Algorithms

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Algorithms

Algorithms Today

- web: search, caching, crypto
- networking: load balancing, synchronization, routing
- machine learning: data mining, recommendation
- bioinformatics: alignment, matching, clustering
- hardware: design, simulation, verification
- business: allocation, planning, scheduling
- AI: robotics, games, LLMs

Definition

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algorithm: a precisely defined set of mathematical or logical operations for the performance of a particular task. -*O.E.D.*

- precisely defined
- mechanical steps
- terminates
- input and related output

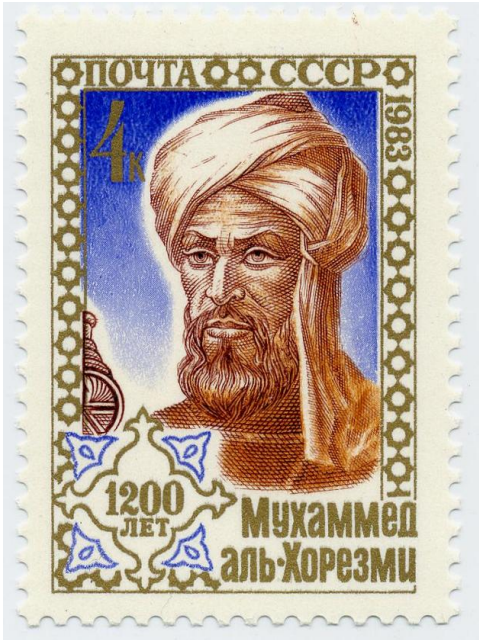
Why?

- Computer scientist $\neq$ programmer
  - understand program behavior
  - have confidence in results, performance
  - know when to abandon optimality
  - solve ‘impossible’ problems
  - set yourself apart
- CPUs aren’t getting faster
- Software is the differentiator
- Everything requires computation

Muḥammad ibn Mūsā al-Khwārizmī

780-850 AD
Born in Uzbekistan, worked in Baghdad
Solution of linear and quadratic equations
Founder of algebra
Popularized arabic numerals, decimal positional numbers
→algorism (manipulating digits)
→algorithm

The Compendious Book on Calculation by Completion and Balancing, 830

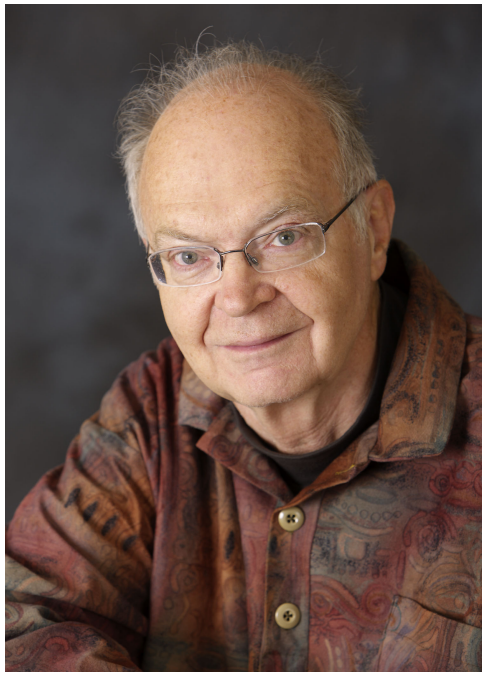


Donald E. Knuth

invented algorithm analysis
The Art of Computer Programming, vol 1, 1968

developed TEX

literate programming



Topics

1. data structures: trees, heaps, union-find
2. algorithms: divide-and-conquer, randomized, dynamic programming, greedy, graphs analysis
3. theory: time and space complexity, invariants

Not including:

1. computability
2. **parallel algorithms**
3. distributed algorithms
4. **numerical algorithms: linear programming**
5. geometric algorithms
6. on-line or ‘run forever’ algorithms
7. **quantum algorithms**