CS 577 - Introduction to Algorithms

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Spring 2021

TopHat Join Code: 524741

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

CS 577 - Introduction to Algorithms: Spring 2021

Analysis of Algorithms

Problem

- Mathematical model of the problem area.
- Rules of the game.

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- Ex: I have kitchen with a stocked pantry and I want a cookie.

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- Step-by-step procedure for solving an *instance* of a given problem.

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Problem

- Mathematical model of the problem area.
- Rules of the game.

- Ex: I have kitchen with a stocked pantry and I want a cookie.

Algorithm

- Step-by-step procedure for solving an *instance* of a given problem.

- Ex: Given a kitchen with a stove, etc... and a pantry with chocolate chips, etc...

Chocolate Chip Cookies

Ingredients:

- 227g (1 cup) butter, softened
- 200g (1 cup) sugar
- 105g (½ cup) brown sugar
- 2 eggs
- 2 tsp vanilla
- 250g (2 cups) all-purpose flour
- 1 tsp soda
- 1 pinch salt
- 1 ½ cups of chocolate chips

Instructions:

1. Beat butter, sugars, eggs and vanilla until light and fluffy.
2. Add flour, soda, and salt; blend well.
3. Add chips.
4. Drop from a teaspoon 2 inches apart.
5. Bake 190°C for 9 min.

Stable Marriage Problem (SMP) (1962)[1][2][3]

Problem Definition

Given a set of n men, M, and an opposite set of n women, W. Each person has a preference ranking of the opposite set. Compute a stable matching between M and W. A matching is stable if it is (i) perfect, and (ii) there are no pairs (m, w) and (m', w') in the matching where m prefers w' and w' prefers m.

[1] Algorithm Design, Ch 1.
[2] Algorithms, Ch 4.5
[3] `http://mathsite.math.berkeley.edu/smp/smp.html`

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- A.k.a Stable Matching Problem.
- There are more complicated variations of the model.
- Used in the real world (e.g. matching doctors to hospitals).
- Nobel Prize in Economics in 2012 (Shapley and Roth).

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Gale-Shapely Algorithm [4] for SMP (1962)

Initially all $m \in M$ and $w \in W$ are free
while *there is a man m who is free and hasn't proposed to every woman* **do**
    Choose such a man m
    Let w be the highest-ranked woman in m's preference list to whom m has not yet proposed
    if *w is free* **then**
        (m, w) become engaged
    else w is currently engaged to m'
        if *w prefers* m' *to* m **then**
            m remains free
        else w prefers m to m'
            (m, w) become engaged
            m' becomes free
        end
    end
end
return *the set S of engaged pairs*

[4] Algorithm Design, p.6

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    (m, w) become engaged
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    if *w prefers m′ to m* **then**
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    else w prefers m to m'
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      m' becomes free
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Is it good?

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- Complete?

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- Correct?

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Is it good?

- Complete?
- Correct?
- Efficient? With respect to what (time, space, ...)?

[4] Algorithm Design, p.6

About You

My current year in school is:

a. Freshman
b. Sophomore
c. Junior
d. Senior
e. Graduate Student
f. Other

About You

I took CS 200 with:

a. Marc Renault
b. Jim Williams
c. Summertime instructor
d. Skipped straight to 300 (AP, etc)
e. Other

About You

My primary reason for taking CS 577:

a. I am very interested in the subject.
b. I am curious to learn more about the subject.
c. It fulfils a requirement for my program, major or certificate.
d. It fits my schedule.
e. I've heard good things about the course.

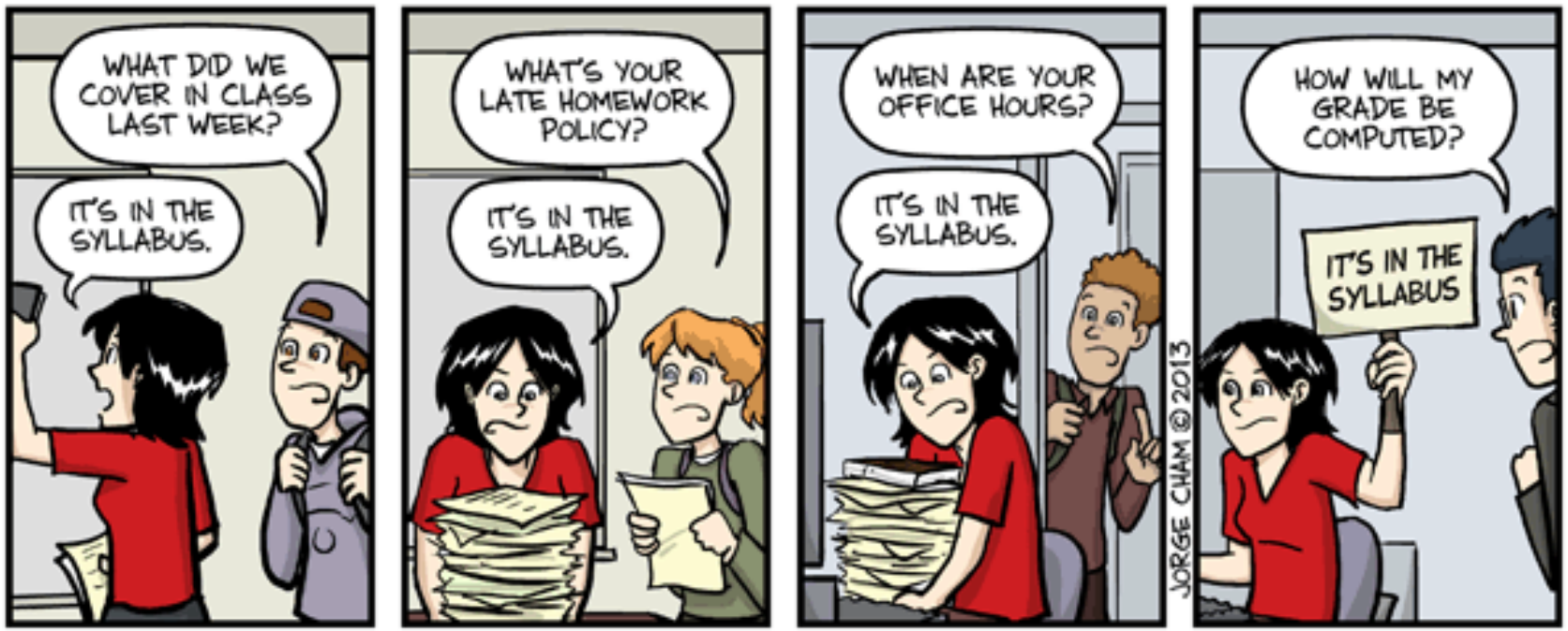
About You

My favourite Star Wars movie (from the trilogies) is:

a. I - The Phantom Menace
b. II - Attack of the Clones
c. III - Revenge of the Sith
d. IV - A New Hope
e. V - The Empire Strikes Back
f. VI - Return of the Jedi
g. VII - The Force Awakens
h. VIII - The Last Jedi
i. IX - The Rise of Skywalker
j. Never seen them

Syllabus (Course Logistics)

https://canvas.wisc.edu/courses/230470



Course Aim

https://canvas.wisc.edu/courses/230470

Overall

- Basic paradigms for the design and analysis of efficient algorithms:
  - greedy,
  - divide-and-conquer,
  - dynamic programming,
  - reductions, and
  - the use of randomness.
- Computational intractability including typical NP-complete problems and ways to deal with them.

Course Aim

https://canvas.wisc.edu/courses/230470

Specific Learning Outcomes

- Design and analyze efficient algorithms based on the paradigms of divide-and-conquer, dynamic programming, and greed.
- Formulate abstractions of computational problems, and design and analyze efficient reductions between computational problems.
- Know, understand, and apply paradigmatic algorithms and reductions dealing with numbers, strings, graphs, and networks.
- Recognize computational intractability, demonstrate NP-hardness, and understand its repercussions.

Getting Started

Getting Started Checklist

https://canvas.wisc.edu/courses/230470

Checklist

1. Review the Syllabus (Course Logistics)
2. Activate Piazza account
3. TopHat Registration
4. Register for Gradescope

2. Activate Piazza Account

`http://piazza.com/wisc/spring2021/sp21compsci577`

Online question resource

- One discussion area for all sections.
- Interaction of students, TAs and instructor.
- First stop for getting questions answered.

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Online question resource

- One discussion area for all sections.
- Interaction of students, TAs and instructor.
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Rules

- Be courteous.
- Don't post answers to homework!
- Search first, post second.

3. TopHat Registration

TOP HAT

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In-class participation

- Facility classroom participation.
- Participation grade (10%).
- Grade is calculated as an average of the percent of questions answered per lecture.

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- 80% rule.

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In-class participation

- Facility classroom participation.
- Participation grade (10%).
- Grade is calculated as an average of the percent of questions answered per lecture.
- 80% rule.
- Will have 1 week to answer questions.

4. Register for Gradescope

How to Register

1. Go to:
   `https://www.gradescope.com/pricing#signupForm`
2. The entry code is KYKG52.

4. Register for Gradescope

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Submission, Testing, and Grading Tool

1. For each assignment, you will upload a pdf of the assignment (and code if there is a coding portion).
2. Once uploaded, you will get some autograder feedback if there is a coding portion.
3. No submission limit or delay.
4. Human-grading will also happen via Gradescope.

1. Review the Syllabus

Grading

- Participation (10%)
  - TopHat Questions

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Grading

- Participation (10%)
  - TopHat Questions
  - 1 week plus the 80% rule
- Homework (50%)
  - 10 problem sets release on Tuesdays.
  - Individual; Discussions will be very helpful for homework.

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Grading

- Participation (10%)
  - TopHat Questions
  - 1 week plus the 80% rule
- Homework (50%)
  - 10 problem sets release on Tuesdays.
  - Individual; Discussions will be very helpful for homework.
- Coding Questions (10%)
  - 10 coding questions.
  - Individual; in Python, Java, C, C++, or C#.
  - Full credit for passing given sample tests.
  - Additional tests provide to further test code, plus leader board.

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Grading

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  - 1 week plus the 80% rule
- Homework (50%)
  - 10 problem sets release on Tuesdays.
  - Individual; Discussions will be very helpful for homework.
- Coding Questions (10%)
  - 10 coding questions.
  - Individual; in Python, Java, C, C++, or C#.
  - Full credit for passing given sample tests.
  - Additional tests provide to further test code, plus leader board.
- Exams (30%)
  - 3 week-long take home exams.
  - Individual; each worth 10%.

1. Review the Syllabus

Flexibility Built-in for Everyone

- 80% rule for Participation.
- 1 week for answering questions.
- 1 week for home work.
- 1 week for exams.

1. Review the Syllabus

Academic Integrity

- Academic dishonesty or misconduct is taken very seriously by the university (see UW–Madison Academic Integrity policy).
- It is academic misconduct to submit someone else's work as your own.
- It is academic misconduct to help another student commit academic misconduct.

1. Review the Syllabus

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Peer Help on Assignments

- Don't; Everything is individual work.
- You may not email, post on Piazza, or otherwise make solutions (or part of) available for others.

Textbooks (optional)

- **Kleinberg, and Tardos. *Algorithm Design*. Addison Wesley, 2006.** My favourite textbook for 577.

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- **Cormen, Leiserson, Rivest, and Stein. *Introduction to Algorithms, 3rd Edition*. MIT Press, 2009.** Now with C-style pseudocode! The classic (presumable because it was the textbook I used in my intro to algorithms course) introduction to algorithms textbook.

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- **Sedgewick, and Wayne. *Algorithms, 4th Edition* Pearson, 2011.** Another introduction to algorithms textbook with working Java code.

Exam Dates

Exams

Exams	Release Date	Due Date	Focus
1	Mar 2	Mar 9	Divide & Conquer, and Greedy
2	Mar 30	Apr 6	Dynamic Programming, and Randomization
3	Apr 28	May 4	Network Flow, and NP-Completeness

Getting Help

Getting Help

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Help!

- Piazza Online Discussion
- Weekly Discussions
- Weekly Study Groups on Specific Topics (Watch Piazza for sign-ups)
- TA Office Hours
- Instructor Office Hours

Appendix

References

Image Sources I

https://tophat.com/

https://piazza.com/

https://brand.wisc.edu/web/logos/

http://bigpicture.typepad.com/comments/images/2008/07/14/dont_panic.png

http://phdcomics.com/comics.php?f=1583

Image Sources II

https://www.linkedin.com/company/gradescope/