SYDE 750 Topic 37 / ECE 750 Topic 33 **Artificial Life: Biology and Computation**
Spring 2020 – University of Waterloo

Instructors:
Prof. Chrystopher L. Nehaniv [redacted] chrystopher.nehaniv@uwaterloo.ca
Prof. Kerstin Dautenhahn [redacted] kerstin.dautenhahn@uwaterloo.ca

Text: Readings (articles, journal papers, book chapters) to be made available to students, assigned weekly. These should be read before the next class meeting. No required textbook.

Home Page: SYDE topic 37/ ECE 750 topic 33 on Learn
Class Times: [redacted] [on-line]

Course Grading:

- 30% Problem Worksheets. Frequent weekly worksheets (including several involving programming) will check and develop student understanding of concepts covered in-class.
- 60% Individual term project: Students first propose and then carry out an individual experimental project using artificial life techniques in a particular application area and critically evaluate the results. This is written-up as an 8-page IEEE-style formatted report to which all code and additional appendices must be added. All projects must be demoed to the instructors. The report has to demonstrate motivating background review, research questions and/or research hypotheses, software/system development, experimental results and analysis, and critical evaluation.
  NB: The written report (**not** the demo) will serve as the main basis of assessment.
- 10% Lecture Notes. Students will take turns on a rota to transcribe and typeset notes (in LaTeX) on the lectures to be shared with the class.

Artificial Life is study of the simulation and synthesis of living or life-like systems. This course treats the basic principles of biology and computation in nature that underpin the organization of living systems in life as we know it, as it might exist elsewhere in the universe, and in digital or artificial media. We explore the mechanisms within living individuals that grow and change in a complex environment. This provides a variety of methods for understanding, modeling, and designing complex adaptive systems, whether naturally occurring or engineered, in simulation, in physical systems, with a view to applications in artificial life as the foundation for artificial intelligence.

Course Topics Outline:

1. Origins of Artificial Life, Cybernetics and AI: Simulation & Synthesis of Living and Life-like Systems, Properties of Life.
2. Biological Background for Engineers – Evolution of Life on Earth, Molecular Genetics, Genetic Code (and its digital aspects), Protein Biosynthesis & Darwinian Evolution. Digital Organisms.
3. Cellular Automata, Synchronous/Asynchronous Automata Networks, Genetic Regulatory Networks
4. Swarm Intelligence & Stigmergy
5. Self-Reproducing Systems
6. Evolutionary Systems, Sex, and Nature-Inspired Optimization
7. Models of Growth and Morphogenesis
8. Ethical issues for Artificial Life
9. Selected topics chosen from the following (if time allows):
   Theory and Applications of Differentiated Multicellularity as a computational paradigm; Evolution of Individuality; Evolution of Evolvability; Evo-Devo;

Symbiogenesis; Major Transitions; Open-ended Evolution; Complexity and Interaction Machines; Origins of Life and Exobiology.

Students are expected to attend all lectures, take detailed notes, and participate in class discussions online. We will endeavor to complete all this synchronously online, despite COVID19, though we understand that may not always be possible and will adapt as needed.

Students should be able to program well in at least one high-level computer language.

ECE M.Eng. students wishing to enroll should have achieved a mark of 80+ in ECE 650, or be able to present evidence of equivalent strong programming ability.

It is expected that students understand the university position on copying (in terms of assignments) and plagiarism (in terms of the project). All work / figures which are not your own must be explicitly identified.

Students enrolling agree to have their work checked on Turn-It-In to guard against plagiarism and collusion. (If you enroll but do not agree, please contact Prof. Nehaniv to discuss within the first two weeks of term.)

Auditors (those not enrolling for credit), if any, are required complete all course elements (including project proposal) except for the final project report.