. This is to encourage good sonar sensing and nice avoidance manoeuvres based on detecting obstacles at a distance. However, you can still get marks if you hit obstacles and keep moving forward, so a back-up plan for a simple robot might be to use a bumper to bounce off obstacles and make a reactive manoeuvre.

Also, there will be an extra marks for robots which keep moving continuously forward rather than stopping to think and rotate. This is to encourage smooth DWA type motion. A smooth approach should also be faster in principle.

As before, the floor surface in this course is the standard lab **carpet**. The course will remain set up throughout the week so you can practise as much as you want.

You should only use the standard equipment in one standard kit which is available to all the groups (in

particular three motors, one sonar).

5   Judging and Marking

Marks will be assigned as follows, based on the **best** run that your robot achieves from the **two attempts allowed**. Note that we will go through all the groups to have one attempt each first, and then do a second round for everybody so there will be a little time to adjust your robots in between, though you must be ready when your group is called. Bear in mind that we will move the obstacles just before each run so that you are not able to program in their locations in advance.

1. **Up to 6 marks for the distance that the robot successfully advances**. I will award 2 marks per metre if the robot crosses that space without touching any obstacles. Any metre distance range which is crossed but where the robot touches an obstacle will be worth 1 mark. The sideways position and orientatin of the robot when it crosses a line do not matter.

2. **1 mark** if the robot achieves travels the full 3m not only while not touching any obstacles, but also while moving forward continuously while turning smoothly in the style of Dynamic Window Avoidance.

3. For robots which achieve the full 3m, up to **3 marks** for the total time taken (from starting the program until the robot crosses the 3m line).

Total time:	0–20 seconds	**3 marks**
	20–40 seconds	**2 marks**
	40–60 seconds	**1 marks**
	slower	**0 marks**

This marking scheme is **tough** but should allow the best teams to shine through.

The winner of the challenge will be the robot which obtains the most marks, with a tiebreak on the same number of marks being decided by the quickest time.

6   Finish and Tidy-Up

Straight after the competition, we need to collect up the robot kits and tidy up the lab. Please:

- Disassemble your robot. Into your numbered plastic box please pack the same items that it contained at the start of the course.
  - Raspberry Pi and BrickPi (these can be left together in their perspex case)
  - Wi-fi dongle
  - SD Card
  - Battery
  - Y-cable (power cable for BrickPi)
  - Battery charger

- HDMI cable

- 3 motors

- 1 sonar

- 2 light sensors

- 2 touch sensors

- 3 Lego motor/sensor cables

- Empty your locker.

- Return your plastic box to us together with your locker key. We will sign these back in and I won't give any groups a coursework mark until you have returned your box and key!

- Return all other Lego parts to the drawers. Please separate your spare Lego cables and wheels and put those into drawers 3 and 4. All other parts can be put unsorted into any of the drawers 7–18 in trays.

- If you have tape measures, scissors, sticky tape, pencils, etc. please put these into drawer 6.

- Any other robotics bits you find around the lab, please return them to us.

- Please help us to have a general tidy up of any Lego or other Robotics bits which might be lying around the lab. Please throw away any waste paper you may have, and if possible remove any tape or other things that are stick to the floor. Thank you.