SYDE 750 Topic 39 / ECE 750 Topic 33   **Artificial Life: Embodied Intelligence**
(Winter 2022)

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Home Page: SYDE/ECE 750 topic 39/33 on Learn
Class Times:
Location:

This course in Artificial Life addresses the foundational role of *embodiment* and *interaction* in living and life-like systems as a paradigmatic approach for Embodied Intelligence in living organisms, complex adaptive systems, agents and interactive social robots. This is fundamental for understanding and modeling social and physically grounded intelligent behavior of living systems, and for the synthesis of embodied intelligence in artificial interactive systems and AI robotics.

Texts: Readings (articles, journal papers, book chapters) to be made available to students, assigned weekly. These should be read before the next class meeting. Also,

Required Books:
- V. Braitenberg (1986), *Vehicles: Experiments in Synthetic Psychology*, MIT Press.
- F. Varela, E. Thompson, E. Rosch (1991/2017), *The Embodied Mind: Cognitive Science and Human Experience*, 1st or 2nd edition, MIT Press.

Recommended Books (certain chapters, ideas or concepts will be covered):
- Ronald C. Arkin (1998) *Behavior-based Robotics*, MIT Press.
- Maja Mataric (2007) *The Robotics Primer*, MIT Press.
- Robin R. Murphy (2019) *Introduction to AI Robotics*, 2nd edition, MIT Press.
- Rolf Pfeifer, Josh Bongard (2007) *How the Body Shapes the Way We Think: A New View of Intelligence*. MIT Press.
- Rolf Pfeifer, Josh Bongard, Don Berry (2011) *Designing Intelligence: Why Brain's Aren't Enough*, Starmind.
- Angelo Cangelosi, Matthew Schlesinger (2015) *Developmental Robotics- From Babies to Robots*, MIT Press.
- Jakob von Uexküll (2010 [1934]), *A Foray into the Worlds of Animals and Humans*, translated by J.D. O'Neil, University of Minnesota Press. [or any other edition].

Course Grading:
- **25% Problem Worksheets.** Frequent worksheets and assignments (including programming, writing) will check and develop student understanding of concepts covered in-class.
- **15% Seminar Notes.** In the course of the semester, graduate students will select from a range of seminars to attend in areas relevant to Artificial Life & Embodied Intelligence specified by the instructors (in-person, online or recorded). Students need submit 4-6 sets of notes on each one (2 page limit, including your name, speaker's name and affiliation, title and date of seminar, notes on content, and your own reflection on the seminar content). These are marked for clarity and quality of scientific writing. The top 4 marks of 6 are counted.
- **60% Individual term project:** Students propose an individual project to carry out, and critically evaluate an individual project using artificial life techniques in a particular application area. An 8-page IEEE conference-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 background review, software/system development, experimental results and analysis, and critical evaluation. **The report will serve as the main basis of assessment.**

Course Outline: (Target topics, subject to modification*)

1. Logic of Life vs. Embodied Artificial Life; Braitenberg Vehicles; Role of the Observer; Emergence; Self-Organization; Self-* Properties (autopoiesis, self-maintenance, etc.)
2. Embodied agents, classification, issues of autonomy and design, degrees of embodiment
3. Enactive, Connectionist, and Cognitivist concepts and paradigms
4. Life-like believable robots and agents, varieties of social intelligence
5. Subsumption and other behaviour-based robot architectures; behaviour selection and modulation techniques, potential fields, behaviour-orientation.
6. Cognitive and developmental approaches to AI robotics; social learning and imitation.
7. Human-Robot Interaction (HRI), and applications
8. Definitions of different types of agents
9. Ethics of artificial life agents
10. Post-Reactive Natural and Artificial Intelligence & Robotics:
    Topics chosen from perception-action loop, Shannon information and empowerment; the temporal horizon: reactive / affective / learning / deliberative / post-reactive agents and robots; autobiographic agents, sensor evolution; interaction games; experience histories; and narrative intelligence.

* The instructors reserve the right to modify the content and order of topics covered in the lectures which may be adjusted, e.g. due to recent developments in the field.

Students are expected to attend all lectures, take detailed notes, and participate in class discussions. *In-person lectures are **not** recorded.* We plan to complete all course activities in-person. In the event of disruption due to Covid-19, we may have to move to online synchronous classes, e.g., for a short time (one week), or longer time in case of lockdown.

Important Dates **(to be confirmed):**

Thursday	17 February 2022	– Individual Project Proposals Due by 5 p.m.
Friday	25 March 2022	– Final Project Reports Due by 5 p.m.
Tues/Wed	29/30 March	– Project Demo presentations in class from 10 a.m.
(Tuesday	5 April	- Demo reserve day if needed, in class, 10 a.m.)

Important. ***To succeed in the course, 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 good mark in ECE 650 prior to taking this course (80% or higher), 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 except for the final project report.

Students are strongly encouraged to talk about assigned work, share ideas, or share code fragments. However, each final submission is to be composed individually. Direct copying of a solution, or providing the copy, is considered cheating. Two key things to remember are "separation" and "disclosure."

Separation means that, after you discuss an assignment with other people, you separate yourself from them and from any shared materials while you then individually compose your solution to hand in. In addition to avoiding direct copying, this will significantly improve your speed of learning.

Disclosure means you indicate on the submitted work any significant help you received, and specify any component which you took directly from another source. You may lose whatever portion of the grade relates to the copied part. However, you won't be cheating and you will be learning from the parts you were able to complete on your own.

Email Policy:
Only emails from a valid uwaterloo email address will be responded to. The email must contain the full student name and student ID, and include your course number in the subject line. We endeavour to respond within 24 to 48 hours during working hours.

Academic Integrity: Avoiding Plagiarism, Cheating & Collusion:

Problem worksheet assignments are open book in the sense that you may consult your readings, course notes, and materials posted in, or directly linked from, the course LEARN site, and also online materials. Inclusion of other material is permitted, but if this is done without proper citation, you may be subject to academic discipline. Use of any other resource without citation (including file- sharing services such as chegg.com, coursehero.com, stackexchange.com, ...) is prohibited. *Assignments need to be completed on an individual basis, you must write up your text and solutions yourself in your own words. You must fully cite any material (e.g. text, figures, diagrams, tables, pictures etc.).*

Individual Project Reports. Make sure to carefully cite the sources of all assertions made in your report, writing *in your own words* and using *quotation mar*ks around any direct quotes. Cite sources and authors of all software code you use or modify in your project. Paraphrasing or quoting long sections of text (more than one sentence), even with citations, from other sources is generally not appropriate, and might constitute academic misconduct.

Seminar Notes. Since these are notes, you are free to summarize and use phrases from the seminar speaker, since this is note-taking and indicates the source of the content. You must do this work yourself and not with any partner. The reflection section must be your own thoughts and writing in your own words regarding the seminar's contents.

All coursework and software code is subject to checking for collusion and plagiarism using Turn-It-In.

Turnitin.com: Text matching software may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the

term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

In case we need to move online for some part of the course:

Privacy and Remote Teaching and Learning:
https://uwaterloo.ca/privacy/about-informaion-and-privacy/guidelines-frequently-asked-questions/privacy-and-remote-teaching-and-learning

Course materials and videos provided by the instructors must not be shared on social media or otherwise distributed in any form (including sharing links to them).
They are for your own personal use while studying at the University of Waterloo only, and are subject to copyright and intellectual property laws, and university privacy policies.
By taking part in the course, you agree not to share this material or any links to it to anyone outside the course without instructor agreement. Please discuss with the instructors if you have concerns.

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

Compassionate Accommodation: If you are facing challenges that are affecting more than one course contact the Associate Chair Graduate Studies. They will review your case and coordinate a reasonable and fair plan in consultation with appropriate others (for example: instructors, Department Graduate Studies Committee, Chair, AccessAbility Services, Engineering Counselling services, Registrar's Office).

FACULTY OF ENGINEERING – MORE FINE PRINT
Faculty of Engineering website: *[Link* Academic Support and Policies *].*

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect, and responsibility. [Check Academic Integrity website for more information. Link Office of Academic Integrity].

Discipline: A student is expected to know what constitutes academic integrity (see link above) to avoid committing an academic offence, and to take responsibility for their actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (for example: plagiarism, cheating) or about expectations for group work/collaboration should seek guidance from the course instructor, academic advisor, or the graduate Associate Dean. Relevant documents include:
- University of Waterloo Policy 71 [Link Policy 71 Student Discipline].
- Academic Penalty Guidelines [Link Policy 71 Penalty Guidelines].
- Assessment of Unauthorized Collaboration: [Link Assessment of Unauthorized Collaboration].

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt please be certain to contact the **Associate Chair for Graduate Studies** who will provide further assistance.
[Link Policy 70 Petitions & Grievance.]

Appeals: A decision made, or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72 (Student Appeals) [Link Policy 72 Student Appeals].