F20/21RO - Intelligent Robotics - Coursework 2 (CW2)

This assessment is worth 50% of your course mark

Due: 3:30 pm, Friday 3rd December 2021 (Week 12)

Overview

This assessment aims to increase your understanding and use of robot simulators and software tools to support the creation of intelligent controllers for robots using advanced bio-inspired techniques, which are covered in the course. It involves using a well known robot simulator, creating specific environment configurations and applying bio-inspired algorithms to create intelligent controllers for robots, analysing the resultant robot behaviours and drawing conclusions from it.

For this assessment you are being formed into groups of **two people**. Each group will develop a controller for a robot to perform a given task by week 12.

You will be randomly matched with another CW partner, no collaboration beyond that is allowed.

Groups will be communicated at most by 01/11/2021 (Monday) via CANVAS, with the subject: “F20RO 2021 – CW PARTNER” for UG students and “F21RO 2021 – CW PARTNER” for PG students including both names and surnames. Once you receive the allocation, please contact your CW partner immediately to start working on your CW assessment.

Each group will develop its own robot controller (in any programming language(*)) for a set of tasks using the Webots simulator software.

(*) we strongly advise you to use the Python language.

PLEASE CONTACT Prof PATRICIA A. VARGAS (p.a.vargas@hw.ac.uk) IF THERE ARE PROBLEMS IN YOUR GROUP.

Please read through these other important points before you begin:

- **You do not need to wait until we have covered all the related topics in the lectures to start working on your coursework**.
- We endeavour to give you **feedback** on average of 15 working days from submission.

This is assessed coursework. You are allowed to discuss this assignment with students, but you should not copy their work, and you should not share your own work with other students, unless they are from your own group. We will be carrying out automated plagiarism checks on both code and text submissions.

Special note for reusing existing code. If you are reusing code that you have not yourself written, then this must clearly be indicated, making clear which parts were not written by you and clearly stating where it was taken from. If your code is found elsewhere by the person marking your work, and you have not mentioned this, you may find yourself having to go before a disciplinary committee and face grave consequences.

Late submission and extensions. Late submissions will be marked according to the university's late submissions policy, i.e. a 30% deduction if submitted within 5 working days of the deadline, and a mark of 0% after that. The deadline for this work is not negotiable. If you are unable to complete the assignment by the deadline due to circumstances beyond your control (e.g. illness or family bereavement), you should complete and submit a mitigating circumstances application:

https://www.hw.ac.uk/students/studies/examinations/mitigating-circumstances.htm

Detailed Description

TASK 1: Add an additional obstacle avoidance behavior layer to your robot from Lab 1 using the BBR approach.

The robot should follow the line AND avoid obstacles. You will have to insert obstacles in the robot arena to test if your controller is working. You will use the behaviour-based controller already implemented during Lab 1 to guide you through the usage of e-puck on Webots.

TASK 2: Use arena, code and the Supervisor from Lab 2 to add a point of light on each corner of the arena and add the obstacle avoidance behaviour of Task 1 to the robot of Lab 2. The lights should "switch on" at one corner at a time in a random sequence.

The robot should perform phototaxis every time any light is ON and avoid obstacles using the BBR approach. You will have to insert obstacles in the robot arena to test if your controller is working. You will use the behaviour-based controller already implemented to guide you through the usage of e-puck on Webots.

TASK 3: You should **evolve** a robot controller to control a single robot on a race circuit as depicted in Figure 1 using an Evolutionary Robotics approach. The robot should follow the line on the ground all the time and avoid obstacles while racing to finish the circuit as quickly as possible. While following the line on the ground if the robot faces an obstacle, the robot should go around the obstacle until it finds the line again in order to continue on the race circuit.

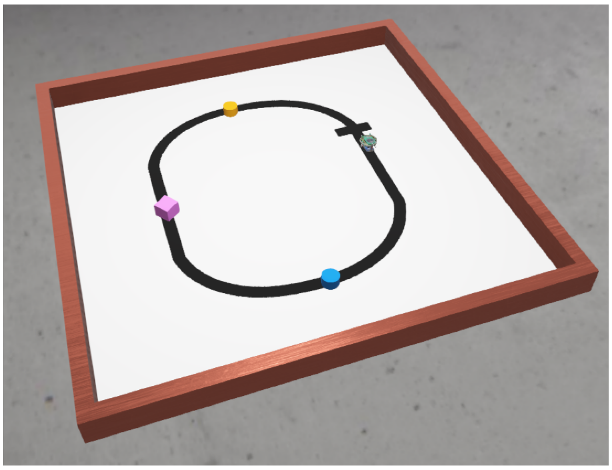


Figure 1 - e-puck_line World display

You should aim to evolve the quickest robot, i.e. the robot that could complete the race circuit in less time. Therefore you should record the time spent on the average of three runs for your best-evolved controller.

You should fill in the following table accordingly and add it to your final report:

Table 1: Statistics.

	Time in minutes			
	First run	**Second run**	**Third run**	**Average Time**
Task				

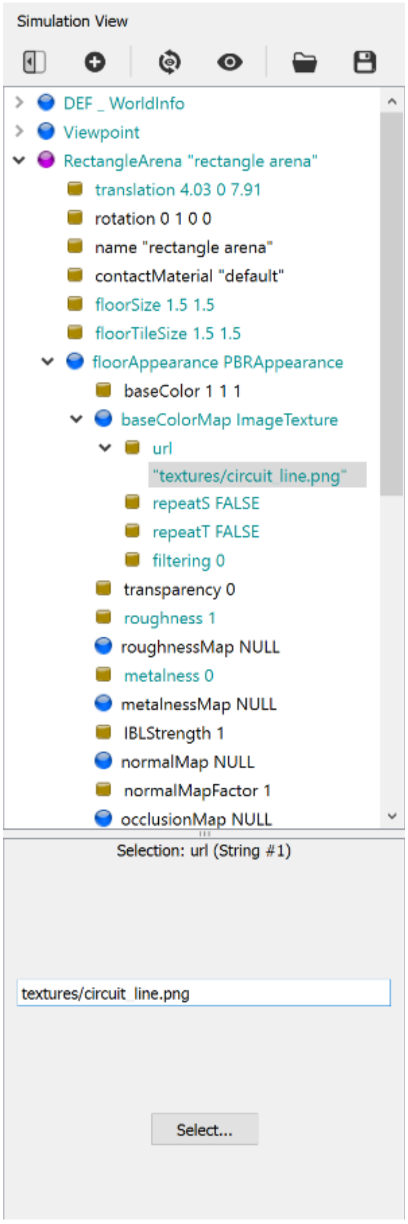
You can find an initial code of the robot evolutionary robotics approach controller on your Lab 3 git repository (https://github.com/jhielson/Robotics_GA), with many gaps that you need to fill in so that your controller will run properly. More info on Lab 3 material.

The basic rules are the following:

- Use the e-puck robot available in the Webots simulator and the given world's files.
- You should NOT move any objects in the arena or try to change the World.
- The dimensions of the arena, areas and obstacles should not be changed.
- The maximum time to perform any of the tasks is 5 min for each part of the coursework. After that, the simulation should be stopped and 5 min should be added to that specific group as the time spent, irrespective if the robot(s) have completed the task or not.

NOTE 1 : If you cannot see the circuit image (in either of the worlds), follow the following steps to add the image:

i. Open the node: *RectangleArena*;
ii. Open the node: *floorApperance*;
iii. Open the node: *baseColorMap*;
iv. Open the desired texture by selecting the correct url.



v. The highlighted part of the image is what you need to change. Press the select button and follow the path *<YOUR PATH>/worlds/textures* and select *circuit_line(lab3).png* that you can find under your Lab3 material.

NOTE 2: To open the control window of the robot.

If you double click on the e-puck robot, the control window will appear to you. The **Robot Window** is the control window of the e-puck, which has all the measurements of the devices, such as the distance sensors, the ground sensors etc. for the simulated and for the real robot (Figure 3).

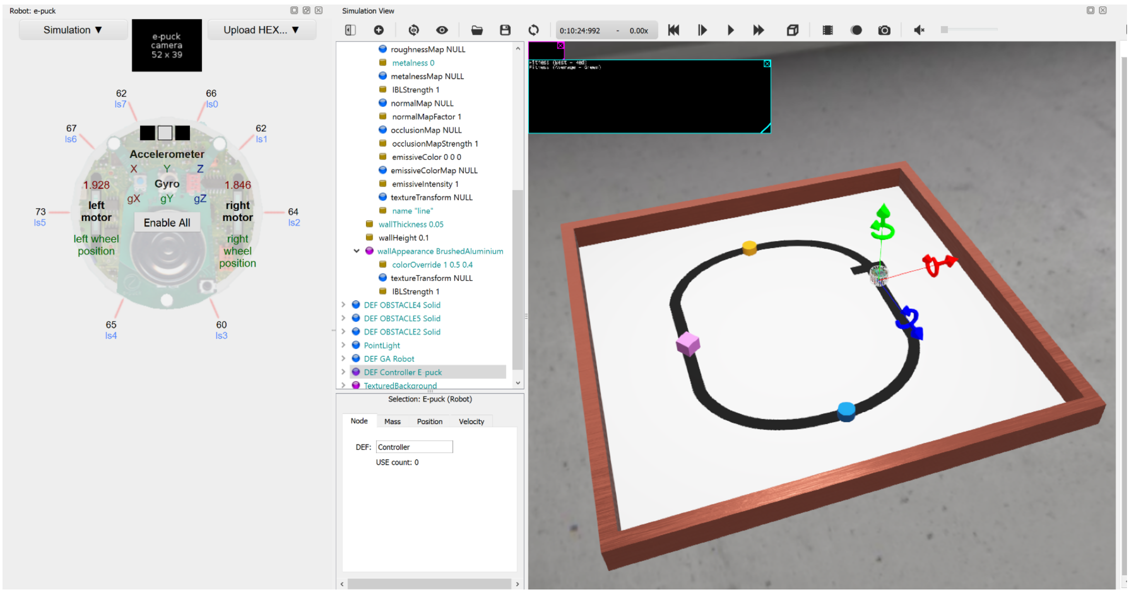


Figure 3 – Robot Window viewer

Activities for each Task

Activity 1*

Choose the corresponding project repository from your lab's material into your coursework folder.

Activity 2*

Create the arena environment.

Activity 3*

Code and run the controller to perform the Task described.

Activity 4

Record a short video (no more than 3min) for the Task showing the final robot behaviour.

Collect data that would illustrate the corresponding final robot behaviour.

Collect statistics for each run for Task 3.

*** you can refer to the past labs activities in order to have some guidance on how to do this.**

What you are asked to do:

1. Implement a robot controller for each Task.

2. Test your controller.

3. Make a short video (no more than 3min) of the final desired behaviour.

4. Write a report and submit the report, short videos and the codes to CANVAS.

5. Sign the “Coursework Group Signing Sheet” and submit it together with your report on CANVAS.

REPORT and CODE (Undergraduate Students) : Write a research report and submit both the report and your code to CANVAS

Your research report should:

- Be between 2,500 and 3,000 words, excluding figure and table legends.
- Describe your implementations of the bio-inspired algorithms, noting any interesting aspects.
- Your report should contain the following sections:
    - Introduction
    - **For each Task Implemented:**
        - Methods and Development Rationale
        - Results and Analysis
    - Discussion and Conclusion
    - References
- Report the results of your experimental investigation. For instance, you might want to use tables, figures, graphs and plots to illustrate your results.
- Referring to these results, discuss which decisions you made that might have affected the performance of your implementations, and say why you think this is the case.
- Prepare a discussion and conclusion addressing the difference between the development of a controller using BBR approach and Evolutionary Robotics approach.
- Include useful references to the wider literature. For instance, you might use references to books, papers and articles to justify particular implementation choices, or you could compare your findings to those reported elsewhere. Use the requested standard referencing style for this, i.e., the Harvard Referencing Style.

You should submit both your report (as a **.pdf** file), short videos (on a **.zip** file) and your code (on a **.zip** file) to CANVAS using the links provided. Grading will use the assessment criteria given in the table below.

NOTE: Your CODE **should not** be uploaded as a PDF, as we need to be able to run your code. If we can NOT run your controller, your CW2 will not be marked, and you will receive 0 marks.

Marking scheme for F20RO Coursework

Please note that all tasks will be assessed following the corresponding criteria below.

Criteria	Weight	A (70-100%)	B (60-69%)	C (50-59%)	D (40-49%)	E/F (<40%)
Implementation *(i.e. code for Tasks, and evaluation, comments and documentation)*	45%	Creative implementations of each Task that exceed the basic requirements. Correct evaluation code. Easy to read and well structured.	Correct implementations of the basic requirements. Generally good coding, structure and documentation.	Some significant issues in terms of correctness, structure, coding practice and documentation.	Major issues in terms of correctness, structure, coding practice and documentation.	Critical errors: for example, the code does not compile and/or run, or inappropriate algorithms have been implemented.
Experimental study *(i.e. choice and validity of experiments performed, presentation of results, including short video)*	25%	Robot behaviours investigated are well motivated and the rationale for choices made are well ellaborated. Suitable results have been collected and are clearly presented and meaningful.	Some minor issues in terms of the motivation or description of resultant robot behaviours, the experiments performed, or the presentation of results.	Some significant issues in terms of the motivation or description of of resultant robot behaviours, the experiments performed, or the presentation of results.	Some major issues: experiments do not make sense, have invalid results, or the Tasks and studies are not adequately described.	Some critical issues: experimental study is nonsensical or missing, the experiments are inappropriate, or the description of the studies are uninformative.
Wider discussion *(i.e. intro, interpretation of results, conclusions, use of the wider literature)*	20%	Clear, insightful discussion that shows a good understanding of BBR (behaviour based robotics) and ER (evolutionary robotics) and includes well chosen references to the wider literature.	Generally clear and insightful, but shows some misunderstanding of BBR (behaviour based robotics) and ER (evolutionary robotics) . Adequate use of the wider literature	The discussion is limited in terms of the depth or volume of understanding it demonstrates. Little or no use of the wider literature.	Some major issues in terms of depth or volume of understanding. No use of the wider literature.	No real demonstration that the subject matter has been understood, or very limited in its scope.
Report *(i.e. structure, language, referencing etc.)*	10%	Report is well structured and divided into sections; good use of language; consistent use of font Arial, size 12; perfect use of Harvard referencing style	Report is suitably structured and divided into sections; mostly good use of language; use of font Arial, size 12; use of Harvard referencing style	Report is structured but not divided into sections; language issues that affect readability; inconsistent use of fonts and sizes; mixed use of referencing styles	Report is poorly structured; substantial language issues that affect readability; use of different fonts and sizes; no referencing style	Report has a nonsensical structure; language issues make it very hard to read; use of different fonts and sizes; no referencing style

REPORT and CODE (Post Graduate Students) : Write a research report using an IEEE paper format and submit both the report and your code to CANVAS

Your research report should:

- Use the IEEE paper template available on CANVAS and
- Be between 4,000 and 5,000 words, excluding figure and table legends.
- Describe your implementations of the bio-inspired algorithms, noting any interesting aspects.
- Your report should contain the following sections:
  - Introduction
  - **For each Task Implemented:**
    - Methods and Development Rationale
    - Results
  - Discussion and Conclusion
  - References
- Report the results of your experimental investigation. For instance, you might want to use tables, figures, graphs and plots to illustrate your results.
- Referring to these results, discuss which decisions you made that might have affected the performance of your implementations, and say why you think this is the case.
- Prepare a discussion and conclusion addressing the difference between the development of a controller using BBR approach and Evolutionary Robotics approach. As a PG student you must present a thorough discussion of both methods and also make comparisons with other methodologies used to create intelligent robot controllers.
- Include useful references to the wider literature. For instance, you might use references to books, papers and articles to justify particular implementation choices, or you could compare your findings to those reported elsewhere. Use the requested standard referencing style for this, i.e., the Harvard Referencing Style.

You should submit both your report (as a **.pdf** file), short videos (on a **.zip** file) and your code (on a **.zip** file) to CANVAS using the links provided. Grading will use the assessment criteria given in the table below.

NOTE: Your CODE **should not** be uploaded as a PDF, as we need to be able to run your code. If we can NOT run your controller, your CW2 will not be marked, and you will receive 0 marks.

Marking scheme for F21RO Coursework

Please note that all tasks will be assessed following the corresponding criteria below.

Criteria	Weight	A (70-100%)	B (60-69%)	C (50-59%)	D (40-49%)	E/F (<40%)
Implementation *(i.e. code for Tasks, and evaluation, comments and documentation)*	40%	Creative implementations of each Task that exceed the basic requirements. Correct evaluation code. Easy to read and well structured.	Correct implementations of the basic requirements. Generally good coding, structure and documentation.	Some significant issues in terms of correctness, structure, coding practice and documentation.	Major issues in terms of correctness, structure, coding practice and documentation.	Critical errors: for example, the code does not compile and/or run, or inappropriate algorithms have been implemented.
Experimental study *(i.e. choice and validity of experiments performed, presentation of results, including short video)*	25%	Robot behaviours investigated are well motivated and the rationale for choices made are well ellaborated. Suitable results have been collected and are clearly presented and meaningful.	Some minor issues in terms of the motivation or description of resultant robot behaviours, the experiments performed, or the presentation of results.	Some significant issues in terms of the motivation or description of of resultant robot behaviours, the experiments performed, or the presentation of results.	Some major issues: experiments do not make sense, have invalid results, or the Tasks and studies are not adequately described.	Some critical issues: experimental study is nonsensical or missing, the experiments are inappropriate, or the description of the studies are uninformative.
Wider discussion *(i.e. intro, interpretation of results, conclusions, use of the wider literature)*	25%	Clear, insightful discussion that shows a good understanding of BBR (behaviour based robotics) and ER (evolutionary robotics) and includes well chosen references to the wider literature.	Generally clear and insightful, but shows some misunderstanding of BBR (behaviour based robotics) and ER (evolutionary robotics) . Adequate use of the wider literature.	The discussion is limited in terms of the depth or volume of understanding it demonstrates. Little or no use of the wider literature.	Some major issues in terms of depth or volume of understanding. No use of the wider literature.	No real demonstration that the subject matter has been understood, or very limited in its scope.
Report *(i.e. structure, language, referencing etc.)*	10%	Report is well structured and divided into sections; good use of language; consistent use of font Arial, size 12; perfect use of Harvard referencing style	Report is suitably structured and divided into sections; mostly good use of language; use of font Arial, size 12; use of Harvard referencing style	Report is structured but not divided into sections; language issues that affect readability; inconsistent use of fonts and sizes; mixed use of referencing styles	Report is poorly structured; substantial language issues that affect readability; use of different fonts and sizes; no referencing style	Report has a nonsensical structure; language issues make it very hard to read; use of different fonts and sizes; no referencing style