COMP5400: Biological and Bio-Inspired Computation
Coursework 2:
Miniproject in Biocomputation, Biorobotics or Bioinspired Computation

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Marking
This coursework is summative and is worth 60% of the total grade for this module.

Assessment
There are two components to this assessment:

- A presentation in front of the class (currently planned in person) after the Easter break worth 50% of the marks. The presentation time will be within the two weeks following the Easter term break.
- Written submission worth 50% of the marks: this will include **one** of the following:
    - Software submission + documentation
    - A report presenting your work.

  The written report will be due by: **10am on Monday, 25 April. 2022.**

Note: This coursework is worth 60% of the marks, and the time allotted to it should be commensurate.

Plagiarism
Projects are individual. You may discuss your project with others, but must do your own work and submit your own work. It is strictly prohibited to borrow or share code. You may help each other with mock presentations or discussions about projects. You may also discuss material covered lectures, your related reading and ideas relevant to the coursework together with your peers.

Overview

Part I: Picking a topic and objective
Choose one of the topics we have covered in lectures, or any other related topic.
Define one specific task for your miniproject. Possible tasks may fall into one of a number of categories:

- Implementation and testing of a bio-inspired approach in a specific problem context
- Algorithm benchmarking or extension in a specific problem context
- Critical discussion of an algorithm
- Critical comparison between different approaches or schools of thought regarding a particular, well defined topic, problem or algorithm
- A critical analysis or discussion of a bio-inspired algorithm, approach or school of thought, etc.

Notes:

- A list of potential topics and objectives are included at the end of this document.
- Multiple students may choose the same topic.

Part II: Presentations

- 10 minutes will be allotted per project (8 minutes including the presentation and time for questions and answers, and 2 minutes for a handover between speakers).
- A characteristic template for presentations includes
    - A clear introduction of the topic and problem statement
    - Relevant Background
    - Methodology/Approach taken
    - Results/Outcomes
    - Discussion and Conclusions

  You may choose to follow this template or adapt it to better fit your specific topic.

The following Mark Scheme will be used (out of 50 point):

Clarity and appropriateness of problem statement and introduction	10 pts
Coverage and evidence of understanding of the relevant background	10 pts
Quality of the work presented (including scope, achievement, methodology, results and conclusions)	20 pts
Quality and clarity of the presentation (including answers to questions)	5 pts
Appropriateness and effectiveness of the structure and style of the presentation (including sticking to the time)	5 pts

Part III: Written submission.

- If the primary component of your coursework was a practical one (involving implementing new software or the modification/extension/exploration of software), a written report is not required. However, you must submit your code, documentation, a readme file with compilation/running instructions, a make file (if appropriate) and (if appropriate) sample inputs/outputs (e.g. inputs/outputs used in your presentation). Your submission should consist of a single zip or tar file.
- If the primary component of your coursework involved a review or critical analysis or a theoretical exploration of some topic, you are required to submit a report. Report length should be no longer than 10 pages, using 11 point font, including figures but excluding references.

Part IV: Suggested/Sample topics and objectives. The following topics are not exhaustive. Students are free to follow up on other suggestions made during lectures, or to suggest their own topics.

A critical analysis of a single paper in the literature, or of a relevant book.
Guidance: reports should not review an entire paper, but consider a fundamental question that is either addressed in the paper, or neglected by it or somehow circumvented. The question must be clearly articulated. Other references may be used to evidence your arguments or to support your approach or conclusions.

- Brooks, "Intelligence without reason" (1991), https://people.csail.mit.edu/brooks/papers/AIM-1293.pdf
- Brooks, "Intelligence without representation" Artificial Intelligence **47**(1–3), pp. 139-159 (1991), https://doi.org/10.1016/0004-3702(91)90053-M.
- Book by Daniel Amit (1989): "Modeling Brain Function: The World of Attractor Neural Networks"
- Dennett "Why not the whole Iguana" Behavioral and Brain Sciences **1**, pp. 103-4 (1978), https://doi.org/10.1017/S0140525X00059859
- Ijspeert et al., (2007) "From swimming to walking with a salamander robot driven by a spinal cord model", Science **315**(5817), pp. 1416-20. doi: 10.1126/science.1138353.
- Boyle et al., "Adaptive Undulatory Locomotion of a *C. elegans* Inspired Robot" IEEE/ASME Trans. Mechatronics **18**(2), 439-448 (2013).
- Lechner, Hasani and Grosu, "Neuronal Circuit Policies" (2018), https://arxiv.org/pdf/1803.08554.pdf
- Marom and Shahaf (2002) "Development, learning and memory in large random networks of cortical neurons: lessons beyond anatomy" Quarterly Reviews of Biophysics, 35(1), 63-87. https://doi.org/10.1017/S0033583501003742
- Li et al. "A Novel Robot System Integrating Biological and Mechanical Intelligence Based on Dissociated Neural Network-Controlled Closed-Loop Environment." PLoS ONE 11(11): e0165600. https://doi.org/10.1371/journal.pone.0165600
- Artificial Immune Systems: any number of articles would be accepted. A recent review of the area is given by: R. Pump, V. Ahlers and A. Koschel, "State of the Art in Artificial Immune-Based Intrusion Detection Systems for Smart Grids," 2018 Second World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4), 2018, pp. 119-126, https://doi.org/10.1109/WorldS4.2018.8611584

Biological inspiration in artificial neural networks

- Various topics can be considered, e.g. exploring analogies between biological and deep neural networks, or common features of both; the validity of backpropagation as a model of biological learning, what deep neural networks can teach us about biological vision, etc.
- Implement or explore an implementation of Hopfield Networks and evaluate their performance.
- Implement or explore an implementation of Self Organising Maps and evaluate their performance.

Neurorobotics

- Using the mouse demo in BEAST, replace the evolutionary learning with other neuro/bioinspired training algorithms. Can you outperform the evolutionary algorithm?
- Using the mouse demo in BEAST, explore different neural architectures. Can you outperform the existing solution?
- Implement or adapt an existing implementation of a simulated hexapod robot based on the original implementation by Gallagher et al. "Application of evolved locomotion controllers to

a hexapod robot" Robotics and Autonomous Systems **19** (1)pp. 95-103 (1996): https://doi.org/10.1016/S0921-8890(96)00036-XGet

Molecular and cellular computation, cellular automata, etc.

- Artificial Life, a critical exploration of Conway's Game of Life (For the first popular description of the game, see Scientific American **223**(4) (October 1970), pp. 120-123. https://www.jstor.org/stable/24927642
- Implement or explore existing implementations of Lindenmayer systems.

Evolutionary and/or co-evolutionary algorithms

- Implement evolutionary and co-evolutionary algorithms, replicating or adapting the algorithm presented by Hillis (1990) for list sorting. Demonstrate successful list sorting.
- Systematically study an aspect of evolutionary (or co-evolutionary algorithms) within the context of one of the demos in BEAST.

Swarm Intelligence/Collective behaviour/Self organization and self-assembly

- Implement a flocking algorithm in BOIDS or in a software framework of your choice. Analyze the contribution of the different rules.
- Implement a flocking algorithm in BEAST.
- Implement the Game of Life in BEAST
- Implement or experiment with an existing implementation of Conway's Game of Life (if using an existing framework.
- Implement an ant-inspired graph partitioning algorithm.
- Bacterial colonies can form fractal patterns on a dish. What is the underlying algorithm and how does it work? (A demo simulating such pattern formation is available in BEAST.)
- Pick a topic relating to the collective behaviour of pedestrians and present a critical analysis of the topic (e.g., comparing different models).