IE 590: Nature-Inspired Computing

Syllabus for Fall 2016

Course Overview

This course is about algorithms that are inspired by naturally occurring phenomena and applying them to optimization, design and learning problems. The focus is on the process of abstracting algorithms from the observed phenomenon, their outcome analysis and comparison as well as their "science". This will be done primarily through the lens of evolutionary computation, swarm intelligence (ant colony and particle-based methods) and neural networks.

Prerequisites: Students must be very comfortable programming in at least one modern programming language such as C/C++/Java/Matlab/Python, and have familiarity with basic optimization methods (e.g., linear programming). Ability to perform basic statistical analyses/hypothesis tests and create plots using a programming language such as SAS/R/Minitab will be required.
** Microsoft Excel and similar software tools will NOT be permitted.*

Instructor	Mario Ventresca E-mail: `mventresca@purdue.edu` Office hours: Tuesdays 1-2pm (appointment recommended) Office location: Grissom 292
Lectures	MWF 12:30-1:20pm, GRIS 126
Textbook	None required. Suggested (one of): • *Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications*, L. N. de Castro (2006), CRC Press. • *Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies*, D. Floreano and C. Mattiussi (2008), MIT Press. • *Evolutionary Optimization Algorithms*, D. Simon (2013), Wiley.
Website	`https://mycourses.purdue.edu/`

*** Contacting instructor via email:** To prevent delay or loss by spam blockers, use the subject line (without quotes and appropriate course component): "IE590: lecture/project/homework/other"

Learning Outcomes

Upon completing this course students will be able to:

1. Describe the natural phenomena that motivate the discussed algorithms.
2. Understand the strengths, weaknesses and appropriateness of nature-inspired algorithms.
3. Apply nature-inspired algorithms to optimization, design and learning problems.
4. Understand fundamental concepts of NP-hardness and computational complexity.
5. Prove algorithm convergence rates using probabilistic arguments.
6. Perform appropriate analyses on and between the outputs of stochastic algorithms.
7. Analyze search space structure using statistical and information theoretic measures, and explain its impact on algorithm behavior and output.

Grading

This course has four grading components, as shown below. Due dates TBD. Assignments will require programming.

Learning Item	Number	Item Value	Percentage of Final Grade
Assignment	5	8%	40%
Project	1	45%	45%
Presentation	1	15%	15%

Your letter grade will be determined as follows, where X is your final percent grade:

Letter Grade	Percentage	Description
A, A+	$90 \leq X$	Excellent. Comprehensive knowledge and understanding of the subject matter.
B, B+	$80 \leq X < 90$	Very Good. Strong knowledge and understanding of the subject matter.
C-, C, C+	$70 \leq X < 80$	Good. Reasonable knowledge and understanding of the subject matter.
D-, D, D+	$60 \leq X < 70$	Marginal. Minimum knowledge and understanding of the subject matter.
F	$X < 60$	Failing. Unacceptable knowledge and understanding of the subject matter.

* For a grade above 80%, your letter grade will be indicated by a '+' if your numerical grade is in the upper half of the interval (i.e., for $X \in [85, 89)$ then you will receive a 'B+'). Where a '-' grade is possible the range will be divided into thirds, i.e., $[70, 74), [74, 77), [77, 80)$. No grade curving will be conducted.

Class Policies

Attendance: The university class attendance policy is available at

`http://www.purdue.edu/studentregulations/regulations_procedures/classes.html`

- Lecture attendance is expected and is your responsibility. Reading lecture slides alone is typically insufficient to attain a high grade in this class. Many topics are elaborated and discussed in lecture, and the information of these discussions is not posted online. Moreover, some topics are not covered in the textbook and lectures notes and class discussion will be invaluable.
- Be on time for lectures and labs. Late attendance (more than 10 minutes) will be considered as absence. If you are late for class please enter and seat yourself in a fashion that does not disturb the class.
- Attendance to student lectures will be considered when determining your final grade.

Homework: will NOT be accepted past the due date.

- MUST be done individually, and include ALL references (not including course notes or the textbook), including web pages.
- You are encouraged to discuss with other students, but handing in highly similar work is plagiarism (see below) and will be punished accordingly.
- ALL assignments will be examined by SafeAssign, a plagiarism detection service available in Blackboard. Do **NOT** rewrite the assignment question.
- ALL assignments must be in a SINGLE file of pdf or doc format, ONLY the most recently submitted assignment will be graded.
- Latex MUST be used to format your assignment. Otherwise, ONLY diagrams can be including by embedding images.
- **MUST** (otherwise a grade of zero) include as the first page, a cover sheet indicating (in order) the course title, assignment number, date, your name, PUID, and a brief statement indicating:

  "I am aware of, and understand, the Purdue Academic Misconduct Policies and attest that this submitted work is solely my own. I accept any repercussions if found in violation."

Project: The project will be completed in two phases. The first phase will be to ensure the project is appropriate, but students should be in communication with the instructor well before the deadline. The final project submission will require an 8-12 page (not including references) double column IEEE formatted report (written in Latex), in addition to all source codes, which are to be properly documented and include instructions for reproducing experimental results. Projects should be completed by groups of 2-3 students.

Lecture: Students will be responsible for preparing and conducting one 50min lecture, allowing for question/answer period. Each lecture will be given by two students and each must present for 50% of the time (25mins). The topic will be assigned by the instructor. Grading and feedback will be 50% based on class input, and 50% from the instructor.

Re-grading: Request for regrading an examination or assignment will be considered only with a clearly written explanation, submitted in class only to the instructor and only AFTER at least 24 hours self-evaluation and within SEVEN days from the time the graded work is returned to the class. The group project is not subject to regrading. A regrade request form is available on Blackboard, and must be submitted with a hard-copy of your assignment/exam.

Class conduct: In order to ensure the best learning environment for all, please:

- be courteous to your fellow students and instructors.
- turn off or put your cellular phones on silent mode. If you must answer the phone, please quietly leave the classroom.
- do not use laptops or tablets during class if you intend to play movies, video games, etc. This disrupts nearby students and negatively affects their learning experience and thus is not permitted. Failure to adhere to this request may result in loss of the privilege.
- raise your hand if you have any questions or comments during the lecture and wait until the instructor calls on you.
- do not chatter with friends or purposely disturb other students.
- leave and re-enter the classroom quietly if you must use the restroom. You do not need to ask permission to leave unless during an examination.

Misconduct: Any type of misconduct as defined in Student Conduct (Part 5) of the University Regulations will not be tolerated: `http://www.purdue.edu/studentregulations/`. The instructors will follow the regulations strictly. These are a few examples:

- substituting on a course or exam for another student
- using someone else to write a paper or assignment and submitting it as one's own work, with or without monetary exchange
- giving or receiving answers by use of signals during an exam
- copying with or without the other person's knowledge during an exam
- doing class assignments for someone else
- turning in a paper that has been purchased from a commercial research firm or obtained from the internet
- padding items of a bibliography
- collaborating with other students on assignments when it is not allowed
- obtaining a test from the exam site, completing and submitting it later
- altering answers on a scored test and submitting it for a regrade
- stealing class assignments from other students and submitting them as one's own
- fabricating data
- destroying or stealing the work of other students
- using the exact language of someone else without the use of quotation marks and without giving proper credit to the author

- plagiarizing published material, class assignments, or lab reports
  - presenting the sequence of ideas or arranging someone else's material (even if expressed in one's own words) without giving appropriate acknowledgment
  - submitting work (in whole or part) written by someone else but representing it as your own

Emergency Procedures

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Changes about the course will be announced through the Blackboard and/or class mailing list.

In case of emergency:

- To report an emergency, call 911.
- To obtain updates regarding an ongoing emergency, and to sign up for Purdue Alert text messages, view `http://www.purdue.edu/emergency/`
- There are nearly 300 Emergency Telephones outdoors across campus and in parking garages that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected immediately.
- If we hear a **fire alarm**, we will immediately suspend class, **evacuate the building**, and proceed outdoors, and away from the building. **Do not use the elevator.**
- If we are notified of a Shelter in Place requirement for a tornado warning, we will suspend class and shelter in the lowest level of this building away from windows and doors.
- If we are notified of a Shelter in Place requirement for a hazardous materials release, or a civil disturbance, including a shooting or other use of weapons, we will suspend class and shelter in our classroom, shutting any open doors or windows, locking or securing the door, and turning off the lights.
- Your course syllabus includes additional preparedness information as it might impact this class, including classroom suspension for severe weather or other emergencies. Please review the syllabus and the Emergency Preparedness website for additional information.
  `http://www.purdue.edu/ehps/emergency_preparedness/index.html`

Tentative Schedule

Week	Date	Topic	Remark
	Aug 22	Course Introduction	
1	Aug 24	Turing machines, computational complexity	
	Aug 26	NP-hardness, Cook's Theorem	
	Aug 29	Reductions	
2	Aug 31	Reductions	
	Sept 1	Approximation algorithms vs heuristics	
	Sept 5	No classes (Labor Day)	
3	Sept 7	No Free Lunch Theorem	
	Sept 9	Empirical Algorithms	
	Sept 12	Empirical Algorithms	
4	Sept 14	Empirical Hardness	Ben
	Sept 16	Characteristics of Natural Systems/Algorithms	
	Sept 19	Cellular Automata and Artificial Life	Liz
5	Sept 21	Evolution	A1 Due
	Sept 23	Evolution	
	Sept 26	Evolutionary Algorithms	
6	Sept 28	Evolutionary Algorithms	
	Sept 30	Learning Classifier Systems	Hyejin/Aparna
	Oct 3	Co-evolutionary Algorithms	Suhas/Abhishek
7	Oct 5	Fitness Landscape Analysis	
	Oct 7	Fitness Landscape Analysis	A2 Due
	Oct 10	No classes (Fall Break)	
8	Oct 12	EA Theory	
	Oct 14	EA Theory	
	Oct 17	EA Theory	
9	Oct 19	Dynamic Environments	Bryan
	Oct 21	Genetic Programming	
	Oct 24	Symbolic Regression	Aparna/Patchara
10	Oct 26	Immunocomputing	Suhas/Zhaoyu
	Oct 28	Swarms/Flocking	A3 Due
	Oct 31	Swarms/Flocking	
11	Nov 2	Ant Colony Optimization	
	Nov 4	Ant Clustering Algorithm	
	Nov 7	Particle Swarm Optimization	Project Phase I Due
12	Nov 9	Multiobjectiveness	Viplove
	Nov 11	Foraging Algorithms	Patchara/Bosung
	Nov 14	Harmony Search	Dali
13	Nov 16	Brains	
	Nov 18	Hebbian Learning, Boltzmann Machines	A4 Due
	Nov 21	Feedforward and Recurrent Networks, Backpropagation	
14	Nov 23	No classes (Thanksgiving Break)	
	Nov 25	No classes (Thanksgiving Break)	
	Nov 28	Spiking Neural Networks	
15	Nov 30	Self Organizing Maps	
	Dec 2	Deep Learning	Uttara
	Dec 5	Slack Lecture	
16	Dec 7	Slack Lecture	
	Dec 9	Slack Lecture	A5 Due
	Dec 10		Project Due (11:59pm)