Probability and Randomness in Computer Science

Jan Dreier, Henri Lotze, Peter Rossmanith

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Outline

- Research
  - You get a topic from us
  - Read and understand it
  - Independently search for other relevant sources
- Presentation
  - Present the ideas from the paper
  - At most 45 minutes
  - Afterwards a short discussion
- Essay
  - Summarize the ideas from the paper
  - Hand in via email
  - At most 8 pages

If you want feedback to your presentation or essay email us in a timely manner.

Regular Meetings

- One meeting per week, during lecture period
- presentation plus discussion
- Takes approx 1.5 hours
- Dates will be fixed before the start offigure the semester

Schedule

To be anounced on the website.

Possible Structure of a Presentation

- Briefly introduce the Topic.
- Why is it interesting? What are typical applications? What techniques are used?
- Give needed background knowledge. Do a quick refresh so everyone is on the same page.
- Present the paper.
- Put the result into context with other research.

Tips:

- Go slooooooowly. You took a couple months to understand the paper. Do not expect everybody to understand everything imediately.
- Keep the slides clean. Often one figure is better than a wall of text.

Essay

- Feel free to use the same structure as for the presentation
- LaTeX is mandatory (tutorial: `https://www.latex-tutorial.com/tutorials/`)
- at most 8 pages with `\documentclass[12pt]{article}`

But:

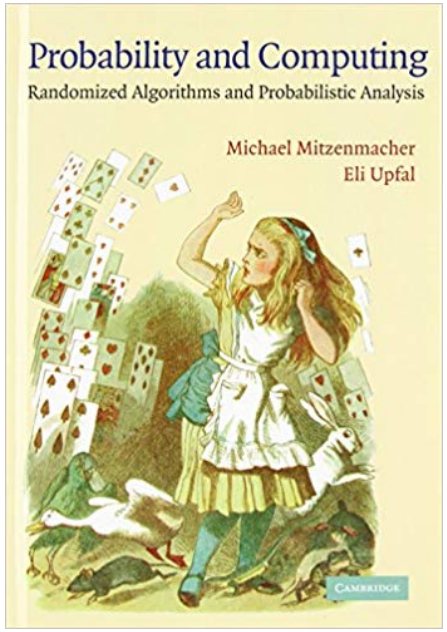
- Do not simply retell the paper!

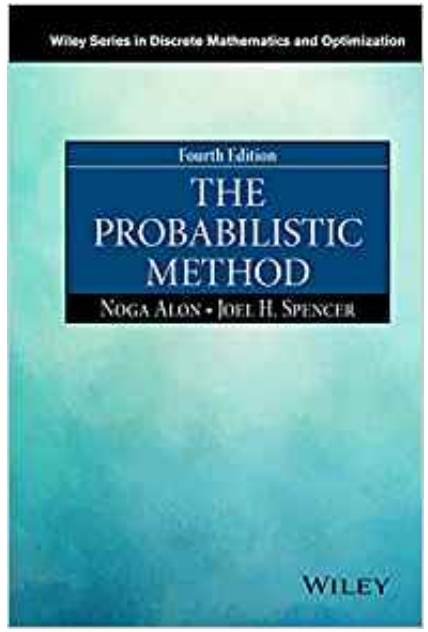
Deadlines

- For the next two weeks you can resign without any consequences. Just write us an email.
- Essay deadline: End of lectures.
- after submission we may tell you to fix something in your essay.

Resources

Textbooks, can be found online or in the CS library.





TAOCP mathematical preliminaries redux, Knuth
`www-cs-faculty.stanford.edu/~knuth/fasc5a.ps.gz`

The Topics

Fundamental Probability Theory

1. Basics

- Events and Probability, Diescrete Random Variables and Expectation (Chapter 1 and 2, Probability and Computing)
- TAOCP mathematical preliminaries redux
- Be very precise in the definitions. At the end of the talk everyone should know the basics.
- Give examples

Fundamental Probability Theory

2. Bounds

- Moments and Deviations, Chernoff Bounds (Chapter 3 and 4, Probability and Computing)
- TAOCP mathematical preliminaries redux
- Give nice applications of these bounds

Fundamental Probability Theory

3. Martingales

- Chapter 7, the Probabilistic Method
- TAOCP mathematical preliminaries redux
- Azuma's inequality and its applications
- Example: Exposure martingales
  `http://www.borisbukh.org/DiscreteMath14/notes_exposure_martingales.pdf`

Statistics

4. Hypothesis Testing

- Induktive Statistik, Diskrete Strukturen II, Angelika Steger et. al.
- the scientific method
- p-values and confidence intervals
  `www.statsdirect.com/help/basics/p_values.htm`
  `www.nature.com/news/scientific-method-statistical-errors-1.14700`
- bayesian vs frequentist statistics `blog.efpsa.org/2015/08/03/bayesian-statistics-why-and-how/`
- what makes a good scientific study and why? what are some common fallacies?

Statistics

5. Resampling

- Bootstrapping, Jackknifing, Permutation Tests
  `en.wikipedia.org/wiki/Resampling_(statistics)#Bibliography`
- Introduction to Statistics Through Resampling Methods, Phillip I. Good
- Induktive Statistik, Diskrete Strukturen II, Angelika Steger et. al.
- pick the most interesting techniques and present them, give applications

Complexity Theory

06. Randomzed Computation

- BPP, amplification, one sided and two sided error ...
- Arora and Barak `http://theory.cs.princeton.edu/complexity/book.pdf`
- mention connection to classical complexity classes

Complexity Theory

07. Isolation Lemma

- what does it say? why is it important? how does it work?
- https://rjlipton.wordpress.com/2009/07/01/the-isolation-lemma-and-beyond/
- http://www.cs.tau.ac.il/~amnon/Classes/2017-BPP/Lectures/Lecture14a.pdf

Randomized Algorithms

8. Schöning's Algorithm for 3-SAT

- homepages.cwi.nl/~rdewolf/schoning99.pdf
- www.cs.yale.edu/homes/spielman/366/schoening.pdf
- present algorithm and compare with other algorithms

Randomized Algorithms

9. Randomized Parameterized Algorithms

- color coding, divide and color, derandomization, ...
- Chapter 5, Parameterized Algorithms, Cygan et. al.
- present techniques and show how they can be applied

Randomized Algorithms

10. Random Number Generators

- what are they used for? how do they work?
- Mersenne twister
  `https://dl.acm.org/citation.cfm?id=272995`

Randomized Algorithms

11. Bolzman Samplers

- what are they used for? how do they work?
  `http://algo.inria.fr/flajolet/Publications/DuFlLoSc04.pdf`

The Probabilistic Method

12. First and Second Moment Method

- chapter 4, the probabilistic method
- present the technique and give nice examples where it can be applied

The Probabilistic Method

13. Local Lemma

- chapter 5, the probabilistic method
- present the technique and give nice examples where it can be applied

- Fundamental Probability Theory
  - 01. Basics
  - 02. Bounds
  - 03. Martingales
- Statistics
  - 04. Hypothesis Testing
  - 05. Resampling
- Complexity Theory
  - 06. Randomized Computation
  - 07. Isolation Lemma
- Randomized Algorithms
  - 08. Schöning's Algorithms for 4-SAT
  - 09. Randomized Parameterized Algorithms
  - 10. Random Number Generators
  - 11. Bolzman Samplers
- The Probabilistic Method
  - 12. First and Second Moment Method
  - 13. Local Lemma