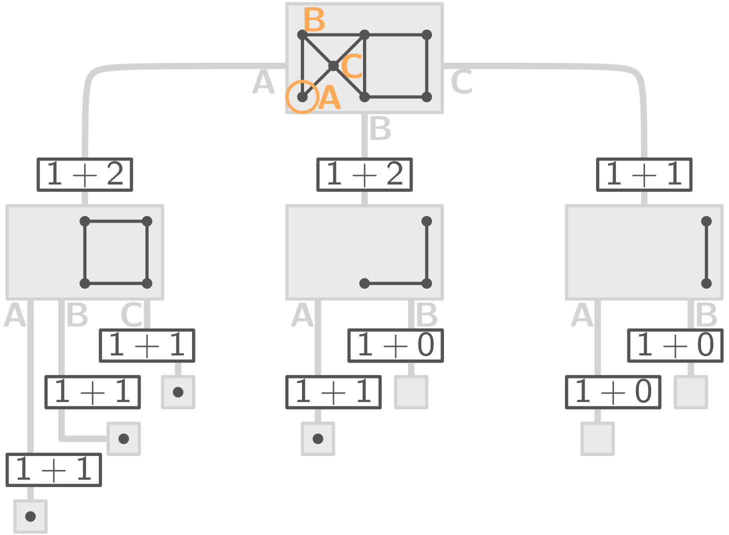
Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

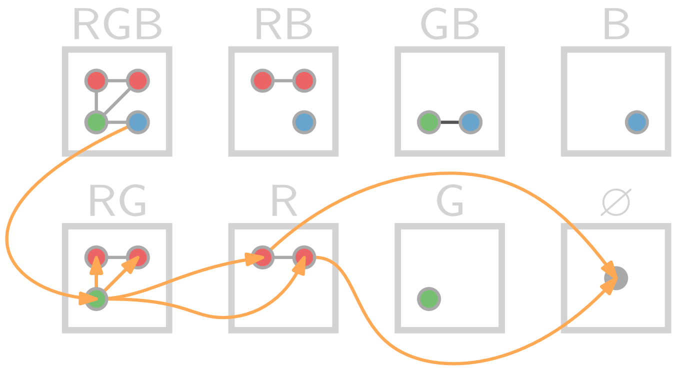
Advanced Algorithms

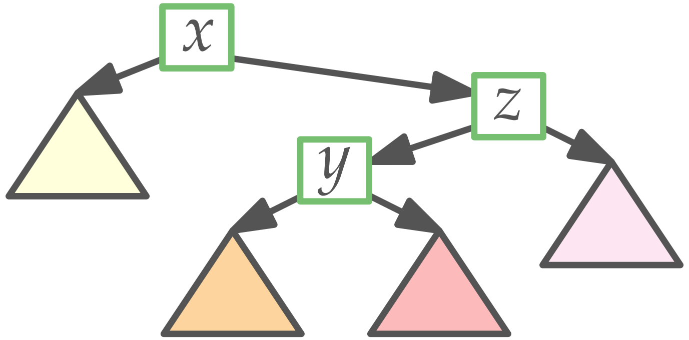
Introduction

Topics, course details, organizational

Jonathan Klawitter · WS20





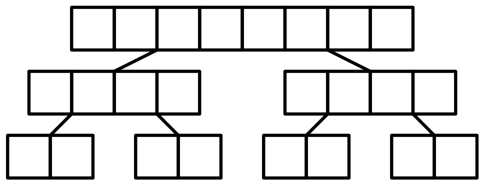


Advanced Algorithms

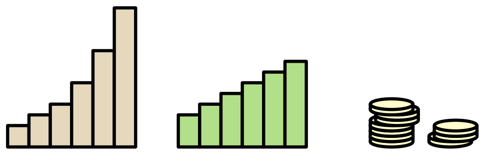
The goal of this course is to offer an overview of advanced algorithmic topics.

You have already learned a lot about algorithms,
but there is much more left. . .

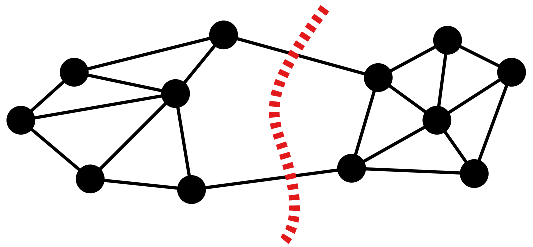
- **Types:** incremental, recursive, D&C, greedy, numerical, exact, approx., randomised, parallel, distributed, . . .



- **Analysis:** correctness, runtime, space usage, amortized, expected, optimality, benchmarking, . . .



- **Problems:** combinatorial, graphs, geometric, strings, biological, geographic, . . .



- **Data structures:** lists, binary search trees

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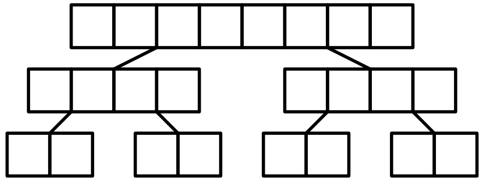

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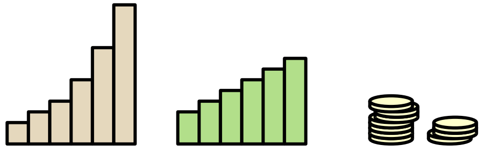

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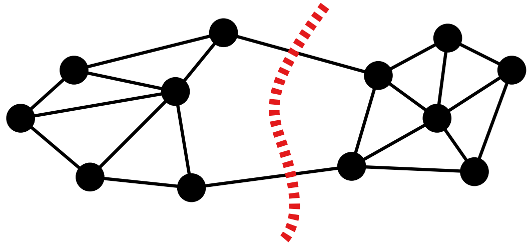
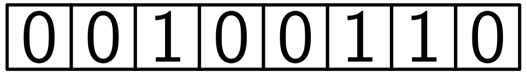


- **Data structures:** lists, binary search trees, dictionaries, succinctness, . . .



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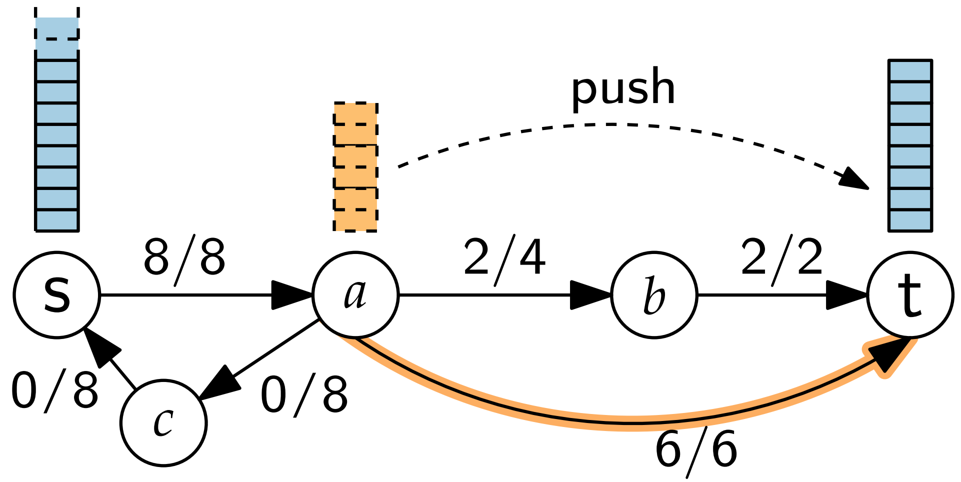
Topics I

- **Better algorithms** for problems you know

MaxFlow problem

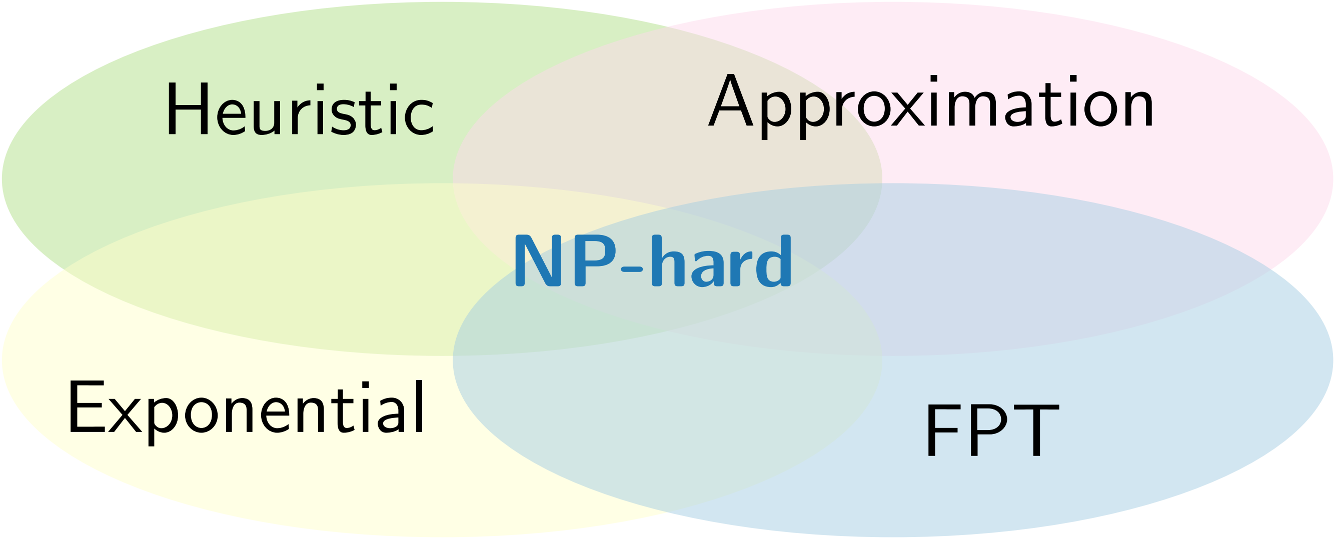


  - Ford-Folkerson algorithm: $\mathcal{O}(|E||f^\star|)$
  - Edmonds–Karp algorithm: $\mathcal{O}(|V||E|^2)$
  - Push-Relabel algorithm: $\mathcal{O}(|V|^2|E|)$ (or even better)

- Shortest paths in graph with negative edge weights

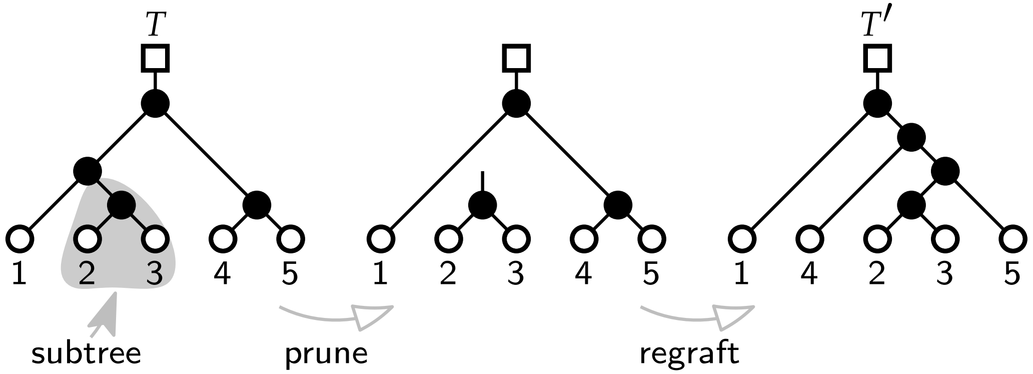
Topics II

- How to deal with **NP-hard problems**



- Sacrifice quality for speed?
- Can we still compute optimal solutions?

- Exemplary problem:
  Rearrangement distance of phylogenetic trees



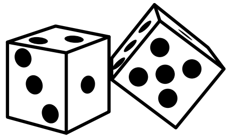
Topics III

- Special **areas**

Randomised algorithms

LONGESTPATH is NP-hard   but easy on acyclic digraphs ⇒ randomly make graph acyclic digraph

⇒ good idea?



Also

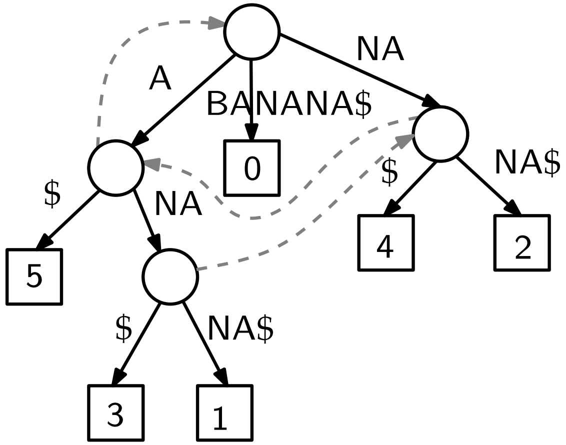
- Online algorithms
- Approximation algorithms
- Algorithmic geometry
- Working with strings

Topics IV

- (Algorithms for) **advanced data structures**

Searching for strings

Given text S, how can we efficiently find all occurences of pattern P?



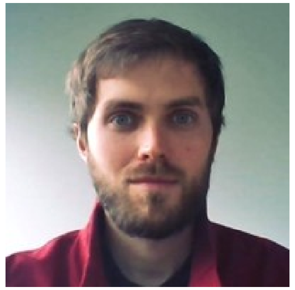
- Suffix trees
- Invest in preprocessing to be faster than full parse

Also

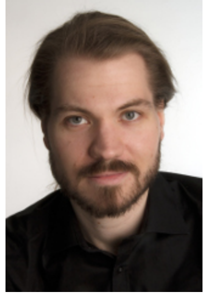
- Succinct data structures
- Splay trees

Lectures

- Jonathan Klawitter



- Boris Klemz



- Guests: Thomas van Dijk, Philipp Kindermann, Johannes Zink

- Recorded videos, released by Monday 10am
- Chat for questions and discussions
- Only 13 lectures due to shorter semester

Tutorials

- Oksana Firmann

Exercise sheets.

- Weekly exercise sheets, $\sim$ 20 points
- Released at lecture time slot
- Submission deadline next lecture time slot
- Digital submission
  - We recommend using LaTeX and our template.
- You may submit in teams of two.
- English submissions preferred, but German possible.

Tutorials.

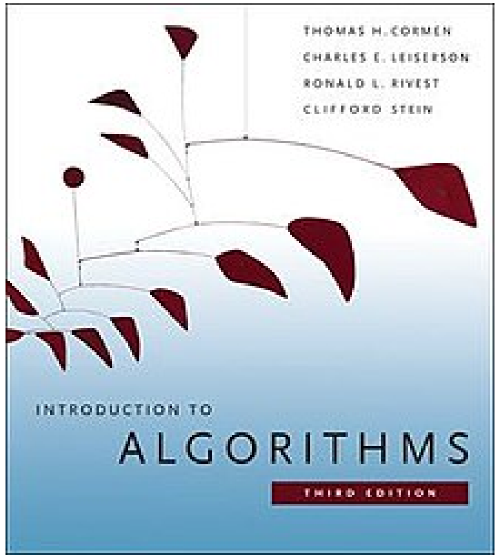
- Solution sheet & discussion
- or Zoom calls

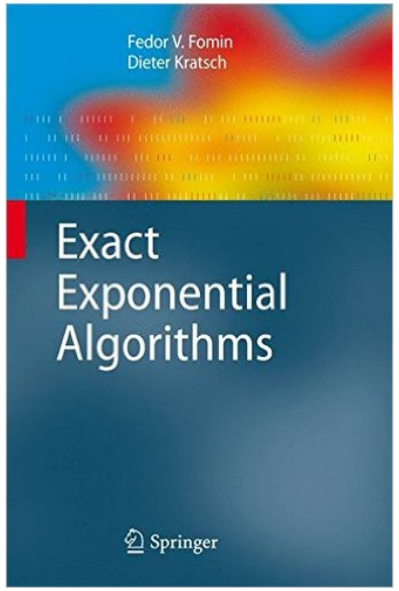
Exam

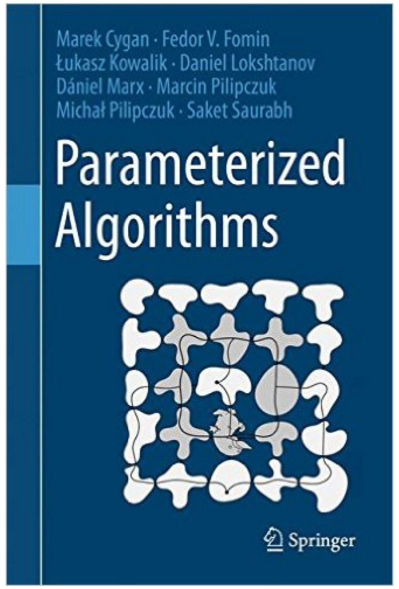
- Oral exam
- $\sim$ 20min
- $\geq$ 50% points on exercises sheets gives one grading step bonus (if passed)
- Date will be announced in time

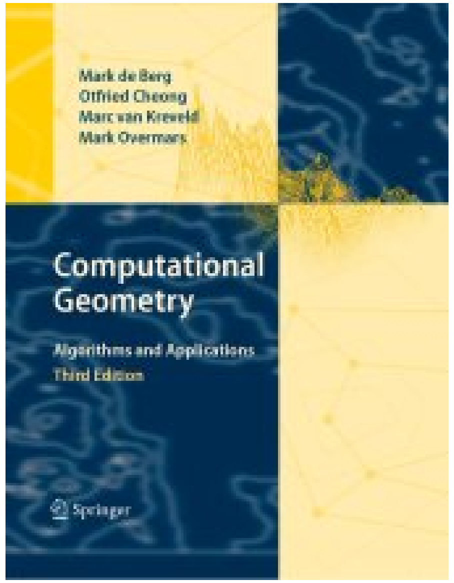
- Don't forget to register in WueStudy
- "Ausgewählte Kapitel der ..."

Literature



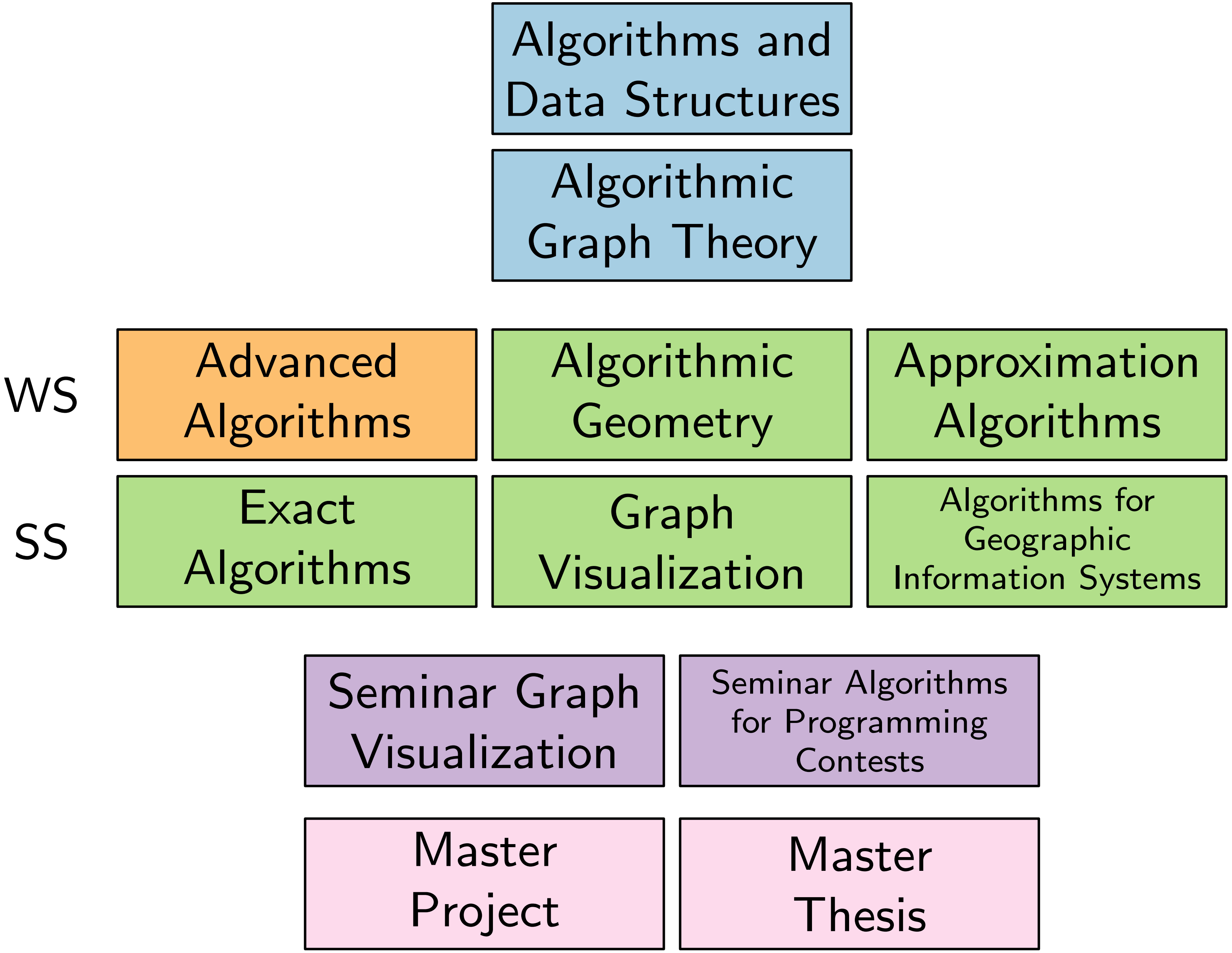



Marek Cygan · Fedor V. Fomin
Łukasz Kowalik · Daniel Lokshtanov
Dániel Marx · Marcin Pilipczuk
Michał Pilipczuk · Saket Saurabh
Parameterized Algorithms
Springer



- Sources at end of every lecture
- Links to more interesting stuff

Our lectures and seminars



Algorithms and Data Structures

Algorithmic Graph Theory

WS	Advanced Algorithms	Algorithmic Geometry	Approximation Algorithms
SS	Exact Algorithms	Graph Visualization	Algorithms for Geographic Information Systems

Seminar Graph Visualization

Seminar Algorithms for Programming Contests

Master Project

Master Thesis

Thanks

Material and slides provided in this lecture have been compiled by many different people. Thanks for that to:

Steven Chaplick, Thomas van Dijk, Philipp Kindermann, Joachim Spoerhase, Sabine Storandt, Dorothea Wagner, Alexander Wolff, Johannes Zink, . . .