CSE 620 Combinatorial Optimization and Modern Heuristics
Fall 2023
Section 01

Description:
CECS 620 Combinatorial Optimization and Modern Heuristics. This course presents classical and modern optimization techniques, including linear programming, Lagrangian and Karush Kuhn Tucker optimization, evolutionary, co-evolutionary, swarm, ant-based, and other meta-heuristics. Case studies include a variety of combinatorial and graph optimization, as well as data analysis applications.

Instructor: Dr. Olfa Nasraoui, olfa.nasraoui@louisville.edu
Teaching Assistant: TBD

Additional Details about the course

- Teaching Method:
- **Section 01:**
  - Offline
  - Delivery Mode:
    - All delivery is **at assigned** meeting dates and times **every Tuesday and Thursday 2:30 - 3:45 PM in Duthie 116**.
    - Exams will be in class or on blackboard. Assignments will be announced and submitted on Blackboard.
- **Section 50:**
  - 100% online
  - Delivery Mode:
    - All delivery is **asynchronous** which means no set meeting dates and times
    - All exams and assignments will be **announced and done online** (announced and submitted later on Blackboard)
- Technology requirements: Computer with access to Blackboard for assignments, announcements, lecture slides and to Blackboard Collaborate Ultra for videos of lectures (online section 50), email, internet, editing software for assignments and presentations, some project assignments will expect some programming (Python or your choice)
- **Office hours will be on Blackboard Collaborate tentative - time TBD Wednesdays from 4-6 PM.**
- Contingency Plans:
  - If the instructor falls ill, the TA with help from Department colleagues, will take over the course.

Prerequisites: Graduate standing and fundamental skills in math, algorithms, and statistics. Given that this is an advanced level graduate computer science course, you are responsible to be able to write, modify, or run code and configure existing code libraries on your own without any assistance from the instructor.

Textbooks: Zbigniew Michalewicz and David B. Fogel, How to Solve It: Modern Heuristics, Springer-Verlag, 2004. ISBN: 3-540-22494-7.

Christos H. Papadimitriou and Kenneth Steiglitz, Combinatorial Optimization: Algorithms and Complexity; Dover Publications; 1998, ISBN:0486402584.

Topics Covered:

1. Review of mathematical preliminaries: sets, matrices, graphs, and others.
2. Mathematical foundations of optimization and some classical optimization problems (convexity, LP, NLP, TSP, SAT, and others)
3. Complete evaluation based optimization and heuristics: Enumeration, local search, backtracking, hill-climbing, Newton-Raphson, Brent, gradient and Hessian-based optimization, Simplex, and others
4. Partial evaluation based optimization and heuristics: Greedy search, divide-and-conquer, dynamic programming, branch and bound, A*, $\alpha-\beta$-pruning, and others
5. Problems, algorithms, computational complexity, NP-completeness theory
6. Modern and Meta-Heuristics and applications: randomized algorithms, simulated annealing, tabu search, evolutionary computation
7. Advanced evolutionary computation: multimodal optimization and niching methods, constrained optimization, multi-objective optimization, cultural algorithms, interactive optimization, co-evolutionary (cooperative and competitive) optimization, artificial immune systems, ant colony and particle swarm optimization
8. Numerical optimization methods: Primal-Dual, Lagrangian & Karush Kuhn Tucker Optimization, Quasi-Newton optimization, Regularization
9. Optimization for Advanced Data Analysis & extended methods: Stochastic Gradient Descent, regularization methods, etc. Case studies: Support Vector Machines, Matrix Factorization, others upon request.
10. Paper and project presentations

Grading:

Paper presentations, class and online forum participation: 30% (15 % if the semester has no paper presentations)
Quizzes, take home exams & assignments: 30% (45% if the paper has no paper presentations)
Final class project and poster presentation: 40%

How will Assignments be Announced and Where to Find them:

All assignments will be announced via two **simultaneous** means:

1) the Announcements page with a LINK to a TEST deployed for that purpose

AND

2) an e-mail to your louisville.edu e-mail account via Blackboard Announcements

NOTE about E-mail: Due to a Blackboard limitation, the test LINK is only visible on the corresponding ANNOUNCEMENT, therefore you need to go to the main page / Announcements for a fast access to the test.

In addition, the tests will be available via the ASSIGNMENTS folder + the UNITS under the Course Documents folder themselves to facilitate finding the links.

Homework Submission Policy:

All homework must be typed, except when permitted to handwrite, (PDF files- LYX or Latex is the preferred editor for Mathematical-rich assignments and reports) and uploaded as response to the test on the website on or before the due date. All details of your work must be shown or no credit. Plagiarism (from any source) and/or cheating will not be tolerated. However, references to online or offline sources are allowed and encouraged with proper citation, including from online forum discussions on the course website.

Communications/Questions:

All communication with instructor should be done using **both** of the following forms (simultaneously):

1. **By e-mail** via Blackboard to TA email (see above TA contact info), and CC to olfa.nasraoui@louisville.edu.
2. **Using the Forums: Questions about homework, etc should also be posted on the forum for that topic.**
    - **Anyone may attempt to reply to any question on the forum.**
    - **Participation in replying to your peer's comments, discussions, questions, etc on the forums will be an important factor in grading (15%).**
    - **You should subscribe to each forum so that you receive notifications when something gets posted**

More Details on Project Reporting, Formatting and Paper Presentations:

- **Paper presentations (synchronous in offline course, only if time permits; asynchronously via posting videos on the forum in the online course)**
  Reading and 20 minute-presentation (in person for offline; video recording for online) by a team of 2 students of an advanced paper and challenging questions submitted by two discussants per paper at least 24 hours ahead of the presentation, and answered by the presenters during the presentation. Grade depends on the student's presentation and answer to the discussant's questions, and on the quality of discussion questions for the discussants.

- **Project** involves the study and solution of a challenging optimization problem using a Meta-Heuristic based optimization method and a computer implementation of the solution (using existing tools and public code is allowed and encouraged, with citations and credits clearly included in your project), along with rigorous experimental evaluation and analysis. Project proposal (approximately 1 month before end of term or by the due date communicated by the instructor) and formal report + slides (1 week before the end of the term, or by the due date communicated by the instructor) must be submitted in PDF format and/or on Google Slides.
    - The project cannot be the same as any other previous or concurrent project done for any other course. If there is any overlap no matter how small, you must inform the instructor, along with your proposal, about the previous project (and share the report for that project), as well as the differences you plan to undertake in the new project before getting approved.

- **Final Project Proposal: In addition to the above guidelines on the proposal, every team must email a summary of their final project to all instructors on the course and get approval before**

- **Final Project Report** (6 pages maximum + additional Appendix allowed for experimental results and code)

    - **Report has to be structured to include:** Team member names, course name, semester and year, project title, introduction, literature review on the studied problem and related problems and prior or classical ways used to solve this problem in the literature. The problem should be related and compared to the most similar known classical optimization problems. The report must include a computational complexity analysis, detailed algorithm, all relevant equations, algorithm implementation details, and experimental results with analysis of proposed solution(s), conclusions, and bibliographic references. The project grade will be evenly distributed between report structure, algorithms, and project poster presentation.
    - Follow ACM formatting guidelines or IEEE formatting guidelines.

- **Final Projects Poster Session:** Prepare and share your project slides (about 16 slides per project team): follow section guidelines for report, use at least Arial font size 20 for all text on all slides. Project slides must follow the exact structural organization of the report as described above.
    - **For Offline Section:** Presentations will be scheduled in lieu of Final exam: TBA (for offline course only - check final exam schedule for current exam). The students will engage in peer feedback and assessment of every other project (required). Online submission and discussion is also required in the merged class on Blackboard.
    - **For Online Section:** Teams will upload their presentation slides and videos on a dedicated Discussion forum thread and the class will engage in discussion and questions. The students will engage in peer feedback and assessment of every other project via replies on the forum discussion thread (required).

Computer Issues and IT Support

Speed IT staff are available by appointment from 9 am to 4 pm to assist you with your technology needs. You may schedule an appointment by sending a detailed email including any relevant error codes and screen snips at SPDHelp@Louisville.edu (preferred) or 502-852-7620.

COVID-19 Issues:

As a Community of Care, all Cardinals are expected to abide by public health guidelines and regulations as published by the University. While masks are currently not mandated, they are strongly encouraged when indoors (including classrooms, shared office spaces, etc), while Jefferson County is in “red level” (high risk) status based on CDC criteria.
Please note, in the event that the public health status changes, the University may reinstitute required masking, or otherwise alter their COVID policies. Students, Faculty, and Staff are expected to abide by any such requirements in the event they are implemented. As a Community of Care, please be courteous to others, whether or not they decide to wear a mask.
Faculty have the responsibility to help students meet these recommendations by allowing students absent for reason of illness and/or quarantine to make up missed work and not penalize students for these absences. Faculty may require documentation.
In the event the instructor becomes ill, he/she will send a notification via Blackboard prior to the subsequent class meeting to provide further instructions. Depending on the type of illness, class may be moved to a remote format (temporarily), may be run by a Graduate Teaching Assistant, or may be canceled. Please be sure to check your University email account regularly in case issues such as this arise.
UofL will post updates to policies, FAQs, and other COVID information here.
Updated COVID-19 Status for the Jefferson County area can be found here.

Title IX/Clery Act Notification

Sexual misconduct (including sexual harassment, sexual assault, and any other nonconsensual behavior of a sexual nature) and sex discrimination violate University policies. Students experiencing such behavior may obtain confidential support from the PEACC Program (852-2663), Counseling Center (852-6585), and Campus Health Services (852-6479). To report sexual misconduct or sex discrimination, contact the Dean of Students (852-5787) or University of Louisville Police (852-6111).

Disclosure to University faculty or instructors of sexual misconduct, domestic violence, dating violence, or sex discrimination occurring on campus, in a University-sponsored program, or involving a campus visitor or University student or employee (whether current or former) is not confidential under Title IX. Faculty and instructors must forward such reports, including names and circumstances, to the University's Title IX officer.

For more information, see the Sexual Misconduct Resource Guide: http://louisville.edu/hr/employeerelations/sexual-misconduct-brochure.

Sexual Harassment

The University of Louisville strives to maintain the campus free of all forms of illegal discrimination as a place of work and study for faculty, staff, and students. Sexual harassment is unacceptable and unlawful conduct and will not be tolerated in the workplace and the educational environment. Unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature constitute sexual harassment, even when carried out through computers or other electronic communications systems.

Students and Instructors are protected from Sexual Harassment according to the Affirmative Action policy, the Student Code of Conduct, and the UofL Computer Account Usage Agreement.

Anyone experiencing Sexual Harassment should refer to the links above and/or contact the PEACC Program at 852.2663 and an advocate will explain your choices. This is a free and confidential service.

Anyone who would like to receive more information or provide training to a classroom can contact a PEACC representative at 852.2663 and may use the educational modules provided by the PEACC Program.

I believe that everyone should be able to participate in my class without the fear of sexual harassment, and I am committed to the university's policy. Additionally, certain behaviors are inappropriate even if they do not meet the technical criteria for harassment. Be respectful to each other.

Students with Disabilities

The University of Louisville is committed to providing access to programs and services for qualified students with disabilities. If you are a student with a disability and require accommodation to participate and complete requirements for this class, notify me immediately and contact the Disability

Resource Center (Stevenson Hall, 502.852.6938) for verification of eligibility and determination of specific accommodations.

For more information, visit the Disability Resource Center.

Academic Dishonesty

Academic dishonesty is prohibited at the University of Louisville. It is a serious offense because it diminishes the quality of scholarship, makes accurate evaluation of student progress impossible, and defrauds those in society who must ultimately depend upon the knowledge and integrity of the institution and its students and faculty.

For more information, visit the Code of Student Rights and Responsibilities (Sections 5. and 6.).

Religious Holy Days and Observances

Federal law and university policy prohibit discrimination on the basis of religious belief. It is the policy of the University of Louisville to accommodate students, faculty, and staff who observe religious work-restricted holy days.

Students: Students who observe work-restricted religious holy days must be allowed to do so without jeopardizing their academic standing in any course. Faculty are obliged to accommodate students' request(s) for adjustments in course work on the grounds of religious observance, provided that the student(s) make such request(s) in writing during the first two (2) weeks of term.

For more information, view the Calendar and Policy on Religious Holy Days and Observances.

Statement on Diversity

The University of Louisville strives to foster and sustain an environment of inclusiveness that empowers us all to achieve our highest potential without fear of prejudice or bias.

We commit ourselves to building an exemplary educational community that offers a nurturing and challenging intellectual climate, a respect for the spectrum of human diversity, and a genuine understanding of the many

differences-including race, ethnicity, gender, gender identity/expression, sexual orientation, age, socioeconomic status, disability, religion, national origin or military status-that enrich a vibrant metropolitan research university.

We expect every member of our academic family to embrace the underlying values of this vision and to demonstrate a strong commitment to attracting, retaining and supporting students, faculty and staff who reflect the diversity of our larger society.

Note: The above is subject to change