Robotics

Week 7 Practical: Object Finding Challenge

Andrew Davison
ajd@doc.ic.ac.uk

1 Introduction

The final practical of term consists of an easy to state challenge, but I will not be giving you specific guidance on how to achieve it. You should use what you have learned in the previous practicals to design robots and algorithms which you believe will be most effective. In this challenge, accuracy and speed are both important. Importantly, we will give marks this week depending on the performance of your robot, and following our generosity in previous weeks *the marking scheme will be very tough!*

We will test and assess this practical in the final session of term, on **Thursday November 28th** in competition form. **The competition will start promptly at 9:00am**. **Groups will be called up one by one in box 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 **25 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.

2 IMPORTANT: CATE SUBMISSION

In the Robotics course we have been providing regular, immediate and face to face 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 can be an empty file. I won't look at it. I DO NOT WANT YOU TO SUBMIT REPORTS, CODE OR ANY OTHER MATERIALS.

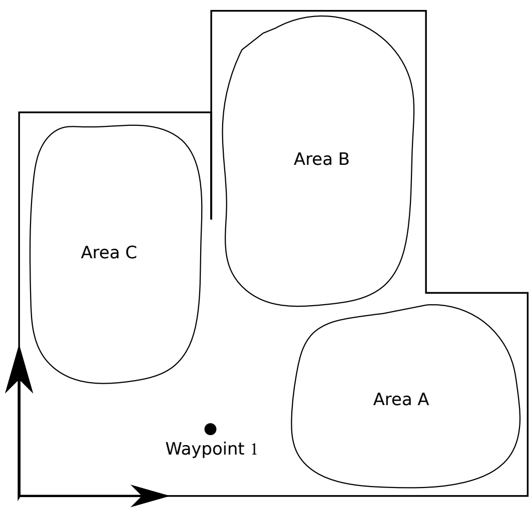
The deadline I will set for submitting the dummy exercise is the end of the day of the final practical. However, since it is easy to do please go ahead and do it straight away so I can make sure you get your marks immediately after the end of term.

3 The Goal

The aim of the challenge this year is for the robot to find three unusual objects placed within a mapped area, touch them, and come back to its starting point as quickly and accurately as possible.

The objects are full soda bottles, which you can consider as heavy vertical cylinders with diameter 10cm. We will run the robots in the **same robot courses** which we have used for the MCL and Place Recognition practicals. As before, the floor surface in this course is the standard lab **carpet**. The courses will remain set up throughout the week so you can practise as much as you want.

On each run, one bottle will be placed randomly by us in each of the approximate areas A, B, C of the mapped area shown below:



For the challenge, we will use one of the marked waypoints from the MCL Practical (Waypoint 1) as the starting position of the robot. As before, Waypoint 1 has the following coordinates:

Point	x	y
1	84	30

In detail, the timed challenge will consist of the following:

1. Your robot will be placed in its starting position at Waypoint 1, pointing forward along the x axis, the same as in the MCL practical. We will start timing when your program starts running.

2. Its goal is to find each of the three objects in the mapped area, drive towards them in any order and prove that it has found each one by bumping into it. It does not matter what order it approaches the objects in, or what kind of motion it takes in between them. Remember that there will be one object in each of the areas A, B and C shown in the picture, but that their locations will be randomised by us for each trial.

3. You can assume that the objects will not be placed close to walls. We will leave at least a 20cm gap between the centre of each object and the closest wall.

4. Having touched all three objects, the robot should return to Waypoint 1 and stop for good. The orientation of the robot when it stops back at Waypoint 1 is not important, only its (x, y) position. The final return to Waypoint 1 will be judged as achieved if the robot stops with its centre less than 20cm from the waypoint position, and more credit will be given for stopping within 10cm or 5cm of the waypoint (see the marking scheme below).
5. If your robot manages to bump into all three objects and return to Waypoint 1 successfully, additional marks will be given for its overall time, from program start to when the robot finally stops. To repeat, there will only be a time mark given if the robot **finds all three objects and returns successfully to Waypoint 1**.

Design of your robots and the choice of algorithms in this challenge is up to you. In this practical only we will not judge the choice of methods, but simply the performance of the robots, hoping to reward those groups who have used their knowledge to make robots that work really well in practice.

To give you some hints though, an approach which should work is a combination of MCL and a simple form of occupancy mapping. As your robot moves through the course, mostly estimating its location using MCL, at regular intervals (either while stopped or continuously while moving) it should scan its sonar around through some large angle to search for objects. It can accumulate evidence of the positions of objects in an occupancy map. It may be the case that more than one sonar observation in consistent positions is needed to be sure of the location of an object, or one confident observation could be enough.

If an object is in between the robot and one of the walls that it is measuring for MCL, if you detect a sonar measurement which is very far from the expected m value for that measurement this immediately gives evidence of the location of an object.

If you are very confident about your odometry, you could trust your robot to localise well based just on this and use the sonar only for object finding.

You should only use the standard equipment in one standard kit which is available to all the groups (in particular three motors, one sonar, two bump sensors). Making your sonar directable by mounting it on the third horizontal motor will be useful for localisation and scanning while moving or while stopped.

Also note that the walls of the course are not necessarily solidly attached to the floor and so bumping off them is not a good strategy. I am assuming that sonar and odometry will be your means of knowing where the robot is. The bottle objects will be heavy can the robot can use bump sensing to detect collisions with them.

4 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. The objects will have been moved to different locations between your two attempts.

All judging will be done by me and the lab assistants in real-time from observing your robot in action. We will not need to see on-screen displays, though of course as usual you will find visualising things very useful during your development.

We will award:

1. Up to **5 marks** which we will judge subjectively based on whether you your robot is making a good attempt to locate the objects in the map. Is it moving around the course and making sonar

measurements in different directions to look for the objects? For most groups that progress to finding some objects we will give these marks automatically.

2. For each of areas A, B, and C: **1 mark** for successfully entering that approximate area of the map; and **3 marks** for successfully bumping into the object in that area.

3. Up to **3 marks** for successfully returning to Waypoint 1 and stopping after successfully touching all three objects. We will mark target circles around Waypoint 1 and award **3 marks** if the robot's centre is within 5cm, **2 marks** for within 10cm, and **1 mark** for within.

4. For robots that touch all three objects and successfully return to Waypoint 1, up to **5 marks** for the total time taken until it stops, according to the following scheme:

Total time:	0–45 seconds	**5 marks**
	45–60 seconds	**4 marks**
	60–75 seconds	**3 marks**
	75–90 seconds	**2 marks**
	90–120 seconds	**1 marks**
	slower	**0 marks**

A reminder that **the marks for returning to Waypoint 1 are only given if the robot has touched all three objects**; and **the marks for time are only given if the robot has touched all three objects and returned to Waypoint 1**. So no shortcuts to a fast time!

So a perfect run, touching all three objects and returning accurately and fast to Waypoint 1, will gain the full 25 marks. This marking scheme definitely is **tough** but is designed allow the best teams to shine through while still allowing a good number of marks for teams that are partially successful.

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.

5 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)
  - Micro SD Card (before giving it back, make sure you have a copy of your code somewhere safe where all the team can see it, because looking at this could be useful for your revision)
  - Battery
  - Y-cable
  - Charger
  - HDMI cable
  - 3 motor/sensor cables

  - 3 motors
  - 1 sonar
  - 2 touch sensors

- Return your plastic kit box to us. We will sign these back in and I won't give any groups a coursework mark until you have returned your box and we have checked the components!
- Return all other Lego parts to the big Lego drawers and boxes.
- If you have tape measures, scissors, rulers, sticky tape, pencils, etc. please put these separately into the special box we have for these things.
- Please help us to have a general tidy up of any Lego or other Robotics bits which might be lying around both the teaching lab and the old server room where the courses are. Please throw away any waster paper you may have, and if possible remove any tape or other things that are stuck to the floor. Thank you.