Advanced Algorithms

Introduction

Topics, course details, organizational
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, dictionaries, succinctness, ...
Topics I

- **Better algorithms** for problems you know
- Maximum flow problem

- Ford–Folkerson algorithm: $O(|E||f^*|)$
- Edmonds–Karp algorithm: $O(|V||E|^2)$
- **Push-Relabel** algorithm: $O(|V|^2|E|)$ (or even better)

- Shortest paths in graph with negative edge weights
Topics II

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

**Heuristic**

**Approximation**

**NP-hard**

**Exponential**

**FPT**

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

- Example problem:
  Rearrangement distance of phylogenetic trees
Topics III

- **Special** areas

**Randomized algorithms**

- \texttt{LONGESTPath} is NP-hard
- but easy on acyclic digraphs
  \Rightarrow\hspace{1em}\text{randomly turn given graph into acyclic digraph}
  \Rightarrow\hspace{1em}good idea?

Also
- Online algorithms
- Approximation algorithms
- Computational geometry
- Working with strings
Topics IV

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

**Searching for strings**

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

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

Also

- **Succinct data structures**
- **Splay trees**
Lectures

- Johannes Zink (primarily)
- Alexander Wolff (at the beginning)
- Guests: Diana Sieper, Tim Hegemann

- In-person lectures Wed, 14:15–15:45, ÚR I
- With time for questions and discussions
- Contact also via email: firstname.lastname@uni-wuerzburg.de
- 13–15 lectures
- Old videos from 2020 will be made available on WueCampus
Tutorials

- Oksana Firman

Exercise sheets.
- Weekly exercise sheets, \( \approx 20 \) points/sheet
- Released at the lecture day (Wed)
- Submission deadline next lecture (Wed, 14:15)
- Digital submission
  - Recommended to use our LaTeX template
- Submission in teams of two
- Submissions in English (preferred) or German

Tutorials.
- In-person Mon 10:15–11:45
- ÜR I
- Discussion of the previous exercise sheet
- Time to work on & ask about the current exercise sheet
- Questions and discussions
Exam

- Oral exam
- $\approx 20\text{min}$
- $\geq 50\%$ points on exercises sheets gives one grading level bonus (if passed)
- Date will be announced during the semester
- Don’t forget to register in WueStudy: “Ausgewählte Kapitel der . . .”
Literature

- Sources at the end of every lecture
- Links to further interesting stuff
Our lectures and seminars

- Algorithmic Graph Theory
- Algorithms and Data Structures
- Approximation Algorithms
- Advanced Algorithms
- Algorithmic Geometry
- Graph Visualization
- Exact Algorithms
- Algorithms for Geographic Information Systems
- Seminar Algorithms for Programming Contests
- Seminar Graph Visualization
- Master Thesis
- Master Project

WS: currently suspended
SS: currently suspended
Thanks

Material and slides provided in this lecture have been compiled by many different people. Special thanks to:

Jonathan Klawitter, Boris Klemz, Steven Chaplick, Thomas van Dijk, Philipp Kindermann, Joachim Spoerhase, Sabine Storandt, Dorothea Wagner, . . .