CE 597E SYSTEMS OPTIMIZATION USING EVOLUTIONARY ALGORITHMS
Tu-Th 2:30p-3:45p
101 Leonard Building

INSTRUCTOR: Dr. Patrick Reed
OFFICE: 215 B Sackett Building
TELEPHONE: 863-2940
EMAIL: preed@engr.psu.edu
OFFICE HOURS: Tuesday 9am –11am, Friday 9am-11am or by appointment

REQUIRED TEXT:

Bäck, T., Fogel, D., and Michalewicz, editors (2000). *Handbook of Evolutionary Computation,* IOP Publishing Ltd. and Oxford University Press.
Free Online Access: http://www.iop.org/Books/CIL/HEC/index.html

TEXTS ON RESERVE:

Goldberg, D. E. (1989). *Genetic Algorithms in Search, Optimization and Machine Learning.* Addison-Wesley Publishing Company, Reading, Massachusetts.
Goldberg, D. E. (2002). *The Design of Innovation: Lessons from and for Competent Genetic Algorithms*, Kluwer Academic Publishers, Norwell, Massachusetts.
Deb, K. (2001). *Multi-Objective Optimization using Evolutionary Algorithms*, John Wiley & Sons LTD, New York, NY.

RECOMMENDED REFERENCES:

Cantu-Paz, E. (2000). *Efficient and Accurate Parallel Genetic Algorithms*, Kluwer Academic Publishers, Norwell, Massachusetts.
Coello Coello, C. A., D. A. Van Veldhuizen, and G. B. Lamont. (2002). *Evolutionary Algorithms for Solving Multi-Objective Problems,* Kluwer Academic Publishers, Norwell, Massachusetts.
Dasgupta, D. and Z. Michalewicz. (1997). *Evolutionary Algorithms in Engineering Applications*, Springer-Verlag, New York, NY.
Z. Michalewicz and D. Fogel. (2000). *How to Solve It: Modern Heuristics*, Springer-Verlag, New York, NY.

COURSE DESCRIPTION:

Evolutionary algorithms (EAs) are global optimization heuristics that search for optima using a process that is analogous to Darwinian natural selection. Since their inception in the 1960s, evolutionary algorithms have been used in a tremendous array of applications. The growing popularity of evolutionary algorithms stems from their ease of implementation and robust performance for difficult engineering and science problems.

This course provides a comprehensive introduction to the field of genetic and evolutionary computation (GEC). The course will emphasize state-of-the-art methods for designing and implementing evolutionary algorithms for computationally intensive engineering and science problems. Course concepts are demonstrated using case studies drawn from the disciplines of the students enrolled.

COURSE GOALS:

I intend for this course to assist you in using EAs in current or future research. After this course, you will be able to

- Implement evolutionary algorithms on challenging engineering and science applications
- Design and parameterize evolutionary algorithms for maximum efficiency
- Critically assess the relative benefits and limitations of available algorithms
- Effectively present and communicate your EA-based results

CLASS FORMAT:

Class periods will be a mixture of lecturing and group discussion. I will expect you to actively participate in each lecture. Your participation will require that you keep current with the course reading assignments and actively participate in group discussions. As the semester progresses, a portion of class periods will be dedicated for discussion of homework assignments, case studies, final projects, and your course-related research interests. This course is uniquely interdisciplinary and should be viewed as a forum for building a broad understanding of the challenges and benefits of using EAs.

PREREQUISITES:

I will assume that you have a basic familiarity with computer programming and optimization. You should have at a minimum Math 220, Math 250, and CMPSC 201. You will be expected to perform straightforward programming using Fortran or C source code.

HOMEWORK:

The homework should be done in groups with 2 or 3 students. There will be 2-3 homework assignments that will require the formulation, implementation, and solution of problems using an array of the EAs. These assignments will require each group to present their results in well written professional reports (report clarity and quality will be graded).

The homework due dates will be strictly enforced. You will lose 10% of your grade for every day your assignment is late up to a maximum of 5 days after which you will receive no credit.

In addition to these assignments, each group will asked to prepare a lecture that presents an array of innovative real-world applications of the concepts and algorithms discussed in the course. I will work with each group in the selection of their case studies and the preparation of the lecture. This will be a great way for us to share research ideas in a "think-tank" setting!

TERM PROJECT:

You will be required individually or in your groups to apply one of the methods we discuss in class. These applications should fall in one of the following categories:

(a) Real-world application
(b) Algorithm modification or development to solve a problem class of interest to you
(c) Theoretical analysis of evolutionary algorithm performance

You may use any existing source code or software available to you. This project is meant to help you integrate your research into the course. You will be required to prepare a detailed project abstract early in the semester, a midterm progress report, and submit a final written paper at the end of the semester.

GRADING:

Participation	10 %
Homework	40 %
Case Studies	20 %
Final Project	30 %

Letter grades will be based on the weighted average specified above and assigned as follows:

- A = 94-100%
- A- = 90-93%
- B+ = 87-89%
- B = 84-86%
- B- = 80-83%
- C+ = 76-79%
- C = 70-75%
- D = 60-69%
- F < 60%

I reserve the right to adjust your grades. Your grade will only improve if adjustments are necessary. Feel free to contact me during office hours or by appointment if you have grade-related questions or concerns.

TENTATIVE COURSE SCHEDULE

WEEK	TOPIC	READING
1-14	Introduction	NONE
	Review of Nonlinear Optimization	NONE
1-21	Introduction to Evolutionary Computing	A1.1-A1.3, A2.3
	Basic Evolutionary Algorithms	B1.1-B1.3
1-28	Representing & Evaluating Your Designs	C1.1-C1.7, C4.1-C4.3
	Fundamental Operators—Selection	C2.1-C2.8
2-4	Fundamental Operators—Mating & Mutation	C3.1-C3.4
	The Race, The Hurdle, The Sweet spot	HANDOUT 1
2-11	Design & Parameterization for Single Objective Applications	HANDOUT 2
	Constrained Optimization	C5.1-C5.6
2-18	CASE STUDIES	TBA
	CASE STUDIES	TBA
2-25	Competent Genetic Algorithms	HANDOUT 3
	Competent Genetic Algorithms	HANDOUT 3
3-4	Multimodal Optimization Problems	C6.1-C6.4
	Maintaining Diverse Solutions	HANDOUT 4
3-11	Introduction to Multiobjective Optimization	C4.5, HANDOUT 5
	Multiobjective Evolutionary Algorithms	HANDOUT 5
3-18	SPRING BREAK NO CLASS	TBA
	SPRING BREAK NO CLASS	TBA
3-25	Multiobjective Evolutionary Approaches	HANDOUT 5
	Design & Parameterization for Multiple Objective Applications	HANDOUT 6
4-1	CASE STUDIES	TBA
	CASE STUDIES	TBA
4-8	Enhancing Efficiency—Hybridization	D3.1-D3.2, HANDOUT 7
	Enhancing Efficiency—Hybridization/Time Continuation	HANDOUT 7
4-15	Enhancing Efficiency—Parallelization	HANDOUT 8
	Enhancing Efficiency—Parallelization	HANDOUT 8
4-22	Enhancing Efficiency—Fitness Evaluation Relaxation	HANDOUT 9
	Enhancing Efficiency—Fitness Evaluation Relaxation	HANDOUT 9
4-29	CASE STUDIES	TBA
	CASE STUDIES	TBA