# CSE 848 Syllabus, Introduction to Evolutionary Computation, Online Edition - Spring 2021

## 1. Description

Understanding principles of evolutionary computation algorithms, their scope in solving practical problems from science, engineering and business, a few variants including genetic algorithms, differential evolution, particle swarm optimization, genetic programming, evolutionary strategies, and a few other popular metaheuristics. Discussing advancements in evolutionary computation algorithms in constraint handling, multi-criterion problem solving, combinatorial problems, multi-level optimization, and others. Emphasizing their use in handling practicalities, such as uncertainties, computationally expensive problems, dynamic problems and others. Presenting recent applications to machine learning, artificial intelligence, biosciences, social sciences, engineering, astronomy, energy, and other areas.

## 2. Objectives

At the completion of this course, students should be able to:

- Comprehend the basic principles of evolutionary computation algorithms
- Understand their scope in solving various application problems
- Learn how best to use representations, operators and overall control parameters to apply EC algorithms to various problems and compare them with other competing approaches
- Be able to understand newly proposed algorithms from the literature
- Work on individual projects that apply EC algorithms in different domains

## 3. Instructors

Professors Wolfgang Banzhaf, Kalyan Deb, Erik Goodman (banzhafw,kdeb,goodman@msu.edu) jointly teach this course.

## 4. Textbooks

There is no required textbooks. Instead, we will be surveying the literature. A number of papers will be referenced, others will be available for discussion. You can always look for papers anywhere that is appropriate. Remember, you have free access to many resources through MSU's Electronic Resources access point. Some recommended books for getting additional materials are as follows:

- "Genetic Programming: An Introduction", Banzhaf, Nordin, Keller and Francone, MorganKaufmann
- "Linear Genetic Programming", Brameier and Banzhaf, Springer
- "Multi-objective Optimization Using Evolutionary Algorithms", Deb, Wiley
- "Introduction to Evolutionary Computation", Eiben and Smith, Springer
- "Genetic Algorithms in Search, Optimization and Machine Learning", Goldberg, Addison-
- Wesley
- "Introduction to Genetic Algorithms", Mitchell, MIT Press
- "A Field Guide to Genetic Programming", Poli, Langdon, and McPhee, electronic resource

- "Evolutionary Optimization Algorithms", Simon, Wiley

Past GECCO proceedings are relevant for paper selection. However, you are always free to look for papers anywhere that is appropriate. Remember, you have free access to many resources through MSU's Electronic Resources access point.

## 5. Grading

The grading scheme will be as follows:

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|---|---|
| Home Assignments | 20% |
| Paper Presentation/Summary | 30% |
| Term Project Presentation/Report | 50% |

There will be three components to the overall grading procedure. Some home assignments will be posted on D2L. Students are expected to return solutions at the announced due date. Some assignments may require computer coding and running them to get results. There will be one paper presentation assignment in which the student is expected to choose a suitable paper of interest on EC, read it carefully, prepare a two-page summary and make a presentation to the class. Finally, students are also expected to do a term project, either alone or in a group of two formed by the students themselves. The project report will be due on last day of classes of the semester.

This is a graduate course, thus, all work is expected to be of professional quality. Mature programming skills are expected, such as in-program documentation (whenever asked to submit), style and completeness, and the projects will be graded on these qualities as well as on their results.

**In particular**, students are expected to read the paper summaries scheduled for presentation before class. If the instructor feels that students are not participating in class due to a lack of effort, a midterm and/or a final might be scheduled to rectify the situation.

There is no late policy for grades. Anything turned in late gets 0% credit unless excused under university policy.

Office hours will be established once the semester is under way. There will be a discussion forum on D2L to ask and answer questions that might be of interest to the whole class, such as clarifications of assignments, etc. Appointments outside of normal office hours are available on request through email.

## 6. Academic Integrity

Article 2.3.3 of the Academic Freedom Report states
"The student shares with the faculty the responsibility for maintaining the integrity of scholarship, grades, and professional standards."

In addition, the Department of Computer Science and Engineering adheres to the policies on academic honesty as specified in General Student Regulations 1.0, Protection of Scholarship and Grades; the all

University Policy on Integrity of Scholarship and Grades; and Ordinance 17.00, Examinations. (See Spartan Life: Student Handbook and Resource Guide)

Therefore, unless authorized by your instructors, you are expected to complete all course assignments, including homework, projects, quizzes, tests and exams, without assistance from any source. You are expected to develop original work for this course; therefore, you may not submit course work you completed for another course to satisfy the requirements for this course. Students who violate MSU academic integrity rules may receive a penalty grade, including a failing grade on the assignment or in the course. Contact your instructor if you are unsure about the appropriateness of your course work. (See also the Academic Integrity webpage.)

## 7. Course Topics

The following is the schedule of course topics. This may change as we move through the material.

**Week 1&2**: Module 1: Search and Optimization Problems from Practice
**Week 3 – 5:** Module 2: Principles of Evolutionary Computation and Early Methods
**Week 5 - 8:** Module 3: Other Evolutionary Computation Methods
**Week 9 - 10:** Module 4: Extensions to Evolutionary Computation for specific problem types
**Week 11**: Module 6: Student Paper Presentations
**Week 12**: Module 4, continued: Extensions to Evolutionary Computation for specific problem types
**Week 13:** Module 5: Case Studies in Evolutionary Computation Methods
**Week 14-15**: Module 7: Student Project Presentations

## 8. Presentations

Each student will be required to make one paper presentation to the class, and also to present a term project (either alone or in a group of two). The paper presentations will last 15 minutes (questions will be posed on a dedicated D2L discussion forum). Presentations will have to be recorded and uploaded to D2L. For the paper presentation, you will prepare a two-page summary paper that summarizes the paper to be presented and is to be submitted one week before the presentation. This summary should provide an overview of the important points of the paper, as well as any background material that may be required. The summary should address issues like the following:

**Application Papers**

1. Briefly describe, the problem, in terms of inputs, outputs, evaluation function etc.
2. How well does the representation of the problem match the problem itself? What is left out, what important aspects are represented? Is there a better way?
3. What special operators are provided for this problem? Were they necessary?
4. Is EC the "best" way to solve this kind of problem? Is computational complexity growth an issue?

**Theory Papers**

1. What is the fundamental EC problem being addressed by the paper? How does it relate to current EC approaches (is it a rehash)?

2. Are the advantages clearly stated? Proven (empirically, theoretically)?

3. Does the paper address the computationally complexity increases/decreases.

You are expected to provide a copy of the paper and a two-page summary **one week before** your scheduled presentation.

The whole class is expected to read at least the paper summary before the presentation. **Presentations will be judged by all members of the class and feedback provided via the instructors.**

You will turn in a proposal for your paper on D2L by Feb 3, 2021.

## 9. Term Project

There exist a number of toolsets on the internet, any of which you can use to develop your project. You can even develop your own toolset as well.

You will turn in a 2-page proposal for your project on D2L by Feb 26, 2021. This early writeup should serve as an assurance that your project has been properly selected and thought out. An intermediate 2-page progress report is due on D2L by Mar 24, 2021. On the last day of classes (excluding the final exam period), you will submit a report that will detail the following:

- problem description
- evaluation function (which did you write? what did it ignore?)
- operators used (and the rationale for using them [perhaps you tried many which should also be reported])
- any other nuances (parallelism, hybrid approach etc.)
- results (did it get the answer?, how long did it take?, what variations did you try to get the best answer?, what's the complexity?, show offline, online performance graphs etc.)
- comparison to other approaches on the problem.

Write this as if you were trying to publish results in a professional journal or conference. The evaluation of your report will be based on this viewpoint.

One of two things must be true about your project problem:

1. It is not one of the old stand-bys like traveling salesman, set partitioning etc. Pick something different, more interesting (complicated evaluation function, interesting representation, etc.).
2. If it is an old stand-by problem, it is because you are testing out a unique and interesting EC feature/approach and you want to benchmark it against something known. This would be something like a new EC operator.

Deliverables from your project include the final written report, an oral presentation during the last weeks of classes, and the code for your project.

## 10. Notes

This offering of the course is ONLINE ASYNCHRONEOUS. All handouts and videos will be available on D2L for your convenience. Meeting with instructors will take place on Zoom.

The link to the Zoom meeting is here: https://msu.zoom.us/j/94641595960 .

Zoom Meeting ID: 946 4159 5960 Passcode: eccourse

The meeting time is set for every week on Thu, until Apr 15, 2021. Please check announcements for any changes to this schedule.

There is a forum on D2L for discussions of general and module-related questions. Also, there are dedicated fora for paper and project presentations. Instructors and presenters will monitor and answer questions but it is also a place for you to discuss amongst yourselves!

While an attempt has been made to lay out the course in advance, we reserve the right to update/change this syllabus during the course of the semester.

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