UNSW Course Outline

COMP6741 Algorithms for Intractable Problems - 2024

Published on the 28 Jan 2024

General Course Information

Course Code : COMP6741
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Computer Science and Engineering
Delivery Mode : Multimodal
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate, Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

The course focuses on algorithms for solving intractable computational problems, so-called NP-hard problems. Ideally, one would want to design algorithms that solve each instance exactly and in polynomial time. But since no polynomial time algorithm is known for any NP-hard problem,

we will relax these requirements and design algorithms that either do not solve the problem exactly, that only solve a subset of instances, or whose worst-case running time is super-polynomial in the input size or some other parameter of the input.

Among algorithms that do not solve the problem exactly, we discuss heuristics and approximation algorithms. Heuristics do not guarantee to compute optimal solutions but tend to work well in practice. Approximation algorithms give additional guarantees of the quality of computed solution as compared to the optimal solution.

Among algorithms that only solve a subset of instances, we discuss graph classes where NP-hard graph problems often become polynomial-time solvable when the input is restricted to these classes.

Among algorithms that do not run in polynomial time, we discuss exponential-time algorithms and parameterized algorithms. In exponential-time algorithms we discuss algorithmic techniques to solve NP-hard problems provably faster than brute-force in the worst case. In parameterized algorithms, a parameter k is associated with each instance and the goal is to design algorithms whose worst-case running time is fast whenever k is small. We will also see lower bounds for problems and how to rule out certain running times under various complexity assumptions.

In addition to deterministic algorithms, we discuss speed-ups if we have access to randomised algorithms or quantum algorithms.

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.

Relationship to Other Courses

Prerequisite: COMP3121/9101 or COMP3821/9801

Course Learning Outcomes

Course Learning Outcomes
CLO1 : design and analyse non-trivial exponential time algorithms for NP-hard problems using a variety of algorithmic methods
CLO2 : design parameterized algorithms for NP-hard problems using a variety of algorithmic methods
CLO3 : design new proofs showing that certain parameterizations of problems are not fixed-parameter tractable unless FPT = W[1]
CLO4 : design new proofs showing that certain problems cannot be solved in subexponential time or faster than a specific exponential time bound assuming the (Strong) Exponential Time Hypothesis
CLO5 : design heuristics and approximation algorithms for NP-hard problems, as well as polynomial-time algorithms for restricted classes of instances

Course Learning Outcomes	Assessment Item
CLO1 : design and analyse non-trivial exponential time algorithms for NP-hard problems using a variety of algorithmic methods	• Individual assignments • Group assignments • Final Exam
CLO2 : design parameterized algorithms for NP-hard problems using a variety of algorithmic methods	• Individual assignments • Group assignments • Final Exam
CLO3 : design new proofs showing that certain parameterizations of problems are not fixed-parameter tractable unless FPT = W[1]	• Individual assignments • Group assignments • Final Exam
CLO4 : design new proofs showing that certain problems cannot be solved in subexponential time or faster than a specific exponential time bound assuming the (Strong) Exponential Time Hypothesis	• Individual assignments • Final Exam
CLO5 : design heuristics and approximation algorithms for NP-hard problems, as well as polynomial-time algorithms for restricted classes of instances	• Group assignments • Individual assignments • Final Exam

Learning and Teaching Technologies

Moodle - Learning Management System | Microsoft Teams | Echo 360 | EdStem

Additional Course Information

Course website: https://serggasp.github.io/comp6741/

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Individual assignments Assessment Format: Individual	25%	Due Date: week 2 and week 4
Group assignments Assessment Format: Group	25%	Due Date: week 9
Final Exam Assessment Format: Individual	50%	Due Date: Exam Period

Assessment Details

Individual assignments

Assessment Overview

There are individual assignments and group assignments. Groups are decided by the lecturer-in-charge based on earlier individual assignments, where a group contains students who performed similarly in earlier assignments. Each student receives one mark for each individual assignment, and two marks for each group assignment. The lowest such mark is discarded and the assignment mark of a student is the average of the remaining marks. Feedback is given in terms of a marked-up copy of the assignment with recommendations and individual feedback and marks of individual questions, usually within 2 weeks of the assignment submission deadline.

Course Learning Outcomes

- CLO1 : design and analyse non-trivial exponential time algorithms for NP-hard problems using a variety of algorithmic methods
- CLO2 : design parameterized algorithms for NP-hard problems using a variety of algorithmic methods
- CLO3 : design new proofs showing that certain parameterizations of problems are not fixed-parameter tractable unless FPT = W[1]
- CLO4 : design new proofs showing that certain problems cannot be solved in subexponential time or faster than a specific exponential time bound assuming the (Strong) Exponential Time Hypothesis
- CLO5 : design heuristics and approximation algorithms for NP-hard problems, as well as polynomial-time algorithms for restricted classes of instances

Detailed Assessment Description

See course website.

Submission notes

Submission via Moodle

Group assignments

Assessment Overview

There are individual assignments and group assignments. Groups are decided by the lecturer-in-charge based on earlier individual assignments, where a group contains students who performed similarly in earlier assignments. Each student receives one mark for each individual assignment, and two marks for each group assignment. The lowest such mark is discarded and the assignment mark of a student is the average of the remaining marks. Feedback is given in terms of a marked-up copy of the assignment with recommendations and individual feedback and marks of individual questions, usually within 2 weeks of the assignment submission deadline.

Course Learning Outcomes

- CLO1 : design and analyse non-trivial exponential time algorithms for NP-hard problems using a variety of algorithmic methods
- CLO2 : design parameterized algorithms for NP-hard problems using a variety of algorithmic methods
- CLO3 : design new proofs showing that certain parameterizations of problems are not fixed-parameter tractable unless FPT = W[1]
- CLO5 : design heuristics and approximation algorithms for NP-hard problems, as well as polynomial-time algorithms for restricted classes of instances

Detailed Assessment Description

See course website.

Submission notes

Submission via Git

Final Exam

Assessment Overview

Open-book paper-based exam. A trial exam paper is made available to the students a few weeks before the exam. Feedback is given in terms of a marked-up copy of the exam with recommendations and individual feedback and marks of individual questions.

Course Learning Outcomes

- CLO1 : design and analyse non-trivial exponential time algorithms for NP-hard problems using a variety of algorithmic methods
- CLO2 : design parameterized algorithms for NP-hard problems using a variety of algorithmic methods
- CLO3 : design new proofs showing that certain parameterizations of problems are not fixed-parameter tractable unless FPT = W[1]

- CLO4 : design new proofs showing that certain problems cannot be solved in subexponential time or faster than a specific exponential time bound assuming the (Strong) Exponential Time Hypothesis
- CLO5 : design heuristics and approximation algorithms for NP-hard problems, as well as polynomial-time algorithms for restricted classes of instances

Detailed Assessment Description

See course website.

General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 12 February - 18 February	Topic	Introduction; NP-completeness
Week 2 : 19 February - 25 February	Topic	Kernelization; approximation algorithms; (integer) linear programming
	Assessment	Assignment 1 due
Week 3 : 26 February - 3 March	Topic	Kernelization; basics of Parameterized Complexity
Week 4 : 4 March - 10 March	Topic	Parameterized intractability; branching algorithms
	Assessment	Assignment 2 due
Week 5 : 11 March - 17 March	Topic	Branching algorithms; measure & conquer
Week 6 : 18 March - 24 March	Topic	-
Week 7 : 25 March - 31 March	Topic	Randomized algorithms; treewidth
Week 8 : 1 April - 7 April	Topic	Treewidth; quantum algorithms
Week 9 : 8 April - 14 April	Topic	Exponential time hypothesis; heuristics and local search
	Assessment	Assignment 3 (group assigment) due
Week 10 : 15 April - 21 April	Topic	Group assignment presentations; review

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Resources

Recommended Resources

See course website.

Course Evaluation and Development

This course is evaluated each session using the myExperience system.

In the previous offerings of this course, no substantial deficiencies were notes. Students did however make helpful comments on how to improve the course.

Based on their comments, improvements have been made to the course handouts for both black-and-white and color printing, the structure of lectures, references have been given in a more detailed way, feedback on assignments can be expected within 2 weeks of submission, the mid-session quiz has been removed, the weight of the assignments has increased while their number has increased, then decreased again.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Serge Gaspers		K17_506			Yes	No
	COMP6741 Class Account					No	Yes

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address

- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding

academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School Contact Information

CSE Help! - on the Ground Floor of K17

- For assistance with coursework assessments.

The Nucleus Student Hub - https://nucleus.unsw.edu.au/en/contact-us

- Course enrolment queries.

Grievance Officer - grievance-officer@cse.unsw.edu.au

- If the course convenor gives an inadequate response to a query or when the courses convenor does not respond to a query about assessment.

Student Reps - stureps@cse.unsw.edu.au

- If some aspect of a course needs urgent improvement. (e.g. Nobody responding to forum queries, cannot understand the lecturer)

You should **never** contact any of the following people directly:

- Vice Chancellor

- Pro-vice Chancellor Education (PVCE)

- Head of School

- CSE administrative staff

- CSE teaching support staff

They will simply bounce the email to one of the above, thereby creating an unnecessary level of indirection and a delay in the response.