

Advanced Algorithms 2024

Michael Kapralov



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Welcome!

Welcome!

**As Master students, you know that
algorithms are central for**

Welcome!

**As Master students, you know that
algorithms are central for**

- **computer science**

Welcome!

**As Master students, you know that
algorithms are central for**

- ~~computer science~~ **ALL SCIENCES**
- **getting a job**
- **having fun**

Algorithmic Universe is Huge

A magnifying glass with a black handle and a white lens is positioned over a bright, yellowish-white region of a galaxy. The galaxy's spiral arms, composed of blue and white stars and dust, extend across the dark blue, star-filled background of the slide.

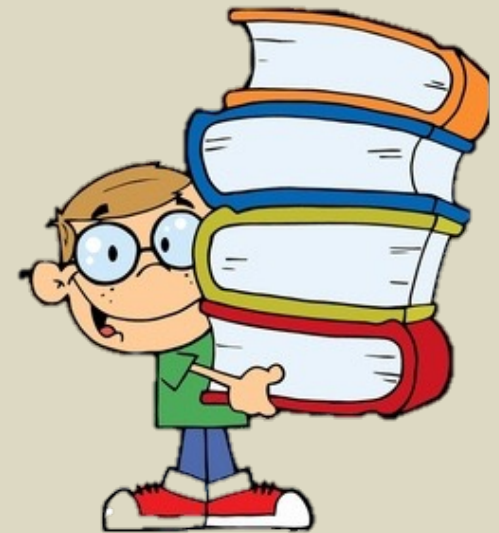
Powerful algorithmic techniques

Interesting applications/models

Theoretical analysis

To enjoy this course (prerequisites)

- You have taken and enjoyed basic algorithms
 - Basic datastructures (lists, queues, stacks, binary search trees, heaps...)
 - Basic algorithms (divide-and-conquer, dynamic programming, greedy, shortest path, spanning trees, flows)
 - Asymptotic analysis
- You have good basic knowledge of (discrete) math and probabilities
- I'll assume that you are now comfortable doing basic proofs



LIST OF (POTENTIAL) TOPICS



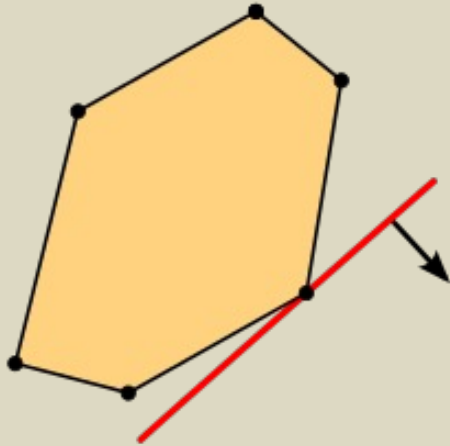
“Greed is good. Greed is right. Greed works. Greed clarifies, cuts through and captures the essence of the evolutionary spirit.”

- Gordon Gecko

When does basic greedy work? The answer is matroids

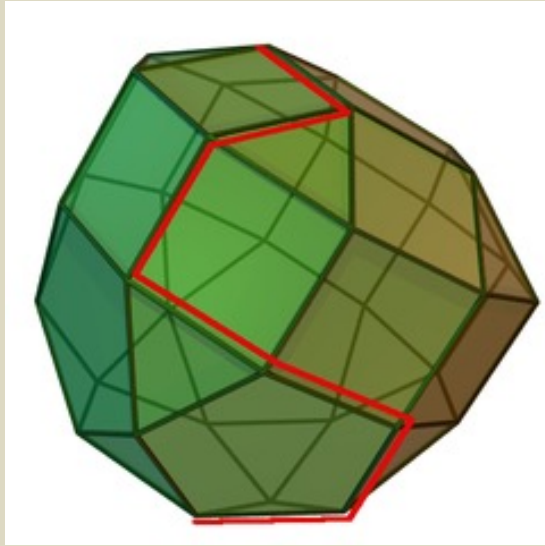
Also matroid intersection

Linear Programming

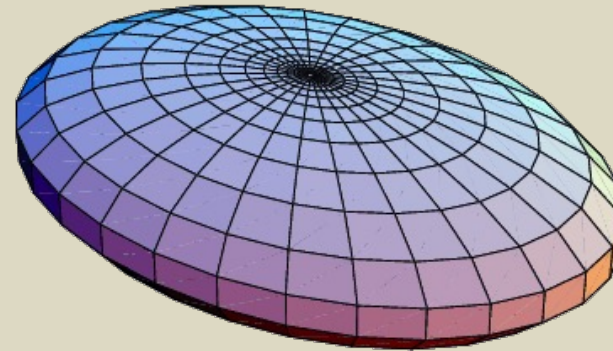


- Important big hammer
- Leonid Kantorovich - “founder of linear programming” Nobel prize in economics’ 1975
- Solution structure, duality
- Their use in the design of algorithms
- How to solve them?

Optimization



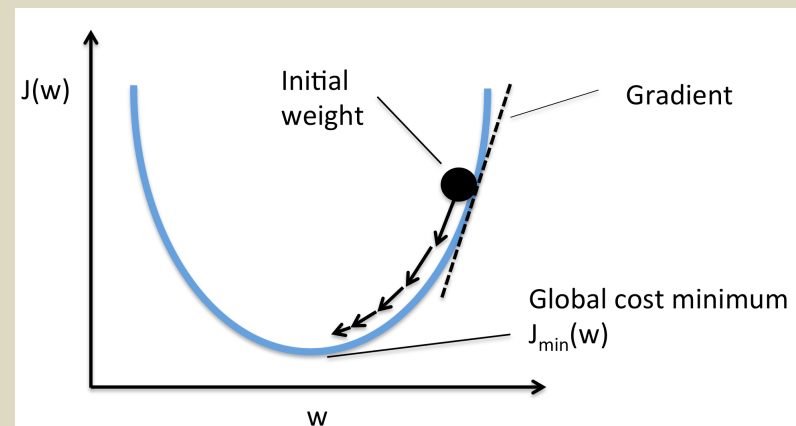
Simplex method



Ellipsoid method



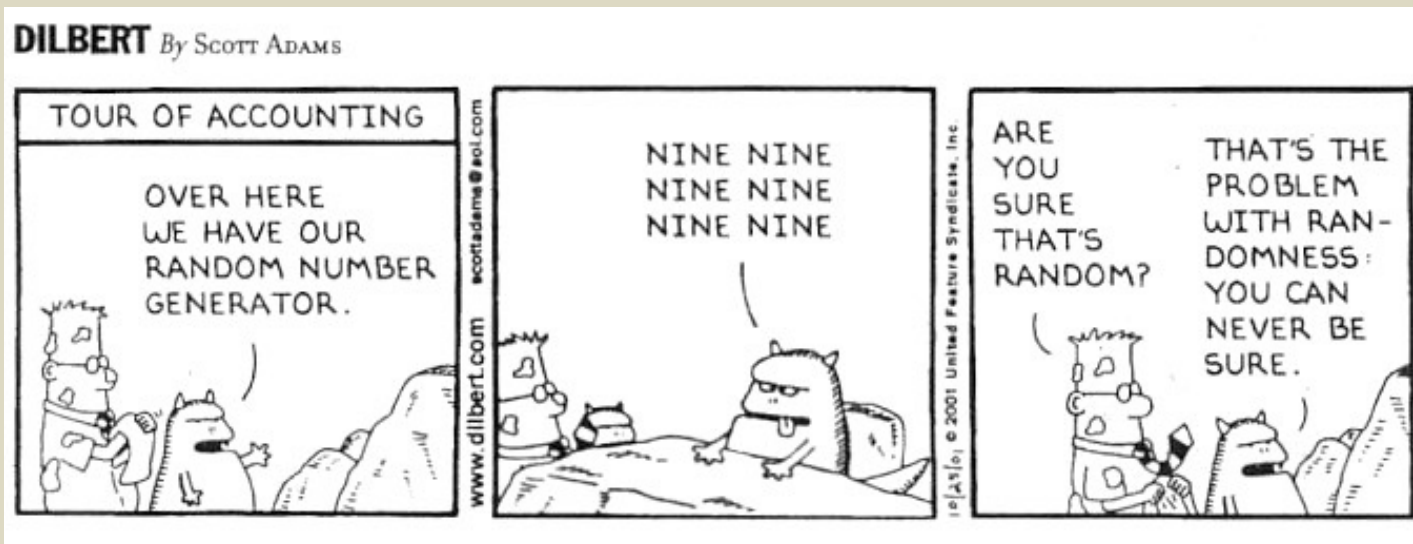
Multiplicative Weight Update



Gradient Descent

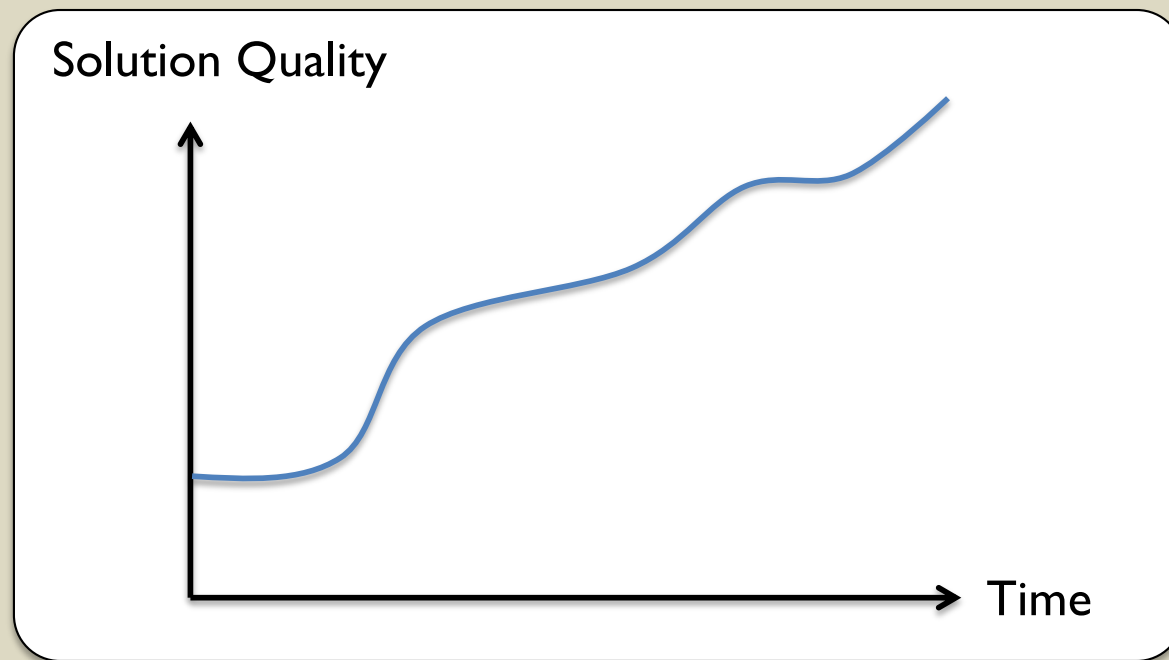
Randomized Algorithms

How to use  to design better algorithms



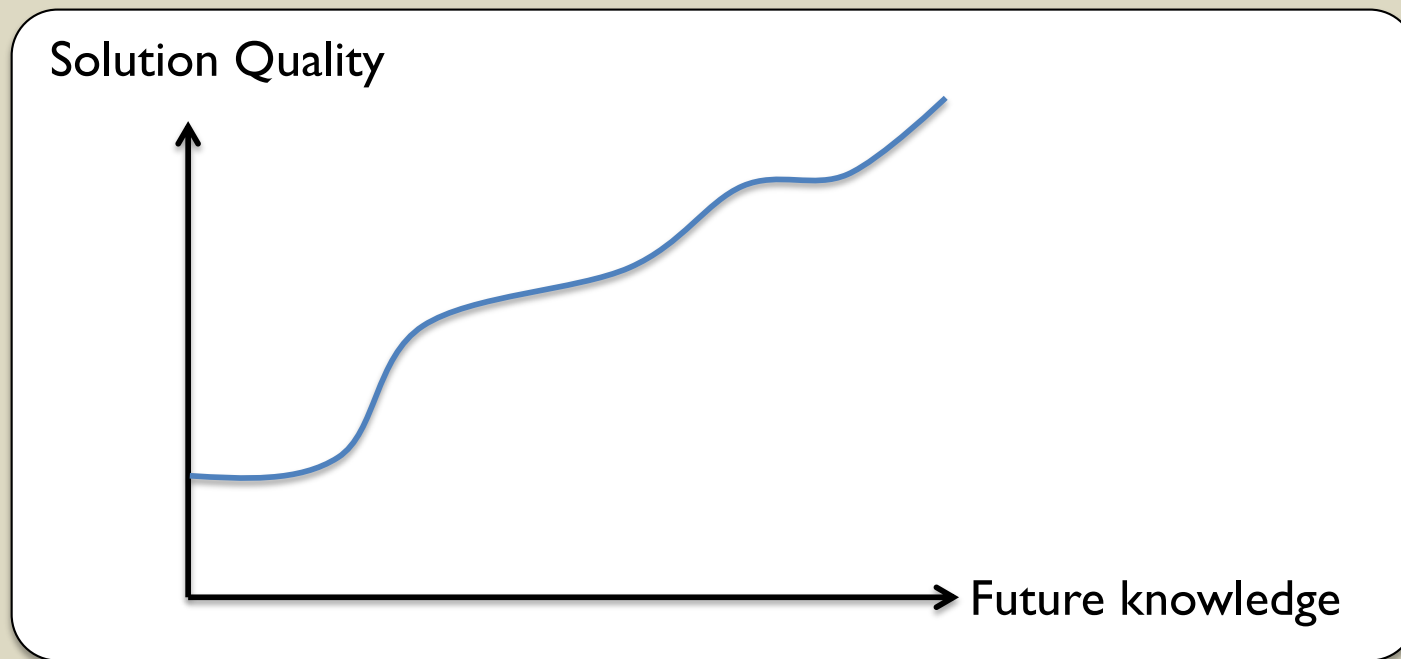
Approximation Algorithms

The study of tradeoff between solution quality and time



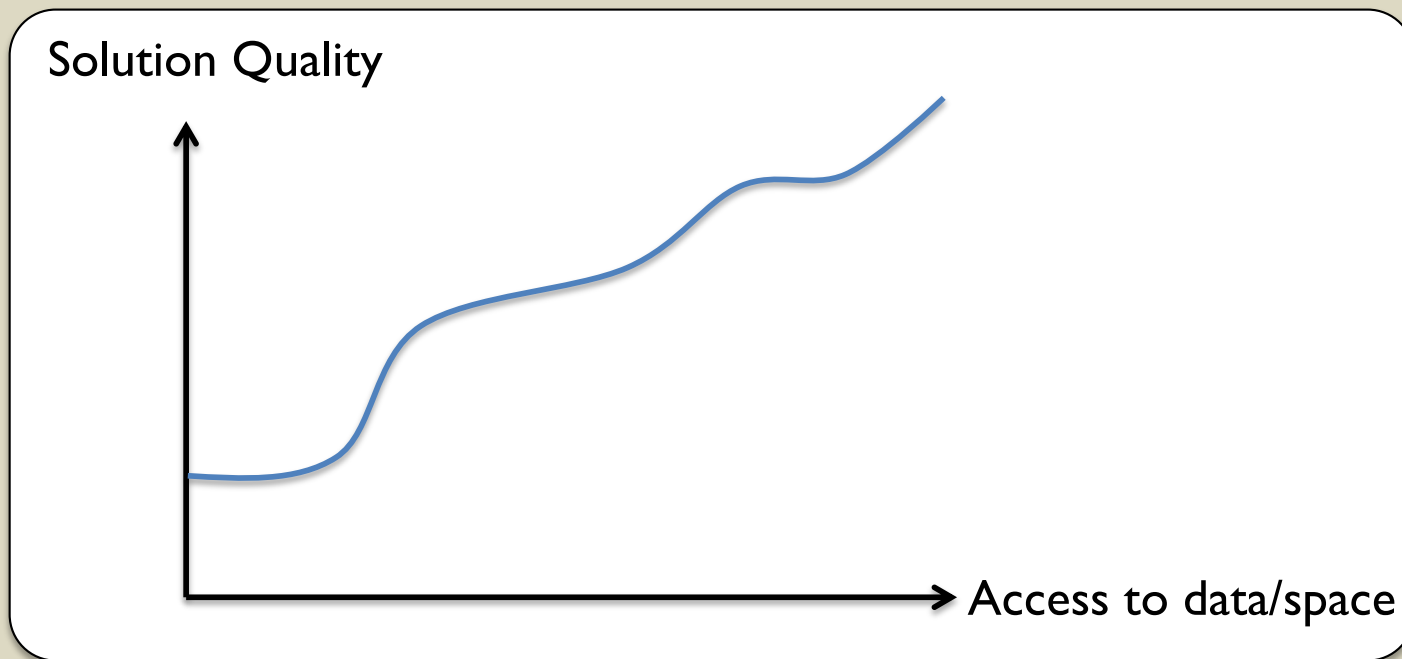
Online Algorithms

The study of tradeoff between solution quality and knowledge about future



Streaming Algorithms

The study of tradeoff between solution quality and massive data (so limited space and access)



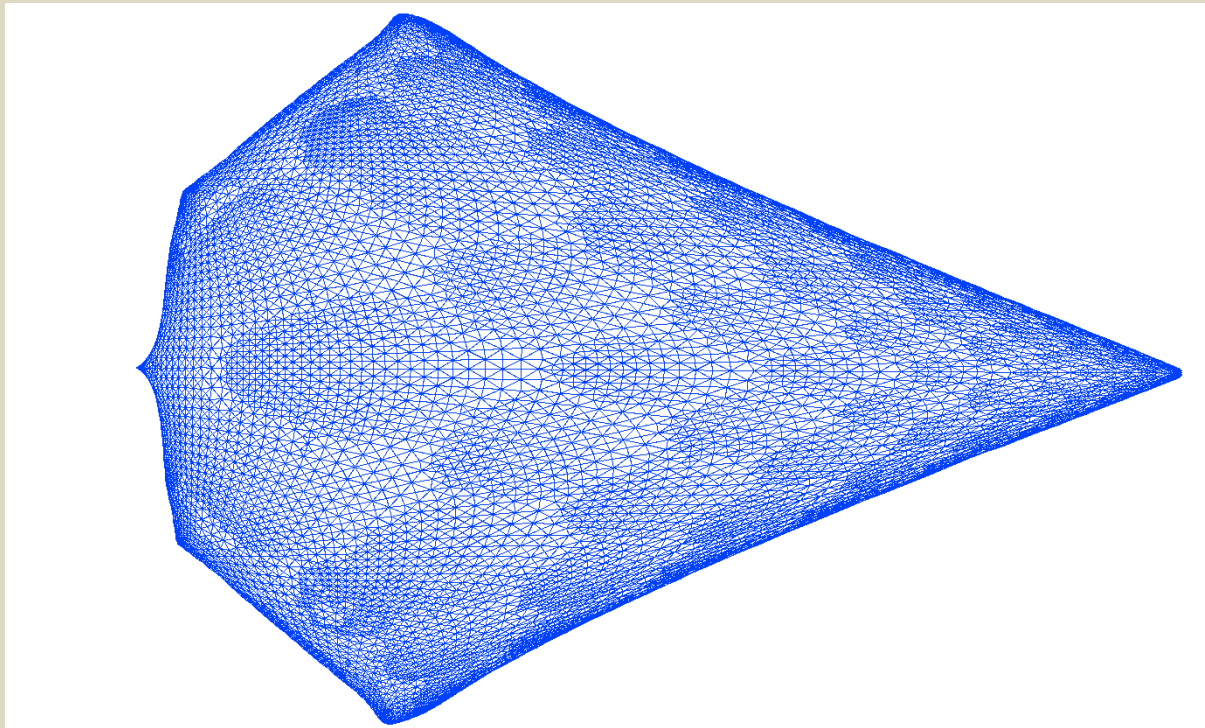
A better illustration...



How much information
must flow in a system to
perform a given task?

Spectral Graph Theory

- Study properties of graph using the eigenvalues/eigenvectors of adjacency matrix



BASIC INFORMATION ABOUT COURSE

Who Am I (the course responsible)?



- Michael Kapralov
 - michael.kapralov@epfl.ch
 - <http://theory.epfl.ch/kapralov>
- Faculty of computer science
 - Research on algorithms
- Office: INJ 113
- Happy to get feedback and to answer questions!

Who Am I (the course responsible)?



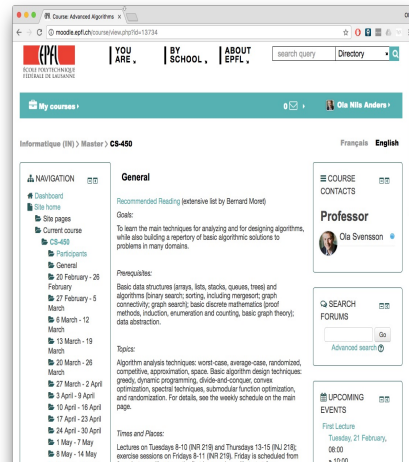
- Ola Svensson
 - ola.svensson@epfl.ch
 - <http://theory.epfl.ch/osven>
- Faculty of computer science
 - Research on algorithms
- Office: INJ 112
- Happy to get feedback and to answer questions!

Dream team of TAs

- Ekaterina Kochetkova
- Davide Mazzali
- Miltos Stouras
- Radu Vintan
- Lukas Vogl
- Guy Weissenberg
- Weronika Wrzos-Kaminska

The Course Essentials

MOODLE



Lecture notes, detailed schedule, forum,
all dynamic information

In short, the place to be

Grading: 5% quizzes, 25% homeworks (will be 2 assignments can be made in a group of up to 3 students), 30% midterm exam, 40% final exam

Comparison to Bachelor Algorithms

- Not only algorithms for solving problems in 20 minutes (more advanced techniques for more complex problems)
- Assume more mathematical maturity

Taking as granted that it would be like most courses, where one can spend a week working on the material during the exam session. **Emphasizing that this is not the case during the presentation of the course seems important to me.**

--- Comment on a previous instalment of the course