CPSC-689 Exact and Parameterized Computation

Fall 2006

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Office Hours: T-Th 2:30pm-3:55pm

TEXTBOOKs:
No textbook is required. The following two survey papers will be used in class discussion:

• G. Woeginger, Exact Algorithms for NP-Hard Problems: A Survey;

The manuscripts will be made available during the class. Moreover, supplementary reading materials will be handed out in class.

PREREQUISITES:
Interests in theoretical computer science and background in (at least undergraduate level) algorithm design and analysis.

COURSE DESCRIPTION
According to the commonly accepted working hypothesis in computer science, P ≠ NP. Therefore, an NP-hard computational problem is practically infeasible. On the other hand, many NP-hard computational problems are extremely important in a wide range of applications, therefore must be solved somehow. Many approaches have been proposed, including approximation algorithms and heuristic algorithms. However, none of these approaches has satisfied all needs requested from industry and applications: approximation algorithms can only provide approximation solutions while many applications may require precise solutions, and heuristic algorithms do not provide formal performance guarantees.

Exact and parameterized computation is a more recently developed new approach dealing with hard computational problems arising from industry and applications. The research in this area has discovered a number of
non-trivial and interesting algorithmic methods that lead to new algorithms that give precise solutions and solve many hard computational problems significantly faster than the trivial enumeration algorithms. In this course, we will discuss in details these new algorithmic techniques and consider how they can be used to solve hard computational problems practically. In particular, the following topics will be studied:

- Dynamic programming techniques
- Effective branch and search
- Exact algorithms for the Satisfiability problem
- Parameterized complexity theory
- Preprocessing and kernelization
- Color-coding
- Randomized techniques
- Sub-exponential time computability
- Strong computational lower bounds
- Algorithm engineering

The course is heavily research oriented. Reading selected recent research papers to understand the fundamentals of the area is essential to the course. However, the most important part of the course is the participation in course research and working on a course project in which students will have an opportunity to practise what they learn from the course to try to derive new research results interesting in the area. Problems for the research project will be suggested by the instructor in the class. Students are also encouraged to find research problems by themselves.

**COURSE EVALUATION**

The course performance will be evaluated based on three components of the course: a paper presentation, a course project research, and a final examination.

**Paper presentation**
Each student should pick a research paper published no earlier than 2002 in a major conference or journal. Please discuss the paper with the instructor and get his agreement. The paper must be on exact and parameterized computation. The student reads the paper, writes a report of at least 5 pages, and gives a 30-minute presentation on the paper to the class (using PowerPoint).

Each student is also responsible for making a homework question for the class based on her/his presentation, handed out on the day of her/his presentation. The student is responsible for grading the homework question. The question maker will get a full grade on that homework assignment. If a student fails to make the question, she/he will get grade 0 and all other students will get full points for that homework assignment.

**Course Research Project**

Each student should pick a research topic to work on as his/her course project, and write a project report on his/her research. Students should submit a 2-page project proposal by November 14 (Tuesday) to give an outline on their course project research. The final project report (of at least 8 pages) is due the last class of the course (December 5).

**Final Examination**

The final examination is on the materials covered in classes by the instructor (i.e., not including materials presented by students). The examination will be given on December 12, 1:00pm – 3:00pm (subject to change).