

BBM 202 - ALGORITHMS



HACETTEPE UNIVERSITY

DEPT. OF COMPUTER ENGINEERING

ERKUT ERDEM

INTRODUCTION

Feb. 17, 2015

Acknowledgement: The course slides are adapted from the slides prepared by R. Sedgwick and K. Wayne of Princeton University.

INTRODUCTION

- ▶ **Introduction**
- ▶ Why study algorithms?
- ▶ Coursework
- ▶ Resources
- ▶ Outline

Instructor and Course Schedule

- Asst. Prof. Erkut ERDEM
- erkut@cs.hacettepe.edu.tr
- Office: 114
- Tel: 297 7500 / 149

- Lectures: Tuesday, 13:00-13:50@D8 (Section 3)
Thursday, 09:00-10:50@D2 (Section 3)
- Practicum (BBM204): Friday, 13:00-14:50@D3

About BBM202-204

- This course concerns programming and problem solving, with applications.
- The aim is to teach student how to develop algorithms in order to solve the complex problems in the most efficient way.
- The students are expected to develop a foundational understanding and knowledge of key concepts that underly important algorithms in use on computers today.
- The students are also be expected to gain hand-on experience via a set of programming assignments supplied in the complementary BBM 204 Software Practicum.

Why study algorithms?

Their impact is broad and far-reaching.

Internet. Web search, packet routing, distributed file sharing, ...

Biology. Human genome project, protein folding, ...

Computers. Circuit layout, file system, compilers, ...

Computer graphics. Movies, video games, virtual reality, ...

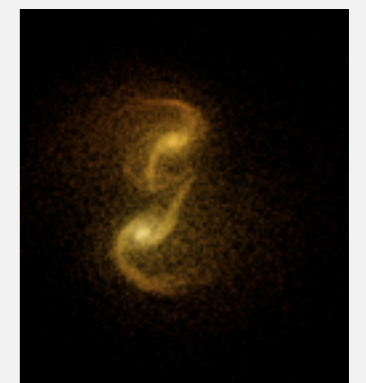
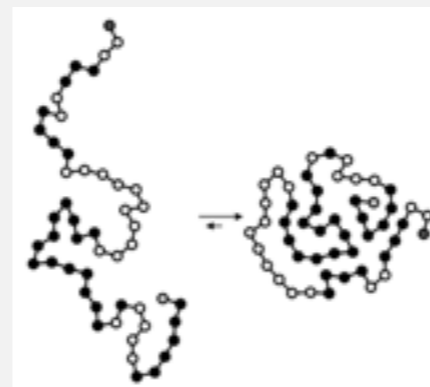
Security. Cell phones, e-commerce, voting machines, ...

Multimedia. MP3, JPG, DivX, HDTV, face recognition, ...

Social networks. Recommendations, news feeds, advertisements, ...

Physics. N-body simulation, particle collision simulation, ...

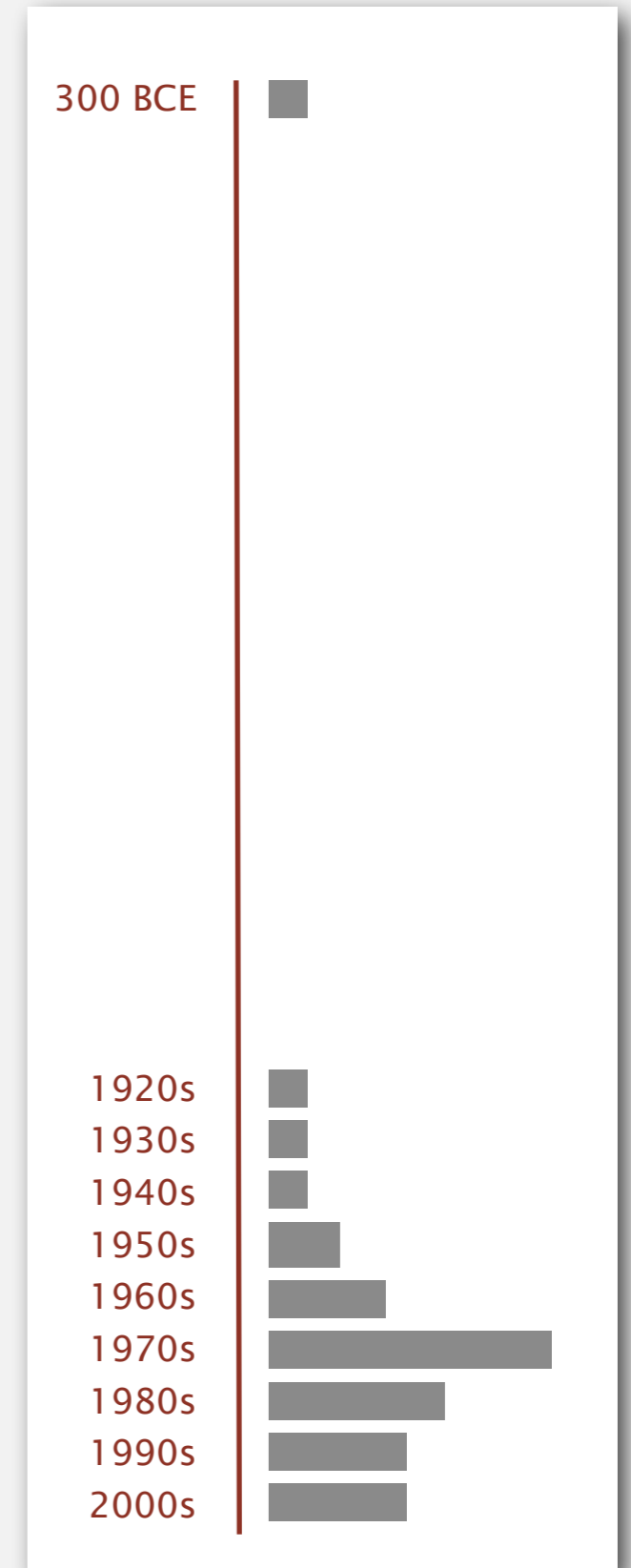
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Why study algorithms?

Old roots, new opportunities.

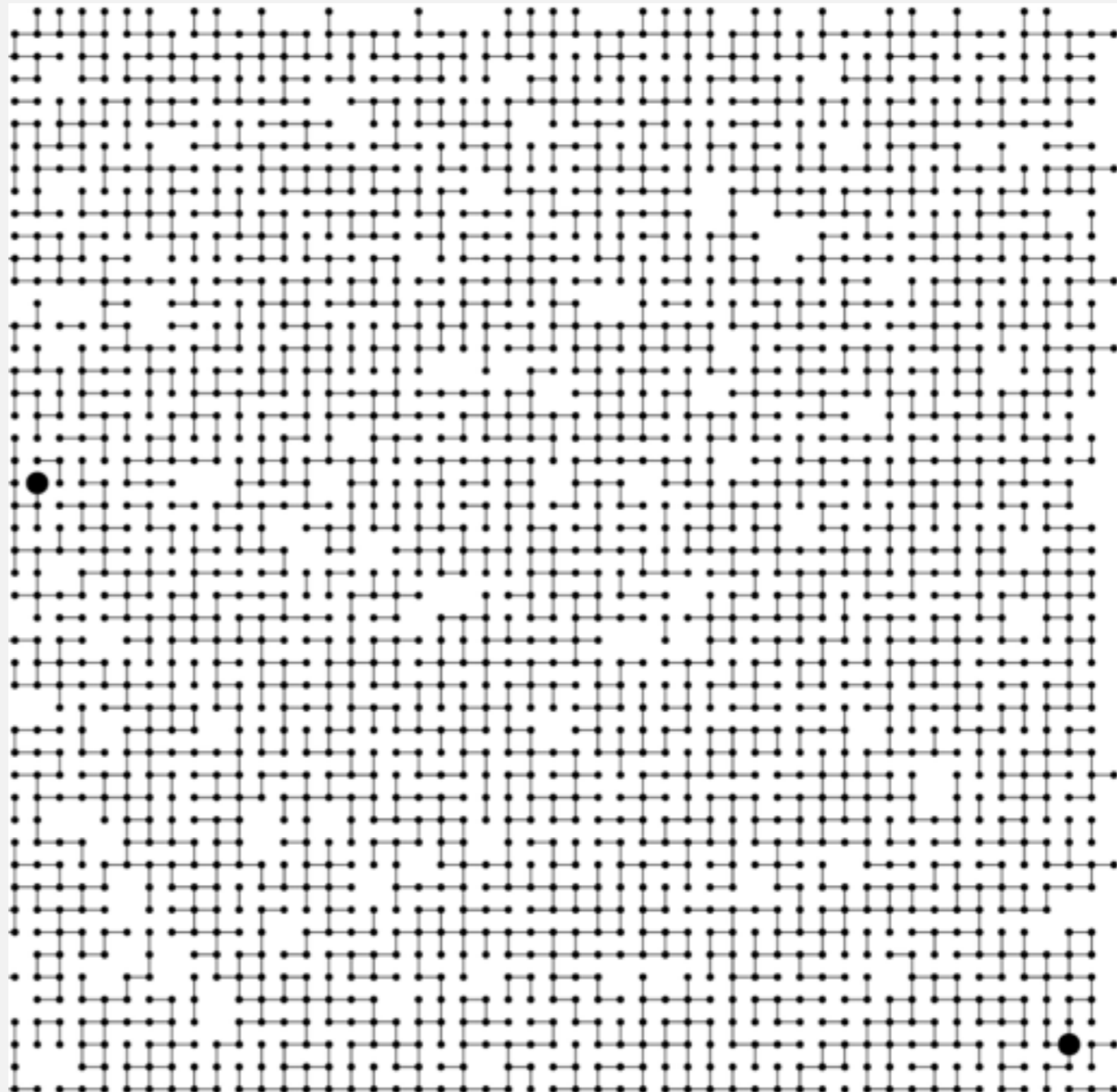
- Study of algorithms dates at least to Euclid.
- Formalized by Church and Turing in 1930s.
- Some important algorithms were discovered by undergraduates in a course like this!



Why study algorithms?

To solve problems that could not otherwise be addressed.

Ex. Network connectivity.

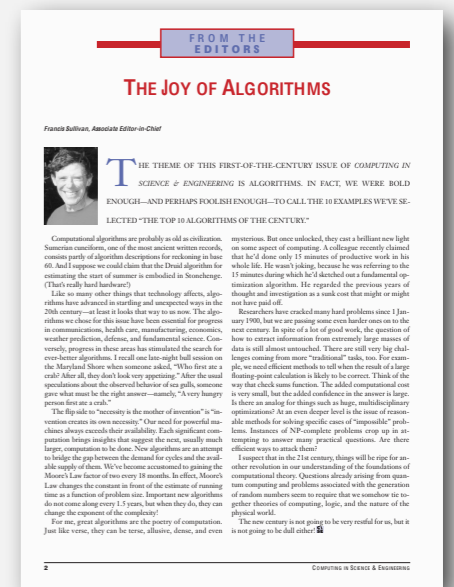


Why study algorithms?

For intellectual stimulation.

“ For me, great algorithms are the poetry of computation. Just like verse, they can be terse, allusive, dense, and even mysterious. But once unlocked, they cast a brilliant new light on some aspect of computing. ” — Francis Sullivan

“ It has often been said that a person does not really understand something until he teaches it to someone else. Actually a person does not really understand something until he can teach it to a computer, i.e. express it as an algorithm. The attempt to formalise things as algorithms lead to a much deeper understanding than if we simply try to comprehend things in the traditional way. algorithm must be seen to be believed. ” — Donald Knuth



Why study algorithms?

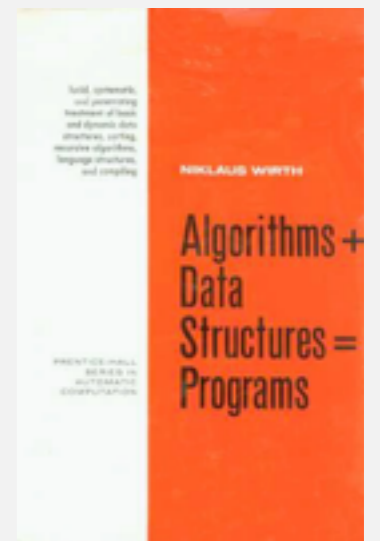
To become a proficient programmer.

“ I will, in fact, claim that the difference between a bad programmer and a good one is whether he considers his code or his data structures more important. Bad programmers worry about the code. Good programmers worry about data structures and their relationships. ”

— Linus Torvalds (creator of Linux)



“ Algorithms + Data Structures = Programs. ” — Niklaus Wirth



Why study algorithms?

They may unlock the secrets of life and of the universe.

Computational models are replacing mathematical models in scientific inquiry.

$$\begin{aligned} E &= mc^2 \\ F &= ma \end{aligned} \quad F = \frac{Gm_1m_2}{r^2}$$
$$\left[-\frac{\hbar^2}{2m} \nabla^2 + V(r) \right] \Psi(r) = E \Psi(r)$$

20th century science
(formula based)

```
for (double t = 0.0; true; t = t + dt)
  for (int i = 0; i < N; i++)
  {
    bodies[i].resetForce();
    for (int j = 0; j < N; j++)
      if (i != j)
        bodies[i].addForce(bodies[j]);
  }
```

21st century science
(algorithm based)

“ Algorithms: a common language for nature, human, and computer. ” — Avi Wigderson

Why study algorithms?

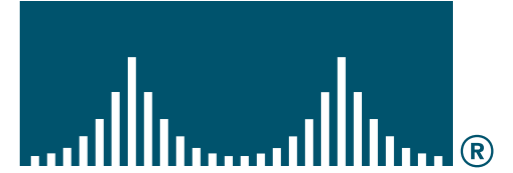
For fun and profit.



Apple Computer

facebook

CISCO SYSTEMS



Nintendo



Morgan Stanley

NETFLIX



DE Shaw & Co

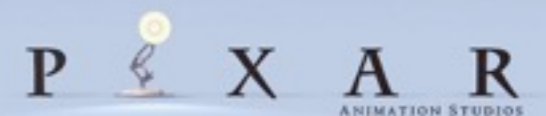
ORACLE



YAHOO!

amazon.com

Microsoft



Why study algorithms?

- Their impact is broad and far-reaching.
- Old roots, new opportunities.
- To solve problems that could not otherwise be addressed.
- For intellectual stimulation.
- To become a proficient programmer.
- They may unlock the secrets of life and of the universe.
- For fun and profit.

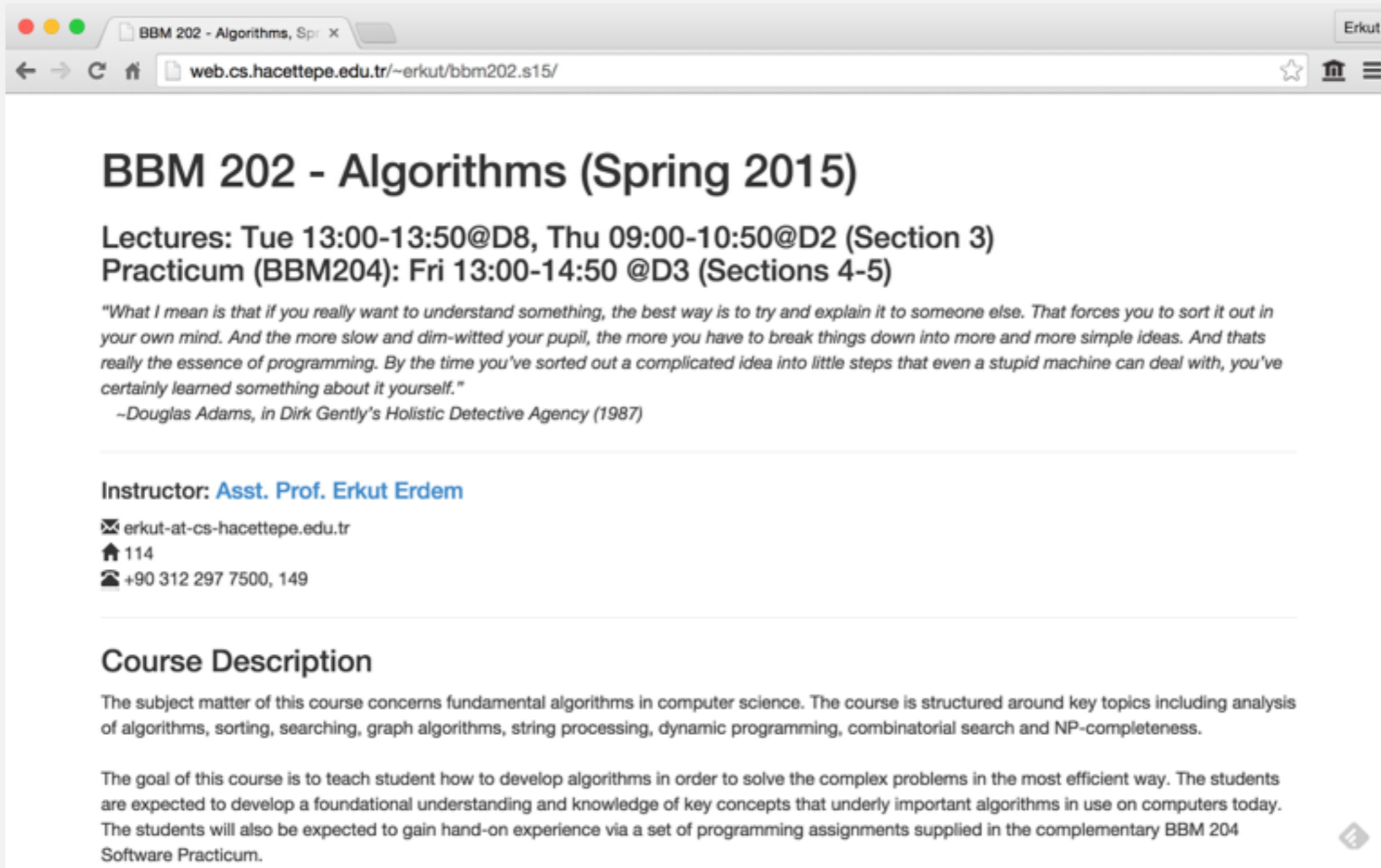
Why study anything else?



Communication

- The course webpage will be updated regularly throughout the semester with lecture notes, programming assignments and important deadlines.

<http://web.cs.hacettepe.edu.tr/~erkut/bbm202.s15>



BBM 202 - Algorithms (Spring 2015)

Lectures: Tue 13:00-13:50@D8, Thu 09:00-10:50@D2 (Section 3)
Practicum (BBM204): Fri 13:00-14:50 @D3 (Sections 4-5)

"What I mean is that if you really want to understand something, the best way is to try and explain it to someone else. That forces you to sort it out in your own mind. And the more slow and dim-witted your pupil, the more you have to break things down into more and more simple ideas. And that's really the essence of programming. By the time you've sorted out a complicated idea into little steps that even a stupid machine can deal with, you've certainly learned something about it yourself."

–Douglas Adams, in *Dirk Gently's Holistic Detective Agency* (1987)

Instructor: [Asst. Prof. Erkut Erdem](#)

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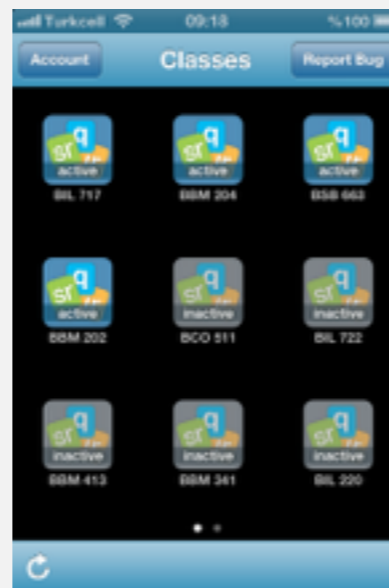
Course Description

The subject matter of this course concerns fundamental algorithms in computer science. The course is structured around key topics including analysis of algorithms, sorting, searching, graph algorithms, string processing, dynamic programming, combinatorial search and NP-completeness.

The goal of this course is to teach student how to develop algorithms in order to solve the complex problems in the most efficient way. The students are expected to develop a foundational understanding and knowledge of key concepts that underly important algorithms in use on computers today. The students will also be expected to gain hand-on experience via a set of programming assignments supplied in the complementary BBM 204 Software Practicum.

Getting help

- Office Hours
- BBM204 Software Practicum
 - Course related recitations, practice with algorithms, etc.
- Communication
 - Announcements and course related discussions
 - through **PIAZZA** : <https://piazza.com/hacettepe.edu.tr/spring2015/bbm202>



Coursework and grading

Midterm exams 60% (12+32+16%)

- Three closed-book exams
 - in class on March 17, April 9 and May 5, respectively.

Final exam. 40%

- Closed-book
- Scheduled by Registrar.

Programming assignments (PAs)

- Five assignments throughout the semester.
- Each assignment has a well-defined goal such as solving a specific problem.
- You must work alone on all assignments stated unless otherwise.

Important Dates

- 19 February, PA1
- 26 February, PA2
- 19 March, PA3
- 9 April, PA4
- 30 April, PA5

Cheating

What is cheating?

- Sharing code: by copying, retyping, looking at, or supplying a file
- Coaching: helping your friend to write a programming assignment, line by line
- Copying code from previous course or from elsewhere on WWW

What is NOT cheating?

- Explaining how to use systems or tools
- Helping others with high-level design issues

Penalty for cheating:

- Helping others with high-level design issues
- Removal from course with failing grade

Detection of cheating:

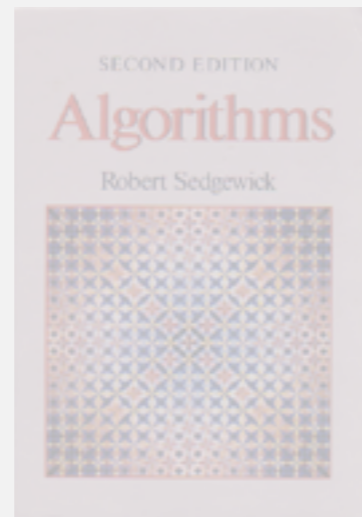
- We do check
- Our tools for doing this are much better than most cheaters think!

Resources (textbook)

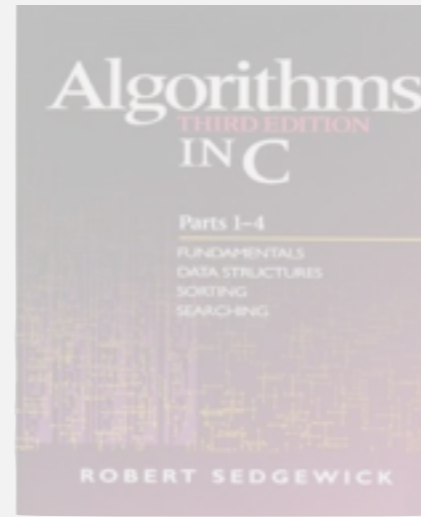
Required reading. Algorithms 4th edition by R. Sedgwick and K. Wayne, Addison-Wesley Professional, 2011, ISBN 0-321-57351-X.



1st edition (1982)



2nd edition (1988)



3rd edition (1997)



Booksite.

- Brief summary of content.
- Download code from book.

ALGORITHMS, 4TH EDITION

essential information that every serious programmer needs to know about algorithms and data structures

Textbook. The textbook *Algorithms*, 4th Edition by Robert Sedgwick and Kevin Wayne [[Amazon](#) · [Addison-Wesley](#)] surveys the most important algorithms and data structures in use today. The textbook is organized into six chapters:

- **Chapter 1: Fundamentals** introduces a scientific and engineering basis for comparing algorithms and making predictions. It also includes our programming model.
- **Chapter 2: Sorting** considers several classic sorting algorithms, including insertion sort, mergesort, and quicksort. It also includes a binary heap implementation of a priority queue.
- **Chapter 3: Searching** describes several classic symbol table implementations, including binary search trees, red-black trees, and hash tables.

ALGORITHMS, 4TH EDITION

1. Fundamentals
2. Sorting
3. Searching
4. Graphs
5. Strings
6. Context

<http://www.algs4.princeton.edu>

Course outline

Introduction

Analysis of Algorithms

- Computational Complexity

Sorting

- Elementary Sorting Algorithms,
- Mergesort,
- Quicksort,
- Priority Queues and HeapSort

Searching

- Sequential Search
- Binary Search Trees
- Balanced Trees
- Hashing,
- Search Applications

Course outline

Graphs

- Undirected Graphs,
- Directed Graphs,
- Minimum Spanning Trees,
- Shortest Path

Strings

- String Sorts, Tries,
- Substring Search,
- Regular Expressions,
- Data Compression

Advanced Topics

- Reductions
- Intractability