F20/21RO - Intelligent Robotics - Coursework

This assessment is worth 50% of your course mark

Due: 3:30 pm, Friday 28th November 2025 (Week 12)

Overview

This assessment is designed to deepen your understanding of robot simulators and software tools by guiding you through the development of intelligent robot controllers using advanced bio-inspired techniques covered in the course. You'll work with a widely used robot simulator (webots) to configure specific environments, apply bio-inspired algorithms, and analyze the resulting robot behaviors to draw meaningful conclusions.

You will work in groups of four, with each group responsible for developing two distinct robot controllers to complete assigned tasks by Week 12.

Group formation should be done via the Canvas group page by the end of week 8.

All controllers must be developed using Python within the Webots simulator environment.

Support Contacts:

If you encounter any issues within your group:

For Edinburgh Campus,
please contact Christian Dondrup at c.dondrup@hw.ac.uk

For Dubai Campus,
please contact Talal Shaikh at t.a.g.shaikh@hw.ac.uk

For questions about the coursework, please ask during the lab slots or post your question on the discussion board:
https://canvas.hw.ac.uk/courses/31900/discussion_topics/211121

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 the deadline which is 19/12/2025.

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 written yourself, 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

Note 1: We suggest that your group of 4 splits into two groups of 2. One group attempts to solve task 1 and 2, the other group addresses task 3.

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: In this task, your goal is to **evolve** a controller for the e-puck robot that can navigate a race circuit (Speed World) efficiently using an Evolutionary Robotics approach. The robot must follow a line on the ground while avoiding obstacles. If an obstacle blocks the path, the robot should intelligently maneuver around it and rejoin the line to continue racing. The objective is to minimize the time taken to complete the circuit, with performance measured over three runs.

This environment is designed to test your ability to:

Develop a robust fitness function that balances speed, accuracy, and obstacle avoidance.

Tune genetic algorithm parameters for optimal evolution.

Implement adaptive behavior that allows the robot to recover from disruptions and stay on course.

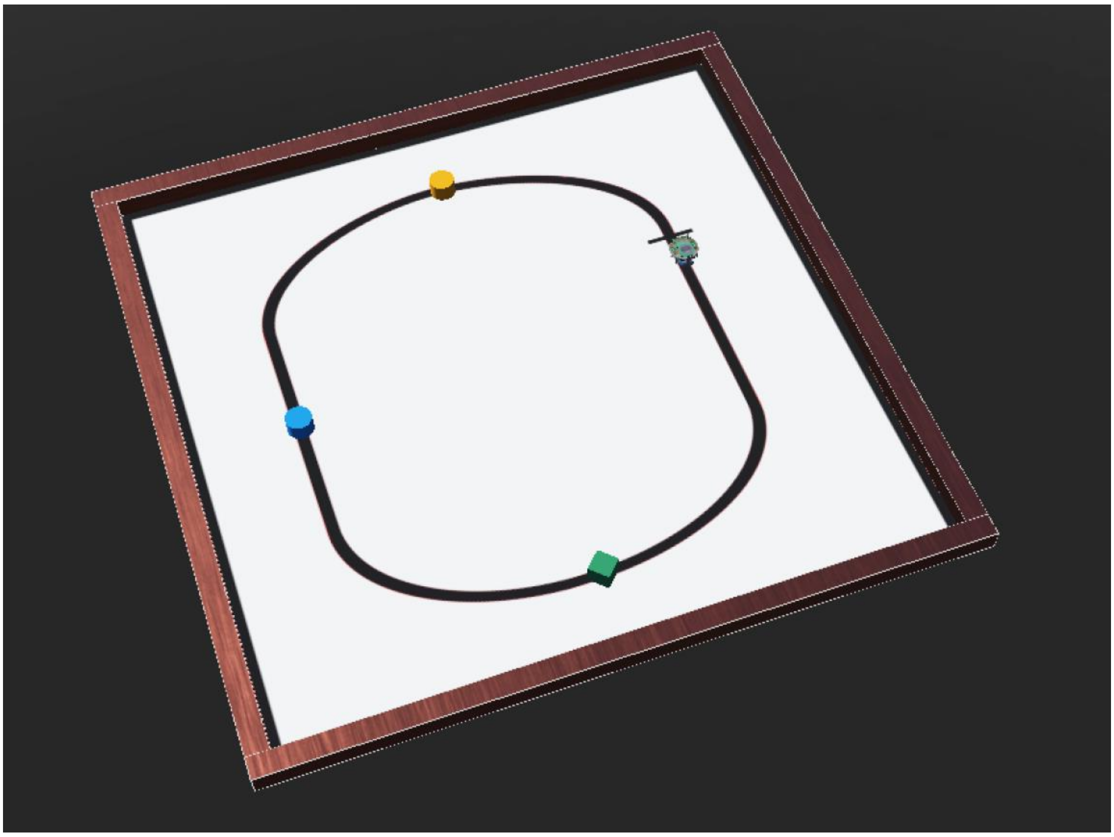


Figure 1 - Speed World display

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 poster:

Table 1: Statistics.

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

Note 2: When you load the world file, you will encounter a Python error. This is expected and occurs due to incomplete sections in the code. These gaps are intentionally left for you to fill in, based on the fitness function you choose to implement. Make sure your fitness function aligns with the behavior you want the Epuck controller to exhibit.

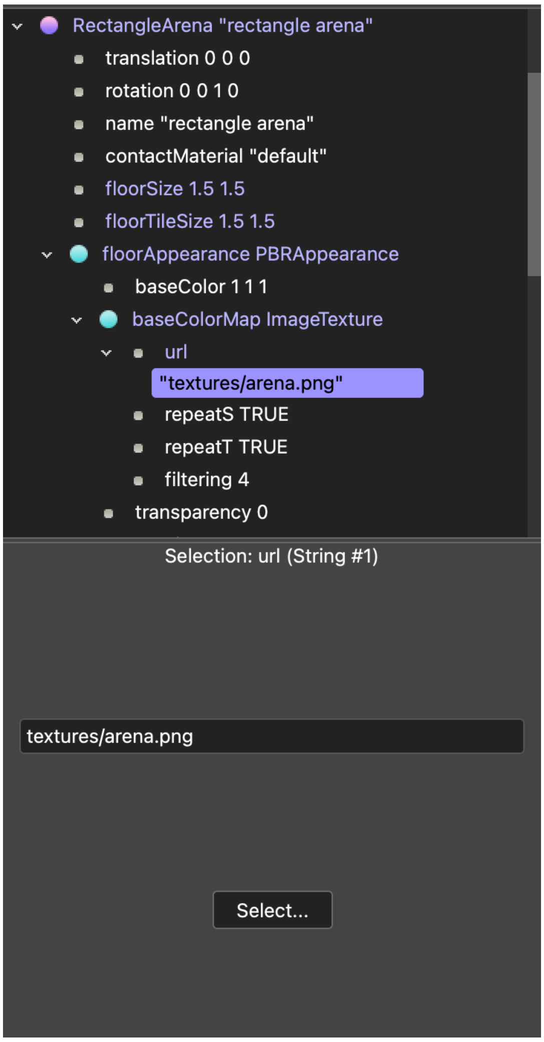
The basic rules are the following:

- Use the e-puck robot available in the Webots simulator and the given world 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 simulation 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 of whether the robot(s) have completed the task or not.

Any special debugging if

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 *arena.png*

NOTE 3: 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).

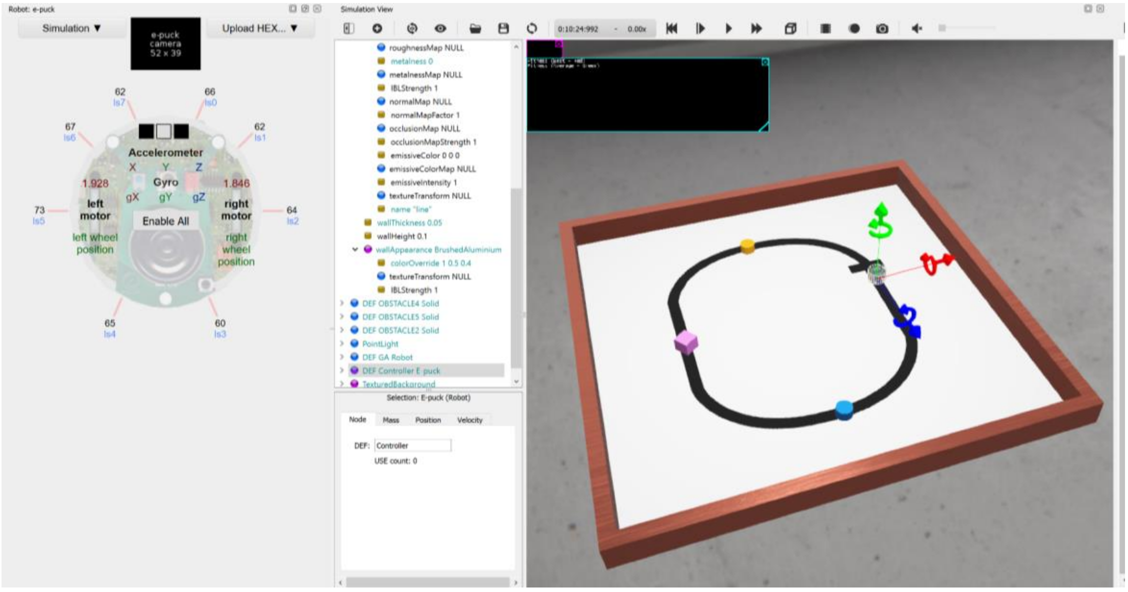


Figure 3 – Robot Window viewer

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 4 min) for the each Task showing the final robot behaviour for each controller.

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.**

Poster & Video Presentation

This includes a poster, a group video presentation, and the code implementation. It is designed to assess both technical understanding and communication skills.

1. Poster Requirements

Your (size A1) research poster should summarize your work clearly and professionally. It must include:

Structure & Content

Title: Include your group name, the names and H numbers of all participants, and the project title.
Introduction: Briefly explain the goal of the coursework and the robot tasks.

Task Breakdown:

Behaviour-Based Robotics (BBR) approach.
Evolutionary Robotics (ER) approach.

For each task:

Methods & Development Rationale: Describe how you implemented the controller, including algorithms used and design decisions.

Results & Analysis: Use graphs, tables, and plots to show performance metrics (e.g., time to complete circuit, obstacle avoidance success).

Comparative Discussion:

Highlight similarities and differences between BBR and ER approaches.

Discuss strengths, limitations, and use cases of each.

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.

Conclusion: Summarize key findings and reflect on what worked well and what could be improved.

References: Use Harvard Referencing Style to cite relevant literature, tools, and algorithms. 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.

Poster Marking Criteria

Your poster will be assessed on:

Content Quality – clarity, depth, and relevance of information.
Layout & Design – visual appeal, readability, and logical flow.
Results Presentation – use of visuals to support findings.
Comparative Insight – quality of discussion between BBR and ER.
Contribution List – clarity on who did what.

2.Video Presentation Requirements

Your group must submit a 10-minute video showcasing your work. The format is:

Structure:

Total Duration: 10 minutes
Group Size: 4 students

Presentation Breakdown:

4 minutes: Two students present the BBR approach.
4 minutes: The other two students present the ER approach.
2 minutes: Two students (one from the BBR and one from the ER approach) discuss the contrasts and similarities between the two approaches.

Participation

Every student in the group must speak during the video. You may use slides, screen recordings of simulations, your poster, or annotated visuals to support your explanation.

3. Submission Instructions

Submit the following to CANVAS:
Poster: PDF format
Video: ZIP file (max 10 minutes)
Code: ZIP file (must be executable; do not upload as PDF)

Important: If your code cannot be run in Webots 2023b, your CW will receive 0 marks.
Only the latest submission will be considered for marking.

Marking scheme for F20RO/F21RO Coursework

Criteria	Weight	A (70-100%)	B (60-69%)	C (50-59%)	D (40-49%)	E/F (<40%)
1. Implementation & Technical Rationale (Explaining the technical development of the controllers)	30%	**Video:** Presents a clear, detailed, and technically rich verbal explanation of the BBR and Evolutionary Robotics controllers. The rationale for implementation choices is expertly justified. **Poster**: Provides an excellent visual summary (e.g., diagrams, flowcharts) of the implementations that perfectly complements the video explanation.	**Video**: Delivers a good technical explanation of both controller implementations with sound reasoning for most design choices. **Poster**: Effectively summarizes the implementations, providing a good visual aid to the video.	**Video**: Gives a satisfactory verbal explanation of the implementations, but it lacks technical depth. **Poster**: Provides a basic summary of the implementations, but may be missing key visual aids.	**Video**: Offers a poor verbal explanation of the implementations with significant technical gaps or inaccuracies. **Poster**: The summary of the implementation is confusing or minimal.	**Video**: Critically lacks a technical explanation of the controllers. **Poster**: Fails to provide any meaningful summary of the implementation.
2. Results & Performance Analysis (Presenting and interpreting experimental outcomes)	25%	**Video:** Superbly showcases the robot's final behaviours using high-quality video evidence. The verbal analysis of performance and data is insightful and thorough. **Poster**: Displays key results (e.g., completed statistics table, graphs, screenshots) in a highly clear and professional manner.	**Video**: Clearly demonstrates the robot's behaviours. The verbal analysis is adequate and covers the main points. **Poster**: Presents the key results clearly, with all required elements (like the table) included.	**Video**: Shows the robot's behaviours, but the verbal analysis is basic and lacks depth. **Poster**: Presents results, but the data is unclear, or elements are missing.	**Video**: Major issues in demonstrating the robot's behaviour or verbally analysing it. **Poster**: The presentation of results is flawed, incomplete, or makes little sense.	**Video**: Fails to show the results of the experimental study. **Poster**: Key results are missing, nonsensical, or do not relate to the tasks.
3. Comparative Discussion & Evaluation (Critically comparing the two bio-inspired approaches)	20%	**Video**: Features an insightful and critical spoken discussion comparing BBR and Evolutionary Robotics, using specific project examples to support arguments. **Poster**: Includes a	**Video**: Presents a clear discussion comparing the two approaches, covering the main points effectively. **Poster**: Has a clear section that	**Video**: Delivers a basic, largely descriptive comparison of the two approaches. **Poster**: The summary of the comparison is superficial or	**Video**: The verbal comparison is minimal, confusing, or contains inaccuracies. **Poster**: There is little to no content	**Video**: No real attempt is made to verbally compare or evaluate the two development approaches. **Poster**: Fails to

		dedicated section that visually and textually crystallizes the comparison, effectively highlighting similarities and differences.	summarizes the comparison between the two approaches.	lacks a dedicated section.	comparing the two approaches.	address the comparison of the two approaches.
4. Video Presentation & Teamwork (Quality of the video delivery and evidence of collaboration)	15%	The video presentation is highly professional, engaging, and adheres to the 10-minute time limit. All students participate meaningfully, speak clearly, and demonstrate excellent collaborative effort.	The video presentation is clear and well-practiced, with good participation from all members. Minor issues with pacing or delivery may be present. Evidence of teamwork is clear.	The video is understandable but lacks polish. Participation may be unbalanced, or there could be issues with audio/visual clarity or timing. Teamwork is adequate.	The video is poorly structured and difficult to follow. Delivery is unclear, and participation is highly unbalanced, suggesting poor collaboration.	The video is unprofessional and nonsensical. There is a clear lack of preparation and no evidence of teamwork.
5. Poster Design & Synthesis (Visual layout, clarity, and content summary on the poster)	10%	The poster has an outstanding visual layout that is both professional and easy to read. It serves as an excellent, concise summary that perfectly synthesizes and complements the video. The contribution list is clear and detailed.	The poster is well-structured with a clean layout. It effectively summarises the key points from the presentation. The contribution list is present and clear.	The poster layout is functional but visually uninspired or slightly cluttered. It summarises some, but not all, key points from the video. The contribution list is present but may lack detail.	The poster is poorly designed, cluttered, or difficult to read. It does a poor job of summarising the project. The contribution list is missing or incomplete.	The poster has a nonsensical structure, is very hard to read, and does not relate to the video presentation. A contribution list is absent.