Group Project Descriptor: Developing an Intelligent Line-Following Algorithm for the Quanser Qbot

Course: ENG5337 Advanced Artificial Intelligence

The objective of this project is to apply advanced AI techniques learned during the course to develop a robust line-following algorithm for the Quanser Qbot. In groups, students will develop their chosen framework in Python and test it in the simulated Quanser warehouse environment.

Project Description

Students will work in groups to select an AI framework and use it to create a line-following algorithm for the Quanser Qbot. The project will be divided into the following phases:

1. Data Selection and Model Identification:
    - Identify the key characteristics of the line-following task. Based on these select the input data (consider what sensor data you will use and how you will filter and process this). Consider the labels you will assign to the input data. Make sure to take on board feedback from the individual project submitted earlier in the semester.
    - Choose a neural network model to implement. Feel free to explore models beyond those introduced in the coursework. Things to consider when making this decision include: the nature of the problem (type of input data and labelling), the size of your dataset, computational expense, and model complexity.
2. Algorithm Development:
    - Develop a neural network model using PyTorch for the labelled data you have collected in step one.
    - Remember to consider your cost function, optimiser, regularisation etc. and to tune your hyperparameters (eg. learning rate, batch size, activation function, number of layers/neurons).
    - Evaluate the performance of your model on your test data.

Remember! Once you have collected your data in the Quanser software, you should develop and test your model outside of the Quanser environment. Once you are happy with the model's performance, you can save the model file and then load it within the Quanser environment for deployment.

3. Simulation Testing:
    - Test the model from Step 2 in the Quanser simulated environment (please use the warehouse environment we've used in tutorials).
    - If the Qbot does not successfully follow the line, you may have to revisit steps 1 and 2 and refine your strategy.
4. Benchmarking:
    - In the individual project, you were asked to develop a function which measured the accuracy of your line follower. Please **identify at least one other metric** which evaluates the robot's performance.
    - Use these performance metrics to compare the developed NN driven line-following algorithm with the classic control line-following algorithm provided in the Quanser tutorials.

Deliverables

This project will be evaluated in an oral group presentation:

- 5 minute demo: The group will be asked to demo their line follower live. Note you may be asked by markers to manually move the robot to a designated location and follow a specific line.
- 15 minute presentation: The group will then give a 15 minute presentation outlining their methodology and benchmarking performance. The markers will be looking for justification behind each decision made in the design of the methodology. The group should also include suggestions for refining and improving their presented framework.
- 10 minute Q&A.

Groups must submit their slides by 5pm on Wednesday 26th March 2025. You should also submit a zip file with all of the necessary Quanser scripts required to run the line-follower (don't forget the qbot_platform_functions.py file), the NN model file, and the python script in which the model was trained, validated and tested.

Evaluation Criteria

- Justification of input data and labelling system and model selection (20%)

- Algorithm Development and Performance (50%): Model development and tuning. Justification of approach. Testing and validation of the NN framework and successful deployment in the Quanser Interactive Labs software
- Benchmarking (20%): Comparison of performance against standard line following code from Quanser using suitable metrics.
- Suggestions for Improvement (10%): Further development and refinement considerations.
- Team Collaboration: Evidence of effective teamwork and collaboration throughout the project. Group members will be asked to weight their team members (and their own) contributions, and this may be used to adjust individual grades.