Course Outline

COMP6741
Parameterized and Exact Computation
Semester 2 2014

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Course Staff

Staff Name	Role	Email	Phone
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Course Details

Course Code: COMP6741

Course Title: Parameterized and Exact Computation

Units of Credit: 6

Course WebSite: http://www.cse.unsw.edu.au/~cs6741/

Handbook Entry: http://www.handbook.unsw.edu.au/undergraduate/courses/2014/COMP6741.html

Course Summary

The course focuses on algorithms for exactly solving NP-hard computational problems. Since no polynomial time algorithm is known for any of these problems, the running time of the algorithms will have a super-polynomial dependence on the input size or some other parameter of the input.

The first part presents algorithmic techniques to solve NP-hard problems provably faster than brute-force in the worst case, such as branching algorithms, dynamic programming across subsets, inclusion-exclusion, local search, and measure & conquer. We will also see lower bounds for algorithms and how to rule out certain running times assuming the (Strong) Exponential Time Hypothesis.

Whereas the first part presents "default" algorithms that one would use without knowing much about the instances one is about to solve, the second part acknowledges that the complexity of an instance does not only depend on its size n. A parameter k is associated with each instance and the parameterized complexity framework aims at designing fixed-parameter algorithms whose running times are f(k)*poly(n) for a computable function f. This gives efficient algorithms for small values of the parameter obtained via techniques such as branching, colour coding, iterative compression, and kernelization (preprocessing). We will also see problems that are not fixed-parameter tractable and not kernelizable to polynomial kernels subject to complexity-theoretic assumptions.

Course Aims

NP-hard problems are often at the core of the most challenging, rewarding, and lucrative computational problems in all areas of science and technology. This course will outline principled ways to approach these problems and will give students a better understanding of when and why NP-hard computational problem can be solved with reasonable resources.

After completing the course, students are able to

- design and analyze non-trivial exponential time algorithms for NP-hard problems using a variety of algorithmic methods
- prove that certain problems cannot be solved in subexponential time or faster than a specific exponential time bound assuming the (Strong) Exponential Time Hypothesis
- design parameterized algorithms for NP-hard problems using a variety of algorithmic methods
- prove that certain parameterizations of problems are not fixed-parameter tractable unless FPT = W[1]

- rule out polynomial kernels for certain parameterizations of problems

Assumed Knowledge

Before commencing this course, students should have basic knowledge in algorithms and complexity, acquired in the course COMP3121

Assessment

Assignments	20%
Midterm	30%
Final Exam	50%

Course Schedule

Week	Lecture
1	Introduction; Dynamic Programming
2	Branching Algorithms
3	Branching Algorithms; Inclusion-Exclusion
4	Inclusion-Exclusion
5	Basics of Parameterized Complexity; Kernelization
6	Kernelization; Parameterized Branching Algorithms
7	Parameterized intractability: the W-hierarchy
8	Parameter Treewidth
9	Iterative Compression
10	Randomized methods and Color Coding; Kernel Lower Bounds
11	Kernel Lower Bounds; Exponential Time Hypothesis
12	Exponential Time Hypothesis; Review of covered topics and discussions

Resources for Students

Recommended readings

- [DF13] Rodney G. Downey and Michael R. Fellows. Fundamentals of Parameterized Complexity. Springer, 2013.
- [FK10] Fedor V. Fomin and Dieter Kratsch. Exact Exponential Algorithms. Springer, 2010.

Other useful resources

- [FG06] JÃ¶rg Flum and Martin Grohe. Parameterized Complexity Theory. Springer-Verlag, 2006.
- [G10] Serge Gaspers. Exponential Time Algorithms: Structures, Measures, and Bounds. VDM Verlag Dr. Mueller, 2010.
- [N06] Rolf Niedermeier. Invitation to Fixed-Parameter Algorithms. Oxford University Press, 2006.
- FPT Wiki