Course Outline

COMP 5206F for Fall 2021
Evolutionary Computing and Artificial Life

Course Information
Instructor: Dr. Mikhail Genkin
Contact: michael.genkin@carleton.ca
Classroom: Virtual classrooms will be set up on Brightspace and Discord.
Lectures: Tuesdays and Thursdays from 11:35 a.m. to 12:55 p.m. EST, delivered via Zoom (the link to the Zoom meeting and the Discord server will be posted on Brightspace). Most lectures will be synchronous, but some may be pre-recorded. If the technology cooperates, recordings of all lectures will be made available for viewing as well.
Assignments: Assignments will be posted on Brightspace.
Office Hours: Arranged by request.

Course Description

Introduction to the theory and application of naturally occurring systems for the creation of computer algorithms. Topics from Evolutionary Computing, Swarm Intelligence, Neural Networks and Artificial Immune Systems will be studied.

Objectives:

Short Description

The principal objective for this course is to have students understand the principles underlying naturally occurring systems and how they can be used for the creation of computer algorithms.

Long Description

The principal course objective is to have a student solve problems using algorithms inspired by the study and analysis of naturally occurring systems. The motivation for this objective is that naturally occurring systems solve complex problems in a robust, scalable, fault tolerant manner using decentralized, self-organizing processes.

During the course a student can expect to analyze several naturally occurring systems which include ant colonies, flocks of birds and evolutionary systems. Tools and techniques used in the analysis of complex systems will also be presented. In order to achieve the above, numerous open-source software packages will be introduced. These may include: JGAP, NetLogo, JAMA. Assignments will be application-centered and test a student's understanding of the material presented during the lectures.

Prerequisites

COMP 3007, or permission of the department.

Required Textbook(s) and Other Resources

There is no mandatory textbook assigned to this course. The following textbooks are recommended to complement the course notes and lectures:

- o Leandro Nune de Castro, "Fundamentals of Natural Computing: Basic Concepts, Algorithms and Applications"

- o Dario Floreano and Claudio Mattiussi, "Bio-inspired Artificial Intelligence: Theories, Methods and Technologies"
- o Eric Bonabeau, Marco Dorigo and Guy Theraulaz, "Swarm Intelligence: From Natural to Artificial Systems"
- o Melanie Mitchell, "An Introduction to Genetic Algorithms"
- o Content is also provided through web links associated with each lecture prefixed by the tag **READING:**

All materials created for this course (i.e., course notes, coding examples, lecture recordings, tutorials, tutorial code, assignments, assignment code bases, marking schemes, tests, exams, and test solutions) remain the intellectual property of the instructor. They are intended for the personal and non-transferable use of students registered in the course. Reproducing, reposting, and/or redistributing any course materials, in part or in whole, without the written consent of the instructor, is a **copyright violation** and is **strictly prohibited**.

Students will be required to use Eclipse, JGAP and NetLogo during this course.

Topics Covered

The course will cover the following topics:

1. Introduction to biologically inspired computing
2. Genetic Algorithms
3. Genetic Programming
4. Gene Expression Programming
5. Principles of Swarm Intelligence
6. Modelling using NetLogo
7. Ant Colony Optimization
8. Particle Swarm Optimization
9. Task Allocation and Division of Labour
10. Neural Networks
11. Artificial Immune Systems
12. L-systems
13. Cellular Automata
14. Membrane Computing
15. Complex Systems analysis tools

Assessment Scheme

The following marking scheme will be used for this course:

Activity	Weight(%)	Comments
Assignments	30	There will be 3 assignments, each worth 10% of the final grade. Assignments will be posted on Brightspace and submitted via Brightspace. All assignments count towards the final grade.
Project Proposal	10	The project proposal is a brief document. It will be submitted via Brightspace as a PDF document using IEEE conference template. It must include an abstract, and an outline of the project paper. The project proposal must be approved by the instructor, before the student can proceed with the project.
Project Presentation	10	Each student will give a brief presentation (10 min) summarizing the key findings of their project paper, followed by a 5-minute discussion period.
Project	50	The project will be a research-style paper, delivered as a PDF document in IEEE conference format – 10 pages maximum including the references.

This course will be delivered on-line, using the blended delivery model. The course will be organised in modules. The modules may be pre-recorded or may be recorded during the class

lecture time. In either case the class lecture time will be used for interactive question and answer.

It is important to note that each student is expected to complete the assignments, the project proposal, and the project, individually. Students should feel free to ask questions pertaining to course material on-line via established communication channels for the course but should not share solutions to assignments.

If you are unsure of the expectations regarding academic integrity (how to use and cite references, how much collaboration with lab- or classmates is appropriate), ASK your instructor. Sharing assignment specifications or posting them online (to sites like Chegg, CourseHero, OneClass, etc.) is considered academic misconduct. You are never permitted to post, share, or upload course materials without explicit permission from your instructor. Academic integrity offences are reported to the office of the Dean of Science. Penalties for such offences can be found on the ODS webpage: https://science.carleton.ca/academic-integrity/.

Important Considerations

Late assignments are never accepted for any reason. Assignment submissions are handled electronically (i.e., through Brightspace) and there is no "grace period" with respect to a deadline - an assignment submitted even one minute after the deadline is late and will receive a mark of zero.

Technical problems do not exempt you from this requirement, so if you wait until the last minute and then have issues with your connection, you will still receive a mark of zero. Consequently, you are advised to:

> Periodically upload your progress (e.g. upload your progress at least daily), and attempt to submit your final submission at least one hour in advance of the due date and time.

> For each assignment, you will be submitting one or more files that contain source code, and these files must be given the correct filename and be provided in the specified format. Assignments that are incorrectly named or in the incorrect format will be penalized and may receive a mark of zero.

> If any of the source code files you submit does not run, it will receive a mark of zero. Consequently, after you upload your submission to Brightspace you should re-download it immediately and ensure that:
> - your submission is the correct file type and has the correct filename

- each of your source code files can be run from the terminal on our official virtual machine
- each of your source code files can be viewed in a text editor (for marking purposes)

You are expected to demonstrate good programming practices at all times and your code may be penalized if it is poorly written. You are also expected to do the necessary preparatory work (i.e., devising an algorithm) before you start coding. You may be asked to present either pseudocode or a flowchart before you will receive any assistance from the instructor or a teaching assistant.

Undergraduate Academic Advisor

The Undergraduate Advisor for the School of Computer Science is available in Room 5302C HP; by telephone at 520-2600, ext. 4364; or by email at undergraduate_advisor@scs.carleton.ca. The undergraduate advisor can assist with information about prerequisites and preclusions, course substitutions/equivalencies, understanding your academic audit and the remaining requirements for graduation. The undergraduate advisor will also refer students to appropriate resources such as the Science Student Success Centre, Learning Support Services and Writing Tutorial Services.

SCS Computer Laboratory

SCS students can access one of the designated labs for your course. The lab schedule can be found at: https://carleton.ca/scs/tech-support/computer-laboratories/. All SCS computer lab and technical support information can be found at: https://carleton.ca/scs/technical-support/. Technical support is available by emailing support@scs.carleton.ca.

University Policies

For information about Carleton's academic year, including registration and withdrawal dates, see Carleton's Academic Calendar.

Pregnancy Obligation. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit Equity Services.

Religious Obligation. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit Equity Services.

Academic Accommodations for Students with Disabilities If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the Paul Menton Centre website.

Survivors of Sexual Violence. As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: carleton.ca/sexual-violencesupport

Accommodation for Student Activities. Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see the policy.

Student Academic Integrity Policy. Every student should be familiar with the Carleton University student academic integrity policy. A student found in violation of academic integrity standards may be awarded penalties which range from a reprimand to receiving a grade of *F* in the course or even being expelled from the program or University. Examples of punishable offences include: plagiarism and unauthorized co-operation or collaboration. Information on this policy may be found here.

Plagiarism. As defined by Senate, "plagiarism is presenting, whether intentional or not, the ideas, expression of ideas or work of others as one's own". Such reported offences will be reviewed by the office of the Dean of Science.

Unauthorized Co-operation or Collaboration. Senate policy states that "to ensure fairness and equity in assessment of term work, students shall not co-operate or collaborate in the completion of an academic assignment, in whole or in part, when the instructor has indicated that the assignment is to be completed on an individual basis". Please refer to the course outline statement or the instructor concerning this issue.