Computational optimization problems occur in science, engineering, business management, and many other application areas. Many of these problems can be solved efficiently by computer programs, while many others seem to be computationally infeasible. Effective computer algorithms have been developed for solving feasible optimization problems and for handling infeasible optimization problems. The study of computational optimization problems has become central in the research in theoretical computer science.

This course will study algorithmic techniques and complexity for computational optimization problems, with focus on how computationally infeasible problems can be handled. After a brief review on algorithmic techniques for solving feasible optimization problems, such as, maximum-flow, matching, and linear programming, we will concentrate on the study of solving NP-hard optimization problems. Different approaches will be discussed, including polynomial time approximation algorithms, faster exponential time algorithms, and parameterized algorithms. The course is heavily research oriented. We will introduce classical results known since early 1980’s, but emphasize on most recent results and approaches developed in the last few years. After the study of this course, students should be well prepared for doing most advanced research in the area, or applying the techniques here to other areas in computer science and engineering.

We will not follow the textbooks chapter and chapter. Instead, we will select proper materials from the textbooks, from research literature, and from unpublished manuscripts. Supplementary materials will be handed out. A more detailed description for the course can be found in page 3.

There will be homework assignments and a final examination. The homework assignments are used for your practice on the concepts and techniques discussed in class, and the final examination is to test your comprehensive understanding of the class lectures. The assignments are due on the designated due dates at the beginning of class. No late submissions will be accepted. Discuss unusual circumstances in advance with the instructor.

1Course materials, including lecture notes, assignments, and this course description, can be found via the instructor’s web page http://faculty.cs.tamu.edu/chen
A major component of the course is a course research project. There are two options for the course research project: (1) reading a very recent research paper, giving a presentation of the paper to the class, and writing a report on the paper; or (2) a mini research project, in which you should produce research results that are unknown in the literature. More details are given under the subtitle “Course Research Project.”.

Prerequisites

A solid background in computer algorithms is required. Familiarity with the materials in the graduate course CPSC-629 Analysis of Algorithms is assumed. The following is a quick test to see if you are prepared for the course:

You should be able to quickly answer these two questions
1. what is an NP-complete problem?
2. are you familiar with Dijkstra’s algorithm for the shortest path problem?

Talk to the instructor and get his permission for taking the course if you have an unusual background.

Textbooks


The following book will be very useful and helpful during our discussion.


Supplementary course notes will also be provided.

Course Research Project

You can take one of the two options below for your course research project. Your research report should be prepared in the format of Lecture Notes in Computer Science, whose class file will be handed out.

A. Paper Reading. you pick a research paper on optimization problems that was published no earlier than 2010 in the proceedings of the following conferences:

ACM Symposium on Theory of Computing (STOC)
IEEE Symposium on Foundations of Computer Science (FOCS)
ACM-SIAM Symposium on Discrete Algorithms (SODA)

You should discuss with the instructor on the paper of your choice. After reading the paper, you should give a 15-minute presentation on the paper (prepared using PowerPoint) to the class, and write a report of at least 10 pages on the paper.
Note that most papers in these proceedings are preliminary versions and with many details missing. You should re-write the main analysis (including the proofs of the key lemmas and theorems) and fill all missing details.

B. Mini-research project. On this option, you will pick a research problem whose solution is still unknown in the literature. The research problem can be one questioned in an existing research paper, or one that is closely related to your own research, or one suggested by the instructor in class. After discussing with the instructor and having instructor’s permission, a student will read related research work in the area and try to solve the problem. The student can expect to gain further direction and advice from the instructor during the research. With the instructor’s permission, students may also work on research problems proposed and suggested by themselves. A project report of at least 12 pages should be submitted that summarizes the new findings during the student’s research.

You must notify the instructor of you choice by Thursday, October 2, 2014. If you choose paper reading, you should inform the instructor of the paper you are going to read. If you choose mini-research, you should submit a 1-page proposal on the mini-research topic.

The course project report (for both paper reading and mini-research) is due December 4, 2014.

Grading

Homework 30%, Final examination 30%, Term project 40%.

Topics to be Covered

• algorithmic background review
• polynomial time algorithms for optimization problems
• approximation algorithms for NP-hard optimization problems
• inapproximability results
• exact algorithms for NP-hard optimization problems
• parameterized algorithms for NP-hard optimization problems
• computational lower bounds
• bigdata algorithms