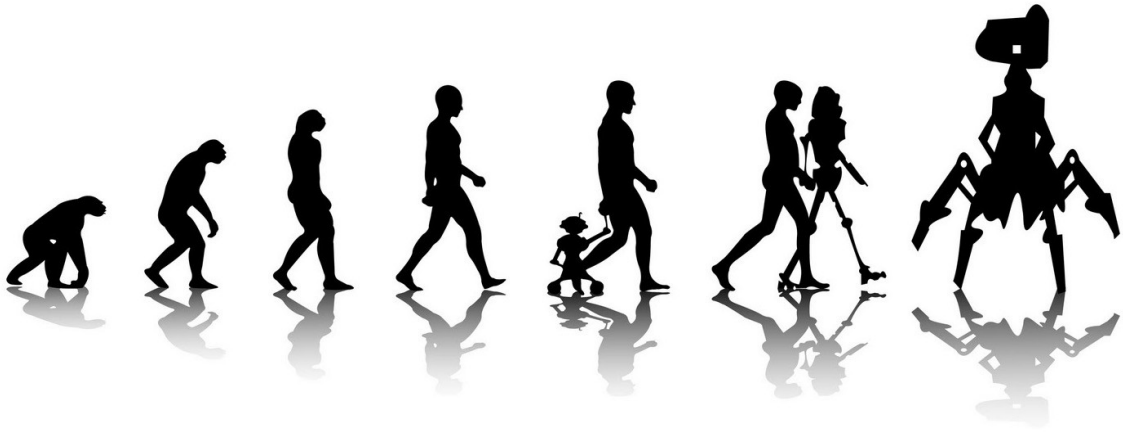
Modern Robots: Evolutionary Robotics

Spring Semester, 2018, University of Wyoming
COSC 4560 / COSC 5560



Time: M,W,F 10:00-10:50am

Place: EN (Engineering) 2108.

Instructor: Dr. Nick Cheney (ncheney@uwyo.edu)

Office Hours: TBD (Engineering 4081B)

Course Website: www.ncheney.com/teaching/robotics.html

Course Discussion Board:
www.piazza.com/uwyo/spring2018/cosc4560cosc5560

TA: Joost Huizinga (jhuizing@uwyo.edu)

TA office hours: TBD (Engineering 4086)

Summary: The course will cover topics in evolutionary robotics, a field in which scientists and engineers evolve the bodies, brains, and behaviors of robots using evolutionary algorithms (a.k.a. genetic algorithms, evolutionary computation, etc.). The first section of the course will cover evolutionary algorithms in some depth before moving on to their applications in robotics. The experimentation in the class will be done on simulated robots, where much of the central concepts can be quickly learned without being slowed down by the inevitable delays associated with working with physical robots. Over the course of the semester, you will incrementally build your own evolutionary robotics experimental platform via a series of homework coding

assignments. You will then use that platform (or something similar) to conduct an original research project, either individually or in a group. You will give a talk summarizing the work to the class and produce a 2-5 minute video of that work. All students are encouraged to do a project that is worthy of submitting to a peer-reviewed conference or journal, although that is not a requirement of the course.

Required Textbook: Floreano, D. & Mattiussi, C. (2008) Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies, MIT Press.

Optional Additional Text: Pfeifer, R. & Bongard, J. (2007) How The Body Shapes the Way We Think: A New View of Intelligence, MIT Press.

Additional Readings: Additional readings will be provided from the scientific literature and posted on the course website.

Acknowledgement: This course is based courses originally designed by Dr. Josh Bongard, a Professor at the University of Vermont and one of the worldwide leaders in evolutionary robotics, and modified by Jeff Clune, an Associate Professor at the University of Wyoming. Professors Bongard and Clune have graciously approved of the adaption of their materials so that we may build off of the strong foundation they created. Joost Huizinga has substantially modified these assignments into their present form for this course, and is deserving of our sincere thanks.

Prerequisite skills: You should know how to program in Python and C++ as well as how to install open source software on your operating system. You will also have to learn how to use that software by reading its documentation, searching for answers in online forums, etc. But do NOT copy code from online (see Academic Integrity section below).

Readings: There will be readings associated with each class that you should read before class. See the course website for those assignments.

Graded Material:

Programming assignments: 50% for Undergraduates, 40% for graduate students.

Each student will gradually build a software system that allows him or her to conduct an evolutionary robotics experiment. This system will be composed of 8 software modules. Each programming assignment will involve implementing one of these modules.

Very Important Note: Because the modules will form a final, integrated system, if you fail to hand in one module, you must hand it in along with the new module the following week, even if you will gain no credit for doing so.
Due dates: The programing assignments are due via email sent by 11:59pm on each due date (the specific dates are announced in class and on the course website).
Another Very Important Note: The homework assignments are to be conducted by you alone, not in collaboration with anyone else. You are not allowed to share code. Please do not post the code you write for these challenges online or share them with anyone else. Discussion of the homework assignments (e.g. if you are stuck and have a question) may take place on the course discussion board (Piazza). All such questions and answers should be high-level and abstract: it is not ok to ask for, give, or receive actual code. Doing so is an act of academic dishonesty according to university policy. Please turn in your code along with your assignment, as it will be checked to make sure it is not a copy of someone else's code or code found online.

Paper Reactions: Graduate students: 10%.
(undergraduate students with an interest/desire to work in scientific research or artificial intelligence are encouraged to complete these paper reactions as well, and will be provided extra credit for doing so)

Each week graduate students will write a reaction (not a summary!) to one of the readings assigned in that week. The reactions should be one-half to one page in length. I would like to hear your opinions, ideas, criticisms, or some other interesting reaction to the paper that shows you understand it deeply and have thought hard about it. This is your chance to engage in the literature and show me your brilliance! Paper reactions are due every Sunday at 11:59pm.

Midterm: 15%.
The midterm consists of writing a grant proposal for your project, including surveying previous work in the area (e.g. from readings and lectures) and describing why what you propose to do is interesting and new. You will also present your funding pitch to a review panel (the class) as a 5 minute presentation to try to get your project funded. If you are in a group for your project, each person must write an equal portion of the report and present an equal portion of the talk.

In the midterm, the goal is to tell your story: what you want to investigate and why that is important.

Here is a suggested outline for your proposal (and talk):

- Intro & motivation

    - A quick description of the overall goal of the field
    - A quick summary what you want to do and why it is important (e.g. why it helps further the goal of the field)
    - A summary of the previous related work
    - A description of how what you want to do is an interesting next thing to investigate
- Research plan
    - A detailed explanation of the experiments you are going to conduct, including why the experiments shed light on your subject
    - A discussion of what the potential outcomes of your experiments are, and what they will reveal.
    - A description of what you will do in the face of certain outcomes (e.g., if that does not work, we will try X because _____ ….. If it does work, we will move on to Y because _____ …. .
    - Please include preliminary data if you have it.
- A brief summary of why this work is important, yet progress can be made on it if your research plan is executed.

The report must be turned in via email as a PDF generated by Latex or Word. It should be as long as it needs to be to tell the story, **and include at least 5 references**. Use the Genetic and Evolutionary Computation Conference (GECCO) Latex or Word style files.

Final Project: 30%.
Individuals or groups will use the software system build during the homework assignments (or another of their choosing) to perform an experiment in evolutionary robotics. Expectations will be higher for groups than individuals, and for groups of three instead of two. Groups of four or larger are not permitted without permission from me. Graduate students are expected to perform more in depth, rigorous studies, and should aim to produce something that would be accepted at a peer-reviewed conference. Undergraduates are encouraged, but not required, to also meet this standard. A video describing the experiment will be presented at the end of the semester.

25% of your Final Project grade will be the average of grades received for your final project status reports. Such reports about the project are due weekly at 11:59pm on Sunday, with the first due when announced in class and/or on Piazza. Status reports describe everything you have done on your project since the last status report. Include papers read, outlines/slides/drafts generated, screen shots of working software, and best of all data from experiments and your thoughts about those data.

Participation: 5%.
You are encouraged to attend class, ask questions, participate in discussions, give high-quality grade evaluations to your peers, and be an active member in the Piazza online forum for the class (join at Piazza.com). Students will be rewarded for asking good questions on Piazza. Good questions share all of the necessary detail and reveal what you have tried to resolve the issue on your own. Students will also be rewarded for providing courteous, informative answers to the questions of others, or proactively making interesting posts (e.g. tricky technical solutions, interesting questions for discussion, relevant news articles and videos, etc.). Students/groups are also required to meet with me at least once during office hours (I would suggest doing so at least two weeks before your midterm presentation to discuss your project topic and scope!).

Additional Information: More information about the midterm and final project will be announced later in the semester. The course schedule is expected to accommodate our speed, it is suggested that you check each class' reading/assignments before completing them.

Late policy: Material within one day late: 10% deduction; within two days late: 25% deduction; within four days: 50% deduction. Five or more days: 100% deduction.

Peer grading: As with peer review, you will evaluate the work of your colleagues and vice versa. These grades you receive from your peers will have an impact on the grades I give you. You will provide a letter grade and comments for your classmates on their midterm and final presentations. The quality of the grades you give will affect your grade as part of the participation score.

Grades:
A: ≥93%, A-: ≥90%, B+: ≥87%, B: ≥83%, B-: ≥80%, C+: ≥77%, C: ≥73%, C-: ≥70%, D+: ≥67%, D:≥63%, D-: ≥60%, F: <60%

Online Community: Please sign up for the Piazza forum for this class at Piazza.com. Doing so is required.

Asking Questions Outside of Class: While questions in class are highly encouraged, please direct technical/logistic questions outside of class to the Piazza forum instead of emailing me. That way your fellow classmates can also benefit from the answer you receive. Students also have been shown to learn much more when they are helping fellow classmates with material and when they are engaged in online communities. Please also help answer questions on Piazza! Note: You should not expect that your question on Piazza will be answered. It is

merely an additional tool that could help. If you need an answer to a question, especially by a certain time, make sure to ask it in class or office hours.

Academic Integrity: You are not allowed to share code amongst yourselves or on Piazza. Do not post the code you write for class challenges online (e.g. GitHub) or share them with anyone else: doing so violates academic integrity. You are encouraged to discuss the class with other students, but you cannot give another student specific algorithms (detailed instructions, pseudocode, code, etc.) for solving the homework problems. If you use anyone else's code (yours or code you find online), you must explicitly report it (not in the comments of the code, but the project write-up: if there is no project write-up, you must mention it in the email in which you submit your assignment, or in some other direct way to me). In addition to these specific issues, you are obliged to follow the University's policy on academic integrity (see http://www.uwyo.edu/generalcounsel/_files/docs/unireg802.pdf). When in doubt, ask first! The University of Wyoming is built upon a strong foundation of integrity, respect and trust. All members of the university community have a responsibility to be honest and the right to expect honesty from others.

Laptops & Smartphones: Please do not open laptops in class or use smartphones in class. Studies show that they distract from your ability to learn [1,2]. Also, they are very distracting to me while teaching, and that's not fair to everyone else.

Differently Abled Students: If you have a physical, learning, or psychological disability and require accommodations, the University policy is that you must first talk to University Disability Support Services (room 330 Knight Hall). They will then contact me regarding how to accommodate your needs, which I am very happy to do.

That's all. Whew! Thanks for reading. Ask any questions about this syllabus in class.