F20/21RO - Intelligent Robotics - Coursework (CW)

This assessment is worth 50% of your course mark.

Due Date and Time

Edinburgh Students(UG and PG):

3:30 pm (Edinburgh local time)**, Friday 25th November 2022 (Week 11)**

Dubai Students(UG and PG):

11:59 pm (Dubai local time)**, Friday 25th November 2022 (Week 11)**

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 an 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. By submitting this coursework you agree to all terms and conditions highlighted on the next page.
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 serious 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 contact your Personal Tutor immediately, and complete and submit a mitigating circumstances application.

Declaration of Contribution and Authorship

Each group should download and sign the "Coursework Group Signing Sheet" and upload it (in PDF format) together with the other assessment material @ CANVAS.

The "Coursework Group Signing Sheet" is a document containing a declaration of authorship and the actual contribution to this assessment. It should be signed by each member of the group.

Your work will not be marked if a signed copy of this sheet is not included with the group's coursework submission.

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 **three people**. Each group will develop controllers for a robot to perform given tasks by the deadline set above.

You will be randomly matched with other CW partners, no collaboration beyond that is allowed.

Groups will be communicated at most by 28/10/2022 (Friday) via CANVAS, with the subject: "F20RO 2021 – CW PARTNERS" for UG students and "F21RO 2021 – CW PARTNERS" 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 controllers (in any programming language(**)) for a set of tasks using the Webots simulator software.

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

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

DUBAI STUDENTS: PLEASE CONTACT Prof TALAL SHAIKH (t.a.g.shaikh@hw.ac.uk) IF THERE ARE PROBLEMS IN YOUR GROUP.

Coursework Detailed Description

1) PROBLEM

A “robot-rat” should start at the beginning of the first T-Maze arm and move forward towards the end of the second arm, by turning right or left at the end of the first arm. The robot should move forward in the T-Maze while avoiding obstacles (e.g., the T-Maze walls).

The ‘food/reward’ will be at the end of one of the second arms. The robot should turn right at the end of the first arm corridor if the “robot-rat” senses a clue left in the environment (e.g., a black mark on the floor in the middle of the first arm). Otherwise, the robot should turn left (Figure 2 - A and B).

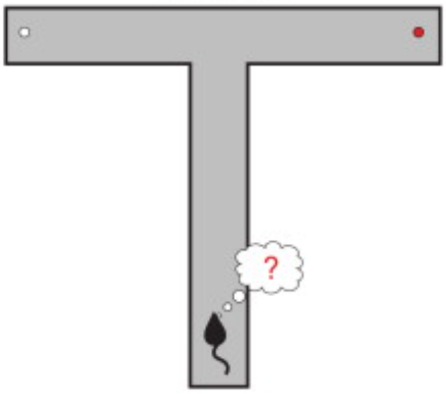

Figure 1 - T-Maze with 2 arms

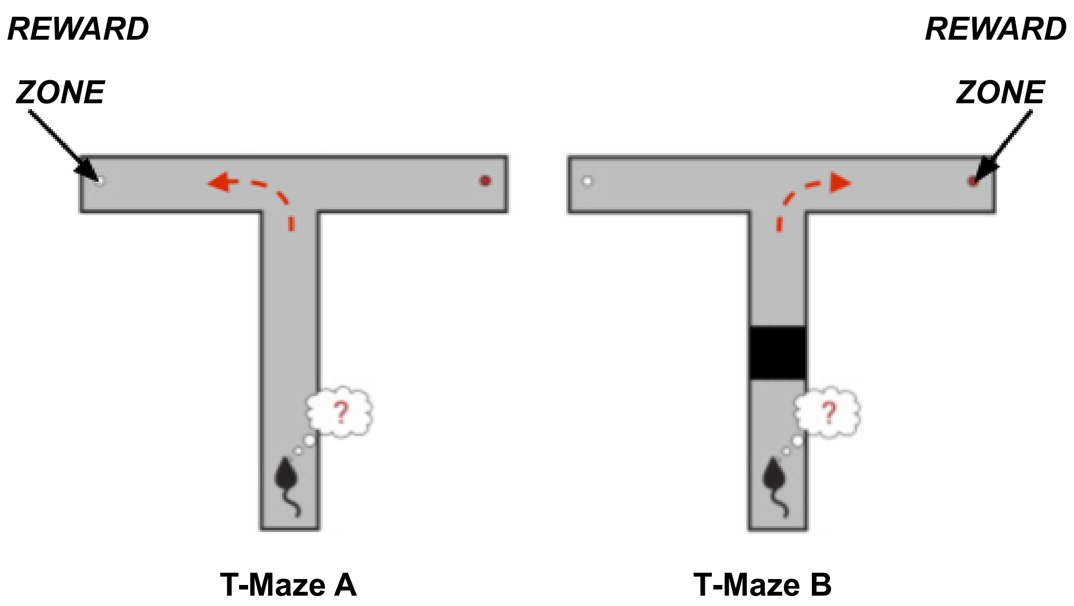

Figure 2 - **T-Maze A** without marks on the floor, indicating the ‘robot-rat’ that it should turn left at the end of the first arm corridor going towards the reward zone. **T-Maze B** with a black mark on the floor, indicating the ‘robot-rat’ that it should turn right at the end of the first arm corridor going towards the reward zone.

TASK 1: You should create a Behaviour-Based Robotics (BBR) approach robot controller to control a single “robot-rat” that is able to solve the **PROBLEM** stated above. You should train your robot using the arena (i.e., world files) provided to you on CANVAS.

TASK 2: Create a robot controller using the Evolutionary Robotics (ER) approach to control a single “robot-rat” that is able to solve the **PROBLEM** stated above. You should train your robot using the arena (i.e., world files) provided to you on CANVAS.

(*) For Task 2, you can find an initial code of the robot evolutionary robotics approach controller on your Lab 3 git repository on CANVAS, with many gaps that you need to fill in so that your controller will run properly. More info on Lab 3 material.

Marks on all Tasks are awarded for creativity and performance as well.

For both Tasks 1 and Task 2, you should aim to create the quickest “robot-rat”, i.e. the “robot-rat” that could explore the T-maze in less time while searching for the food/reward zone. Therefore you should record the time spent to find and stop at the *REWARD ZONE* at T-Maze A and T-Maze B, on the average of three runs for your best BBR and ER controllers.

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 1 T-Maze A				
Task 1 T-Maze B				
Task 2 T-Maze A				
Task 2 T-Maze B				

The basic rules are the following:

- Use the e-puck robot as your “robot-rat”. The e-puck is available in the Webots simulator together with 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.

Activities for each Task

Activity 1*

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

Activity 2*

Choose the appropriate 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 each Task showing the final best robot behaviour in both **T-Maze A and T-Maze B** .

Collect data that would illustrate the corresponding final robot behaviour.

Collect statistics for each run for Task 1 and Task 2.

*** you can refer to the past lab 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 in both **T-Maze A and T-Maze B**.

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, VIDEOS and CODE (Undergraduate Students): Write a research report and submit the report, your code and signing sheet to CANVAS

Your research report should:

- Be between 2,500 and 3,000 words (final **Word Count** should be added to the header of the document), excluding figures, tables and references.
- 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 Implementation 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 the BBR approach and the 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 your report (as a **.pdf** file), the “Coursework Group Signing Sheet” signed by all members of the group (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, VIDEOS and CODE (Post Graduate Students): Write a research report using an IEEE paper format and submit the report, your code and signing sheet to CANVAS

Your research report should:

- Use the IEEE paper template available on CANVAS and
- Be between 4,000 and 5,000 words (final **Word Count** should be added to the header of the document), excluding figures, tables and references.
- 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 Implementation 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 the BBR approach and the 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.

You should submit your report (as a **.pdf** file), the “Coursework Group Signing Sheet” signed by all members of the group (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. (*)
Please ignore the requirement for Harvard Referencing Style when using the IEEE template.

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