Intro to CS16

CS16: Introduction to Algorithms & Data Structures
Spring 2018
What is 16 about?

Algorithms

“sequence of computer instructions for a given task”
Why Study Algorithms?

- Core to Computer Science
- Powerful in practice
  - running in seconds vs. age of the universe
- Interesting and elegant ideas
Web Search in the 90’s
My friend Jeremy tells me about this new engine
- “it’s awesome you should try it out!”

After 10 minutes it’s obvious that
- Google results were more “relevant”

But why?
- Why were Google’s results better?
- What was Google’s secret?

I finally learned why during my PhD
- Google had a **better algorithm**!
Before Google

- search engines ranked pages using keyword frequency
- well-known and worked OK

Larry Page & Sergey Brin (PhD students @ Stanford)

- noticed that links were important too!
- intuition that links conveyed information about importance
- But what exactly? and how can you make use of it?
- Lead them to design the PageRank algorithm
PageRank

- How does PageRank work?
- Why does it work?
- How do you implement it efficiently?
  - Google indexes “hundreds of billions” of pages
  - answers and ranks in 0.5 seconds
  - processes 40,000 queries a second
  - 3.5 billion per day
- Using clever **algorithms** and **data structures**!
A Personal Example

- Searching on encrypted data
  - Really cool idea; but slow
- We thought about this for a few years
  - new approach that was very fast
  - as fast as searching on unencrypted data!
- 10 years later & after a lot more research
  - released an encrypted app based on these ideas
- What was the secret?
  - clever use of **algorithms & data structures**
CS is diverse

- Graphics & Vision
- AI
- Crypto & Security
- PL
- Soft. Eng.
- Algorithms
- Networking
- OS
Welcome to CS 16!
You Will Learn

- How to **design** algorithms
- How to **analyze** algorithms
- How to **implement** algorithms
Content of CS16

- **Analysis of algorithms:** big-Oh, worst-case analysis, amortized analysis, expected running time
- **Design paradigms:** dynamic programming, divide and conquer, greedy algorithms
- **Recursive algorithms:** recurrence relations, induction
- **Elementary data structures:** stacks, queues, trees, hash tables, binary search trees, heaps, graphs
- **Sorting algorithms:** insertion sort, selection sort, heap sort, merge sort, quicksort, radix sort
- **Machine learning algorithms:** decision trees
- **Graph algorithms:** depth-first search, breadth-first search, shortest path, minimum spanning tree, topological sort
- **Advanced topics:** Bitcoin, functional programming, numerical algorithms
Meet your TA's

Villains need love
Goals

- Learn fundamental algorithms and data structures
- Find and design new ones
- Reason about them
- Use them
- Prepare you for more CS
Lectures

- Cover various algorithms & data structures
  - How they work
  - Why they work
  - Analyze them

- Activities & discussions

- You are responsible for content in lecture (whether on slides or not)
Textbook

- No required textbook
- Helpful
  - Dasgupta, Papadimtriou and Vazirani
  - Goodrich and Tamassia
Course Page

- Slides
- Notes
- Announcements
- Helpful readings
Piazza

- Announcements
- Questions and answers
- Links to helpful material (blogs, Youtube videos)
Office Hours

- TA office hours are very helpful
  - Try to get unstuck on your own first
- My office hours ??
- Questions about HW or projects:
  - Post on Piazza
  - Ask in Section
  - TA office hours
  - Schedule meeting with me
Homeworks (30%)

- 10 HWs
- Due every week
- Python code, proofs, analysis, …
Projects (30%)

- 4 projects in Java
Sections (10%)

- 1 hour/week with 2 Tas
- 6–10 students
- Required!
  - If you miss 3 you fail
  - Lose points for every missed section
- Mini assignments
- Mentor
Exams (25%)

- Midterm
  - Date: March 22nd
- Final
  - Date: May 9th
Collaboration

- Encouraged to collaborate on HWs but
  - Write up HWs by yourself
  - Code by yourself
  - No sharing of code or pseudocode
  - No collaboration on Projects

- You will sign the collaboration policy
- We will use code similarity tester
- Random live audits
  - might ask you “what would happen if we did X to your code?”
Override Policy

- Email HTAs if
  - You are a graduate student
  - You are RISD student and need a signature
  - You have not taken CS15
References

- Slide #2
  - A statue of Muhammad ibn Musa al-Khwarizmi; a Persian scholar from the 9th century
  - “Algorithms” is derived from “Algoritmi” which is the Latin translation of his name
  - Worked in mathematics, astronomy and geometry
  - Founded the field of Algebra

- Slide #10
  - Lionel Messi is a soccer player that plays for Barcelona and Argentina
  - He is considered one of the best soccer players of all time
  - Won 5 Ballon D’Ors, 8 La Liga titles, 4 Champions League titles
  - Scored the most goals and made the most assists in La Liga history