Coursework: Integrating brain-inspired constraints in neural network models.

For this coursework, you are tasked with exploring the integration of brain-inspired changes into artificial neural network models, and critically analysing the networks' behaviour.

Your task will be to:

1) Critically discuss how changes to the following can be used to impose brain-like constraints on an artificial neural network, with examples (using equations or figures where helpful).
    a. the architecture [5]
    b. the cost function [5]
    c. the learning rule [5]
    d. anything else (e.g. training data or curriculum, time constants etc.) [5]
2) NeuroGym is a curated collection of neuroscience tasks, with a common interface, designed to facilitate training of neural network models on neuroscience tasks.
    a. Initially, your goal is to train and compare multiple (at least two) models to perform one of these tasks. One model should be a standard recurrent neural network model (e.g. vanilla RNN, leaky RNN, light GRU, GRU, LSTM). One or more of the other models you implement should differ from the standard model based on a brain-inspired change (which you described in your answer to question 1). Describe your models including equations and schematic diagrams, highlighting the key differences. [10]
    b. Compare your models both in how well they learn to perform the task, and by analysing the hidden unit activity of the trained models to understand how the trained models solve the task. Highlight and interpret any differences between the models. [20]
    c. Using the same models, train them to solve a second task from Neurogym, and analyse them as in b). Do your conclusions from b) hold for this second task? [20]
    d. These marks are reserved for something original. Some possibilities could be training networks with a totally different architecture, implementing a different type of learning (e.g. reinforcement), implementing neuromodulation, training on multiple tasks at once, or many tasks or anything else unexpected. Anything presented in this section should be done so in comparison with what you know about how brains and standard ML/AI models learn. This part is only worth 20% of the coursework marks [10% of total], so please do not spend a disproportionate amount of time on it. [20]
3) Conclude with a brief discussion, summarising what you have learned from your analyses, with reference to the literature. [10]

Submission Guidelines:

Your report should be submitted on Blackboard (Cognitive Artificial Intelligence → Assessment, submission, and feedback).

Include the report in PDF format, with necessary code snippets and diagrams embedded. Full code should be submitted as supplementary material (e.g. via a link to a github repository).

Note 1 : Where possible cite papers and/or use simulations/plots to support your claims.

Note 2 : Collaborative work is encouraged for example, for coding and understanding of the algorithm, but every submission should be individual/unique.

Note 3: While AI assistance such as ChatGPT can be used for initial guidance, the final submission must reflect a deep personal understanding of the material. Code and experimental results should be original.

Support provided

We cannot provide direct support on the coursework, but we (TAs and Lecturers) can help with questions you might have about the lectures and labs/workshops. We will be available during the usual lab/workshop times as in your timetable though we may sometimes only be available online.

Deadline

The deadline for submission of all optional unit assignments is 13:00 on Tuesday 26th of November. This is a couple of days earlier than other units to avoid a pile-up of deadlines for you, the students.

Time commitment and marking

You are strongly advised NOT to try and work excessive hours during the coursework period: this is more likely to make your health worse than to make your marks better. If you need further pastoral/mental health support, please talk to your personal tutor, a senior tutor, or the university wellbeing service.

Academic Offences

Academic offences, including submission of work that is not your own, falsification of data/evidence or the use of materials without appropriate referencing, are all taken very seriously by the University. Suspected offences will be dealt with in accordance with the University's policies and procedures. If an academic offence is suspected in your work, you will be asked to attend an interview with senior members of the school, where you will be given the opportunity to defend your work. The plagiarism panel is able to apply a range of penalties, depending on the severity of the offence. These include: requirement to resubmit work, capping of grades and the award of no mark for an element of assessment. It is your responsibility to know the University's rules and guidance on using AI:

Exceptional circumstances

If the completion of your assignment has been significantly disrupted by serious health conditions, personal problems, periods of quarantine, or other similar issues, you may be able to apply for consideration of exceptional circumstances (in accordance with the normal university policy and processes). Students should apply for consideration of exceptional circumstances as soon as possible when the problem occurs, using the following online form: https://www.bristol.ac.uk/students/support/academic-advice/assessment-support/exceptional-circumstances/submit/

You should note however that extensions of any significant length are not possible for optional unit assignments. If your application for exceptional circumstances is successful, you may be required to retake the assessment of the unit at the next available opportunity (for example, during the summer reassessment period).