
Advanced Algorithms

– Course Presentation –

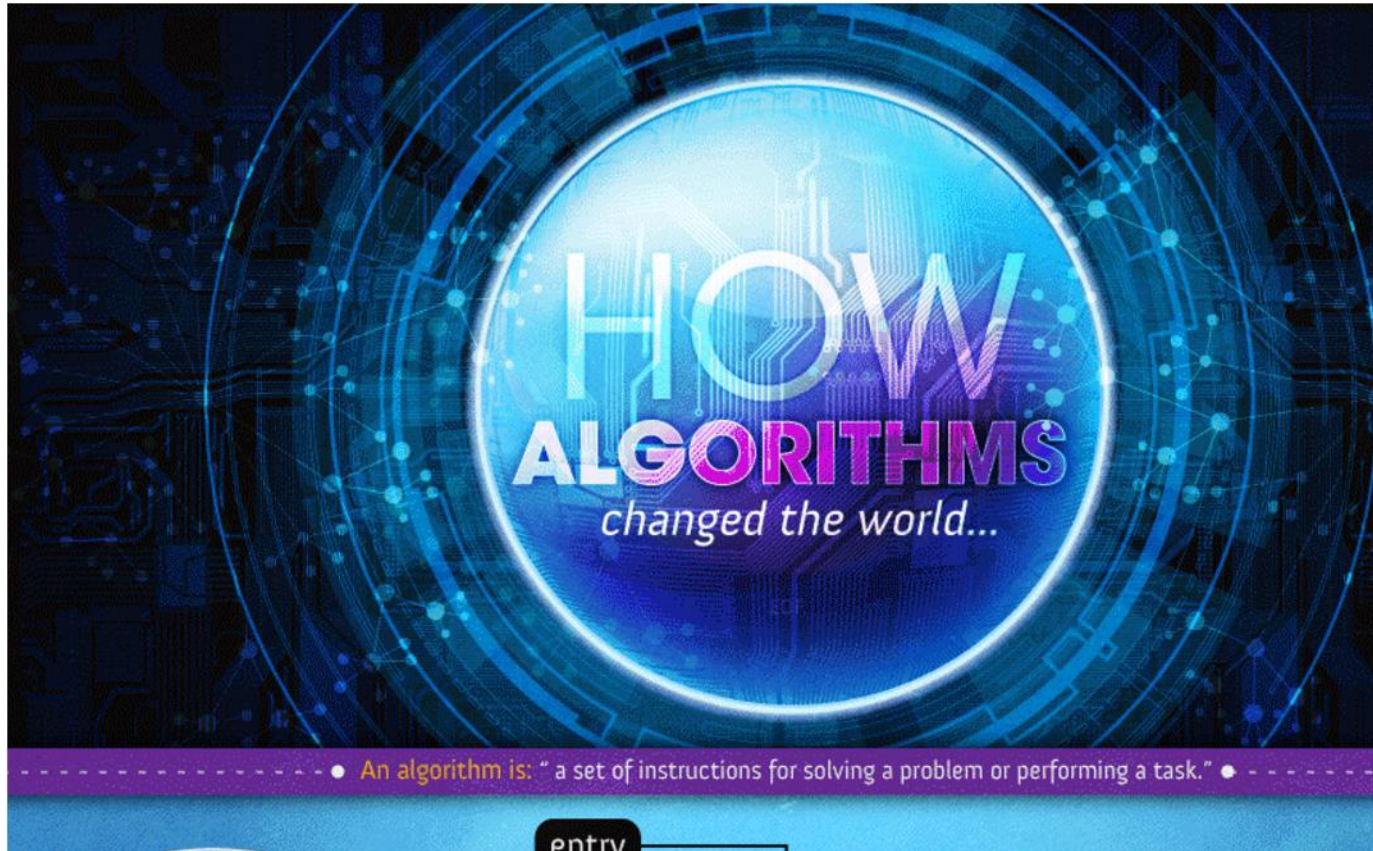
Joaquim Madeira

Version 0.6 – September 2023

Overview

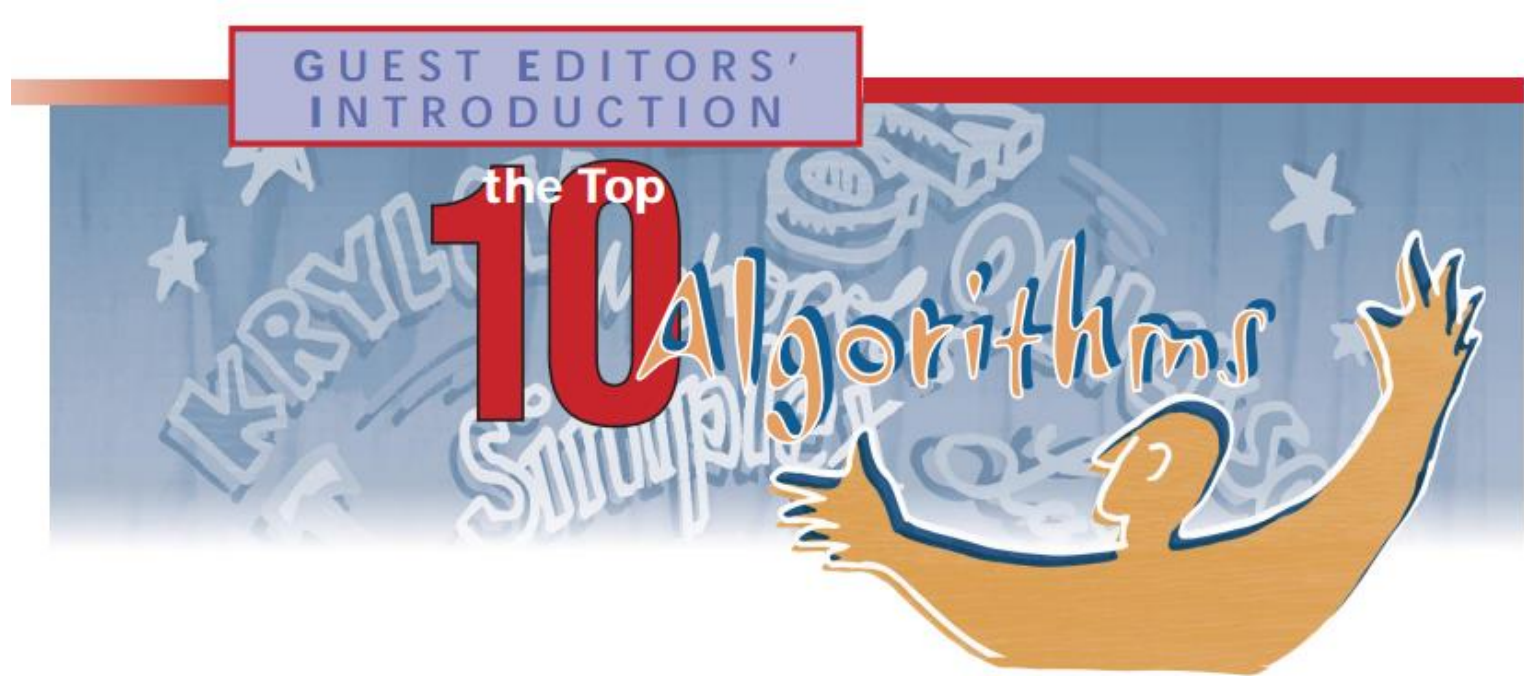
- Motivation
- Goals
- Tentative syllabus
- Evaluation
- Class organization
- Some useful books

Algorithms have changed the world !



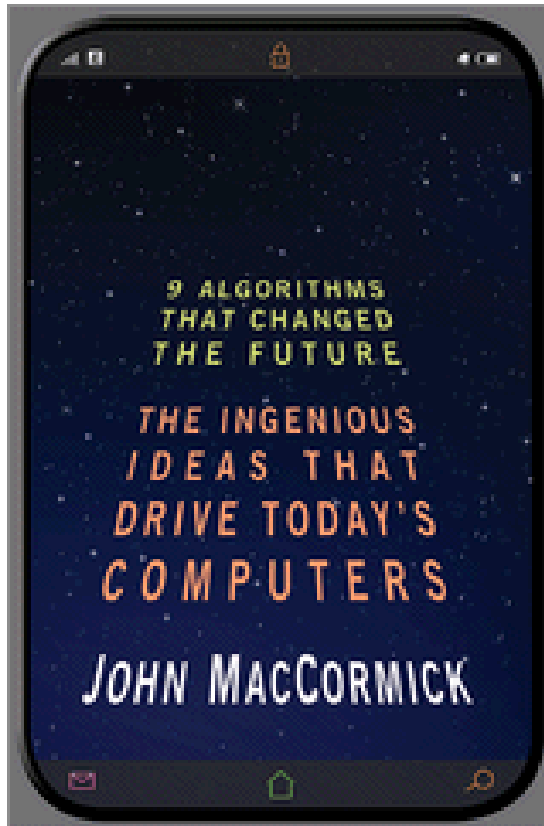
Check the [infographic on the Web](#)

Top 10 algorithms of the 20th century

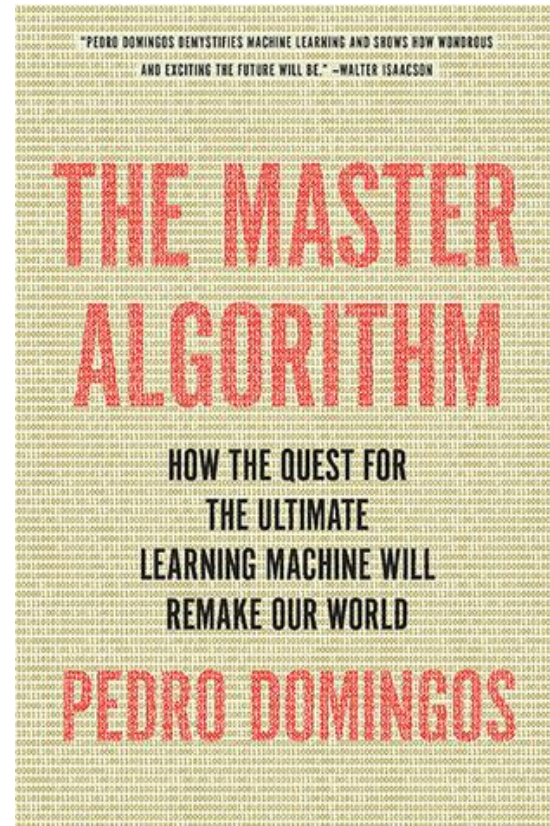


Special issue of IEEE CISE, Jan/Feb 2000

There are even best-sellers !!

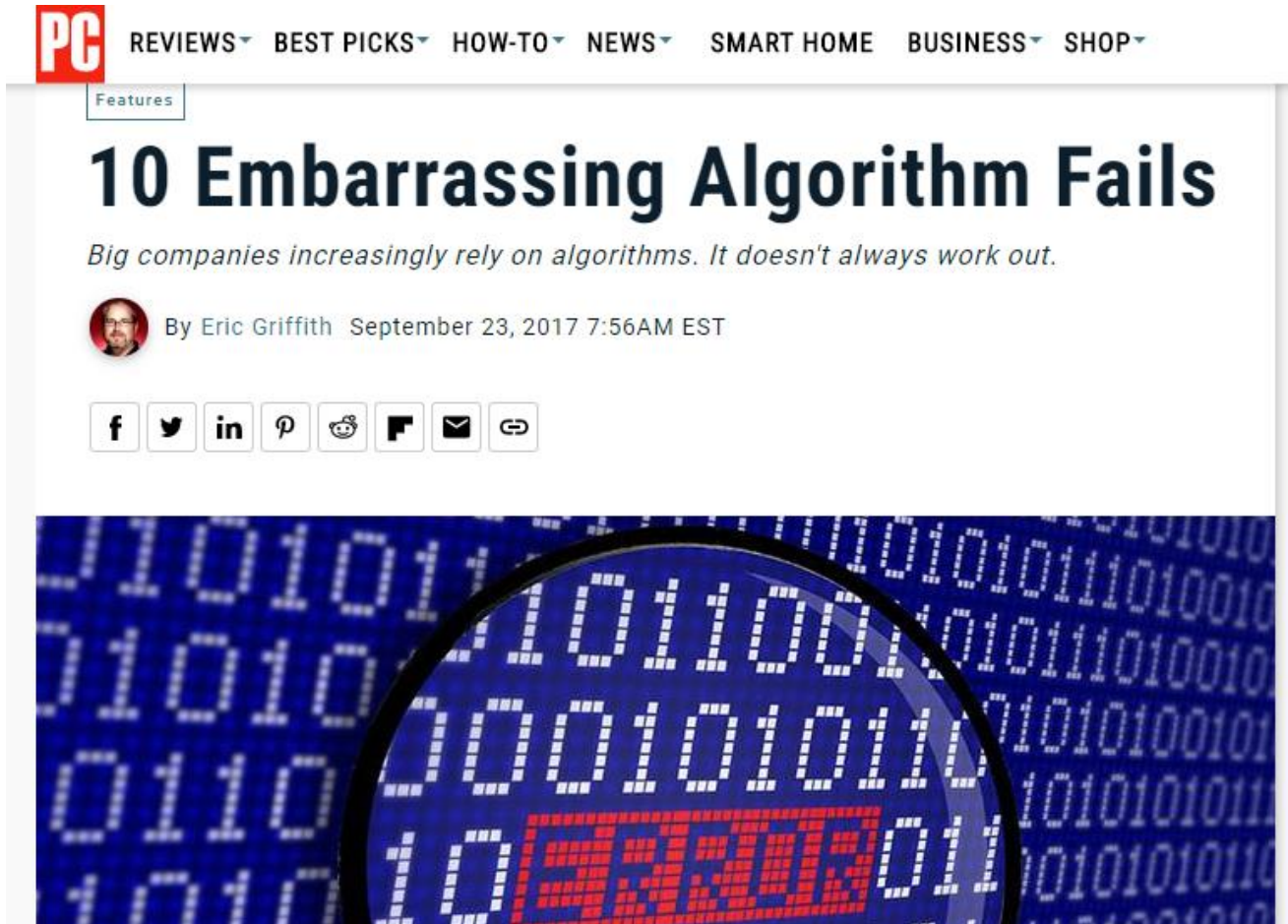


[2012]



[2015]

Algorithm failures !!



<https://www.pcmag.com/feature/356387/10-embarrassing-algorithm-fails>

Algorithm failures !!

11 May 2018 | 17:40 GMT

450,000 Women Missed Breast Cancer Screenings Due to “Algorithm Failure”

A disclosure in the United Kingdom has sparked a heated debate about the health impacts of an errant algorithm

By **Robert N. Charette** (/author/charette-robert-n)



Nearly half a million elderly women in the United Kingdom missed mammography exams because of a scheduling error caused by one incorrect computer algorithm, and several hundred of those women may have died early as a result.

[\[https://spectrum.ieee.org/riskfactor/computing/it/450000-woman-missed-breast-cancer-screening-exams-in-uk-due-to-algorithm-failure\]](https://spectrum.ieee.org/riskfactor/computing/it/450000-woman-missed-breast-cancer-screening-exams-in-uk-due-to-algorithm-failure)

Algorithm failures !!

Franken-algorithms: the deadly consequences of unpredictable code

The death of a woman hit by a self-driving car highlights an unfolding technological crisis, as code piled on code creates 'a universe no one fully understands'

by [Andrew Smith](#)

The 18th of March 2018, was the day tech insiders had been dreading. That night, a new moon added almost no light to a poorly lit four-lane road in Tempe, Arizona, as a specially adapted Uber Volvo XC90 detected an object ahead. Part of the modern gold rush to develop self-driving vehicles, the SUV had

<https://www.theguardian.com/technology/2018/aug/29/coding-algorithms-frankenalgos-program-danger>

IT failures !!

27 Dec 2018 | 15:49 GMT

The Biggest IT Failures of 2018

Technical mishaps occurred in trains, planes, automobiles, and many more places

By **Robert N. Charette**



<https://spectrum.ieee.org/riskfactor/computing/it/it-failures-2018-all-the-old-familiar-faces>

Biased algorithms

The Home Office is using algorithms to sort visa applicants, but they have a history of 'discriminatory' failures

Biased algorithms could be affecting the livelihoods of vulnerable people



<https://inews.co.uk/news/politics/home-office-visa-application-algorithms-history-failures/>

2020 UK's exam grade fiasco

The Observer

From viral conspiracies to exam fiascos, algorithms come with serious side effects



John Naughton

Sun 6 Sep 2020 09.00 BST

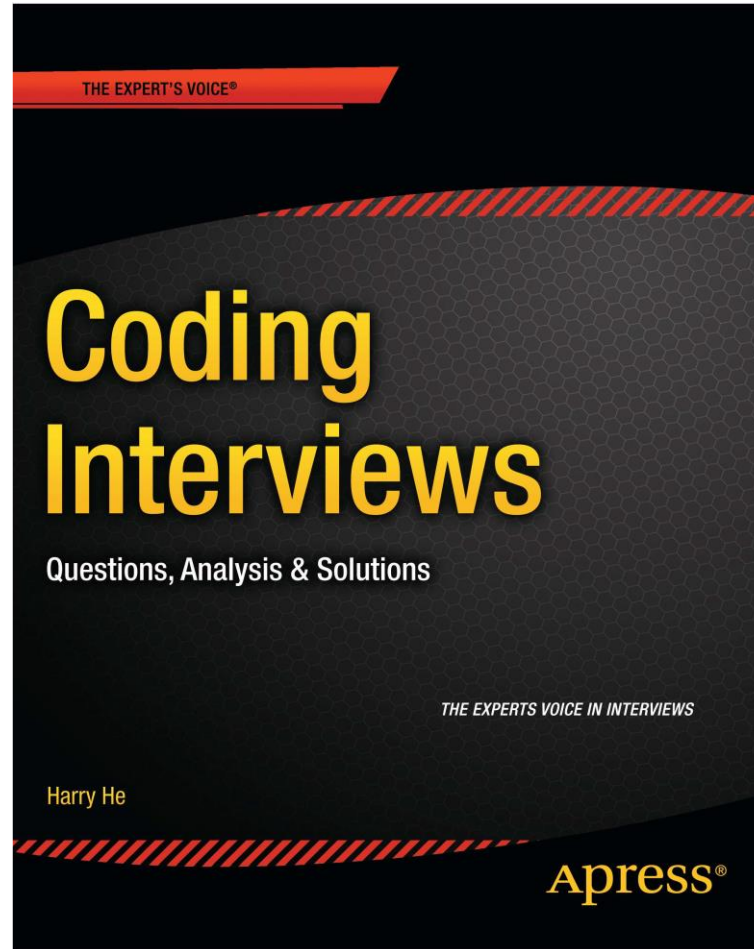
Will Thursday 13 August 2020 be remembered as a pivotal moment in democracy's relationship with digital technology? Because of the coronavirus outbreak, A-level and GCSE examinations had to be cancelled, leaving education authorities with a choice: give the kids the grades that had been predicted by their teachers, or use an algorithm. They went with the latter.

<https://www.theguardian.com/technology/2020/sep/06/from-viral-conspiracies-to-exam-fiascos-algorithms-come-with-serious-side-effects>

Technical Job Interviews – Skills

- Basic programming knowledge, including understanding of **programming languages**, **data structures**, and algorithms
- Abilities to write **clean**, **complete**, and **robust code**
- Capabilities to analyze and solve **complex problems**
- Abilities to improve **time and space efficiencies**
- Skills involving communication, learning, divergent thinking, etc.

Harry He's book



ALGORITHM REPOSITORIES

rosettacode.org



ROSETTACODE.ORG

Community ▾

Explore ▾

Main page [Discussion](#) [View source](#) [History](#)

Rosetta Code

Rosetta Code is a [programming chrestomathy](#) site. The idea is to present solutions to the same task in as many different languages as possible. Languages are similar and different, and to aid a person with a grounding in one approach to a problem in learning another. Rosetta C

Stony Brook Algorithm Repository

Steven Skiena

Dept. of Computer Science

Stony Brook University

Books

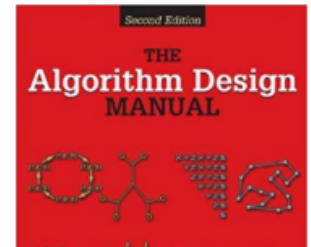
By Language ▾

By Problem ▾

The Stony Brook Algorithm Repository

Steven Skiena

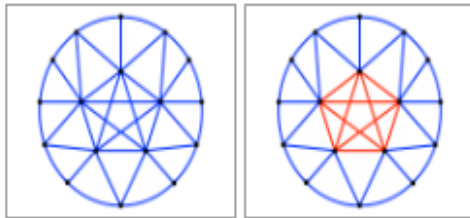
This page provides a comprehensive collection of algorithm implementations for seventy-five of the most fundamental problems in combinatorial algorithms. The problem taxonomy, implementations, and supporting material are all drawn from my book *The Algorithm Design Manual*. Since the practical person is more often looking for a program than an algorithm, we provide pointers to solid implementations of useful algorithms when they are available.



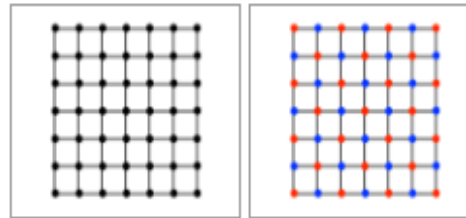
<http://algorist.com/algorist.html>

Stony Brook Algorithm Repository

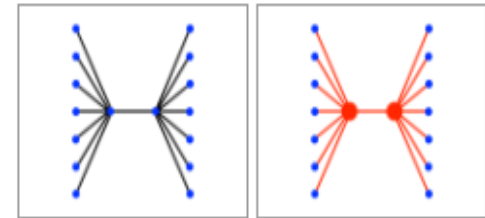
Graph: Hard Problems



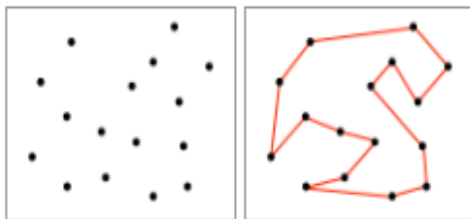
Clique



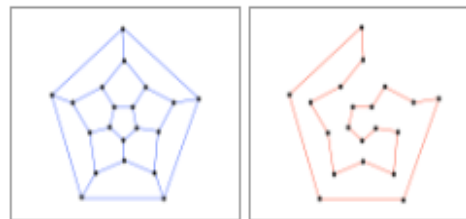
Independent Set



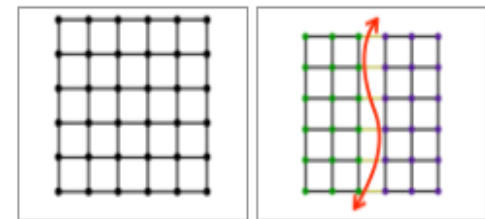
Vertex Cover



Traveling Salesman Problem



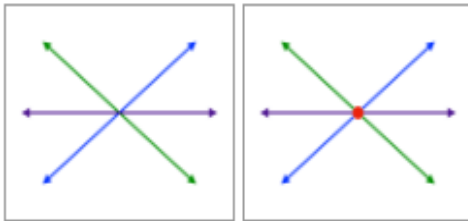
Hamiltonian Cycle



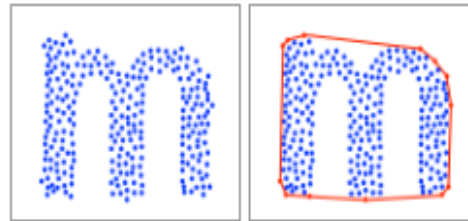
Graph Partition

Stony Brook Algorithm Repository

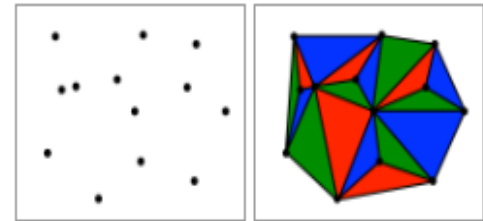
Computational Geometry



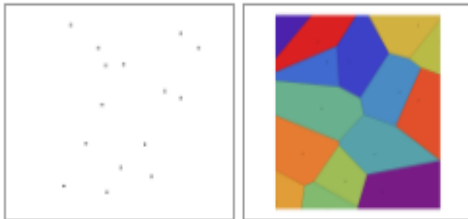
Robust Geometric Primitives



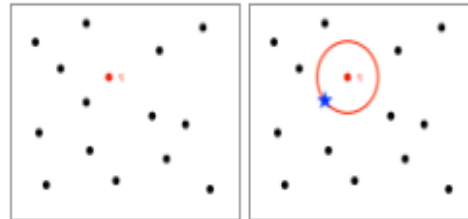
Convex Hull



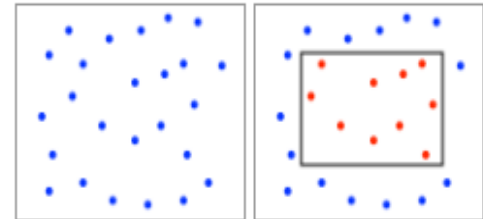
Triangulation



Voronoi Diagrams



Nearest Neighbor Search



Range Search

github.com/TheAlgorithms



The Algorithms

Open Source resource for learning Data Structures & Algorithms and their implementation in any Programming Language

📍 India 🔗 <https://gitter.im/TheAlgorithms> ✉ 1anuppanwar@gmail.com dynamitechetan@gmail.com

📁 Repositories 18

📦 Packages

👤 People 29

📁 Projects

Pinned repositories

📁 Python

All Algorithms implemented in Python

🟠 Jupyter Notebook ★ 55.1k 🍴 16.4k

📁 Java

All Algorithms implemented in Java

🟡 Java ★ 16.8k 🍴 6.2k

📁 C-Plus-Plus

All Algorithms implemented in C++

🟡 C++ ★ 2.8k 🍴 955

📁 C

All Algorithms implemented in C

📁 Go

Algorithms Implemented in GoLang

📁 Javascript

A repository for All algorithms imple
[https://github.com/TheAlgorithms/javascript](#)



[adp.com]

GOALS

Goals

- Review main **algorithm design strategies**
- Introduce **probabilistic / randomized algs.**
- Apply probabilistic methods to large-scale (**big-data**) problems
- Explore problems from different **application areas**

Goals

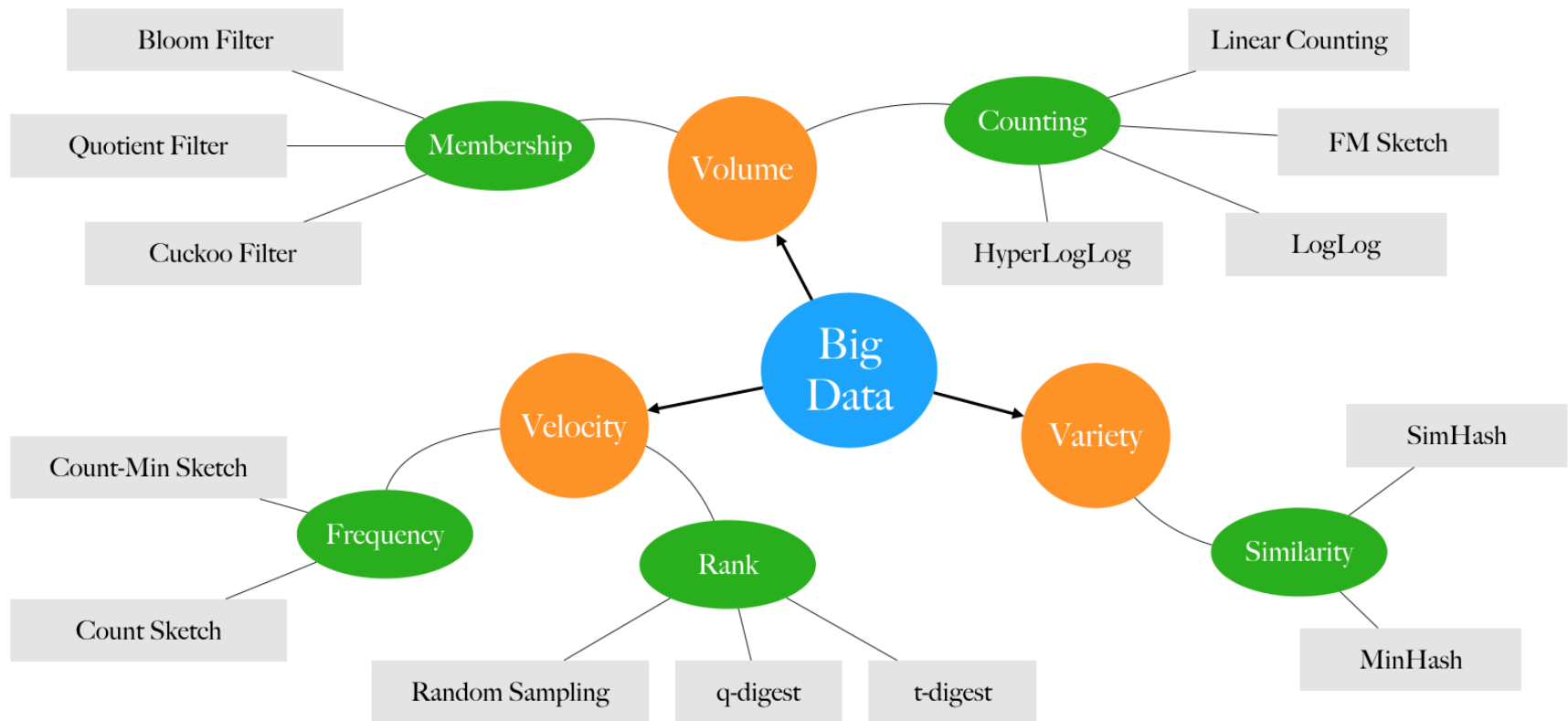
- BUT, course **contents** and **depth** can be somewhat adapted to your background and interests...
- Today's lecture and the first weeks should show us how we can proceed...

Why Big-Data ?

- Many of today's data sets cannot be processed by conventional methods
 - Within a reasonable amount of time !
- Why ?
 - Volume – Huge data volumes
 - Variety – Different data modalities
 - Velocity – Rapid generation and/or growth

PDSA – Probabilistic DSs and Algs

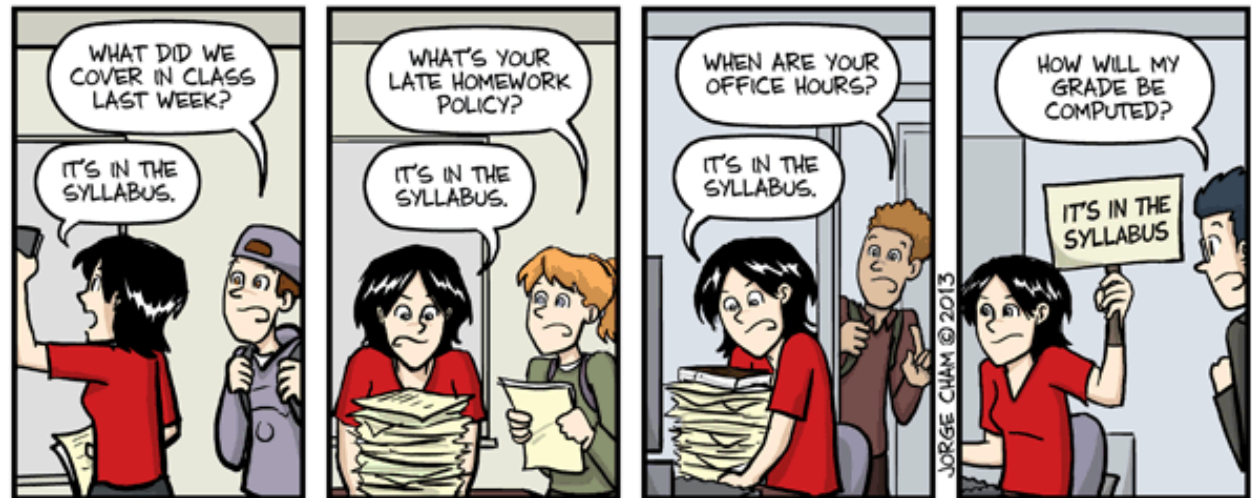
Problems Solved by PDSA



PDSA in Big Data Ecosystem

gakhov

[A. Gakhov – <https://www.gakhov.com/>]



[phdcomics.com]

SYLLABUS

Tentative Syllabus

- Algorithm complexity analysis – Review
 - Complexity classes / Formal and empirical analysis
- Algorithm design strategies – Review
 - Brute-force / Divide-and-Conquer / ...
- Deterministic vs Probabilistic algorithms
 - Las Vegas and Monte Carlo algorithms
- Probabilistic counting
- Sets and membership
- ...



[python.org]

PYTHON

Programming Language

- Python 3 !!
- If you are at ease with it, that's great !!
- Otherwise, it is easy to learn the basics and start coding quickly...
 - And it will be an important addition to your portfolio !

IEEE Spectrum – Top prog. languages

Interactive: The Top Programming Languages 2018

Find the programming languages that are most important to you

Choose a Ranking (choose a weighting or make your own)

IEEE Spectrum

Trending

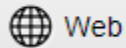
Jobs

Open

Custom

[Edit Ranking](#) | [Add a Comparison](#) | [Twitter](#) [Facebook](#)

Language Types (click to hide)



Web



Mobile



Enterprise



Embedded

Language Rank

Types

Spectrum Ranking

1. Python



100.0

[\[https://spectrum.ieee.org/static/interactive-the-top-programming-languages-2018\]](https://spectrum.ieee.org/static/interactive-the-top-programming-languages-2018)

IEEE Spectrum – Top prog. languages

The Top Programming Languages 2019

Python remains the big kahuna, but specialist
languages hold their own

Rank	Language	Type	Score
1	Python	  	100.0
2	Java	  	96.3
3	C	  	94.4
4	C++	  	87.5
5	R		81.5
6	JavaScript		79.4







[\[https://spectrum.ieee.org/static/interactive-the-top-programming-languages-2019\]](https://spectrum.ieee.org/static/interactive-the-top-programming-languages-2019)

IEEE Spectrum – Top prog. languages

22 Jul 2020 | 18:15 GMT

Top Programming Languages 2020


Python rules the roost, but Cobol gets a pandemic bump



















Language Ranking: IEEE Spectrum					
Rank	Language	Type			Score
1	Python▼				100.0
2	Java▼				95.3
3	C▼				94.6
4	C++▼				87.0
5	JavaScript▼				79.5
6	R▼				78.6

[<https://spectrum.ieee.org/static/interactive-the-top-programming-languages-2020>]

IEEE Spectrum – Top prog. languages

Top Programming Languages 2021 > Python dominates as the de facto platform for new technologies

BY STEPHEN CASS | 24 AUG 2021 | 3 MIN READ | 

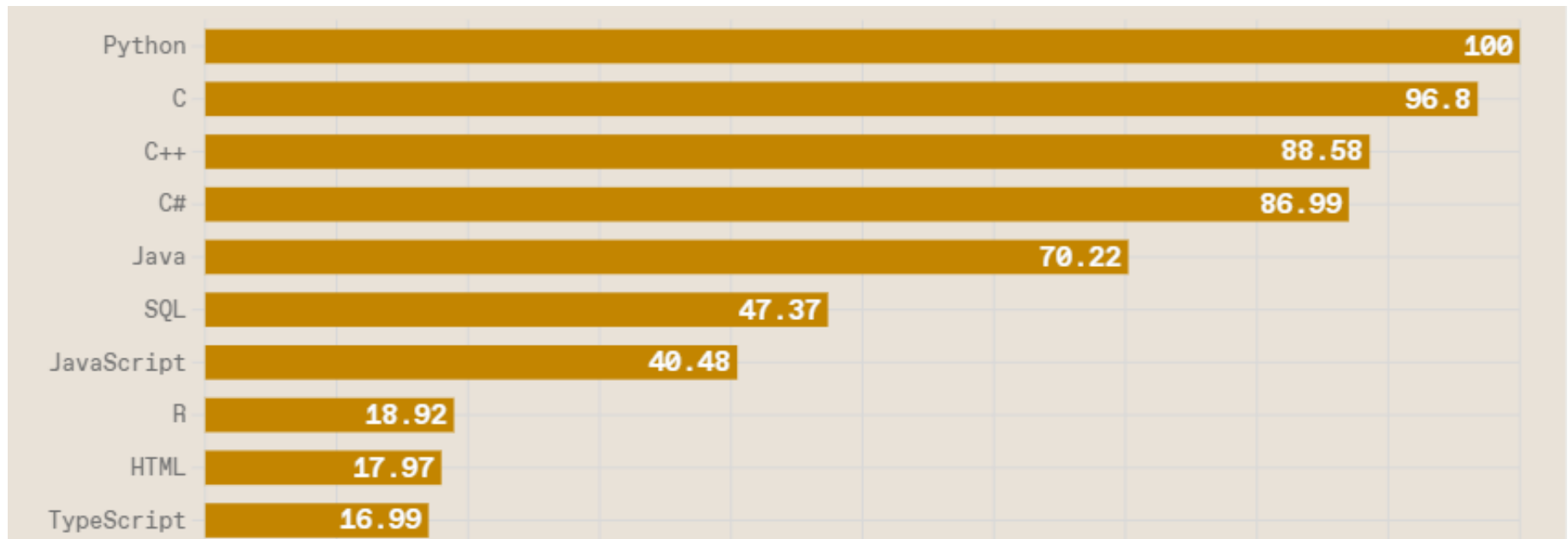
Rank	Language	Type	Score
1	Python 	  	100.0
2	Java 	  	95.4
3	C 	  	94.7
4	C++ 	  	92.4
5	JavaScript 		88.1

[\[https://spectrum.ieee.org/top-programming-languages-2021\]](https://spectrum.ieee.org/top-programming-languages-2021)

IEEE Spectrum – Top prog. languages

Top Programming Languages 2022 › Python's still No. 1, but employers love to see SQL skills

BY [STEPHEN CASS](#) | 23 AUG 2022 | 4 MIN READ | [Bookmark](#)



[\[https://spectrum.ieee.org/top-programming-languages-2022\]](https://spectrum.ieee.org/top-programming-languages-2022)

IEEE Spectrum – Top prog. languages

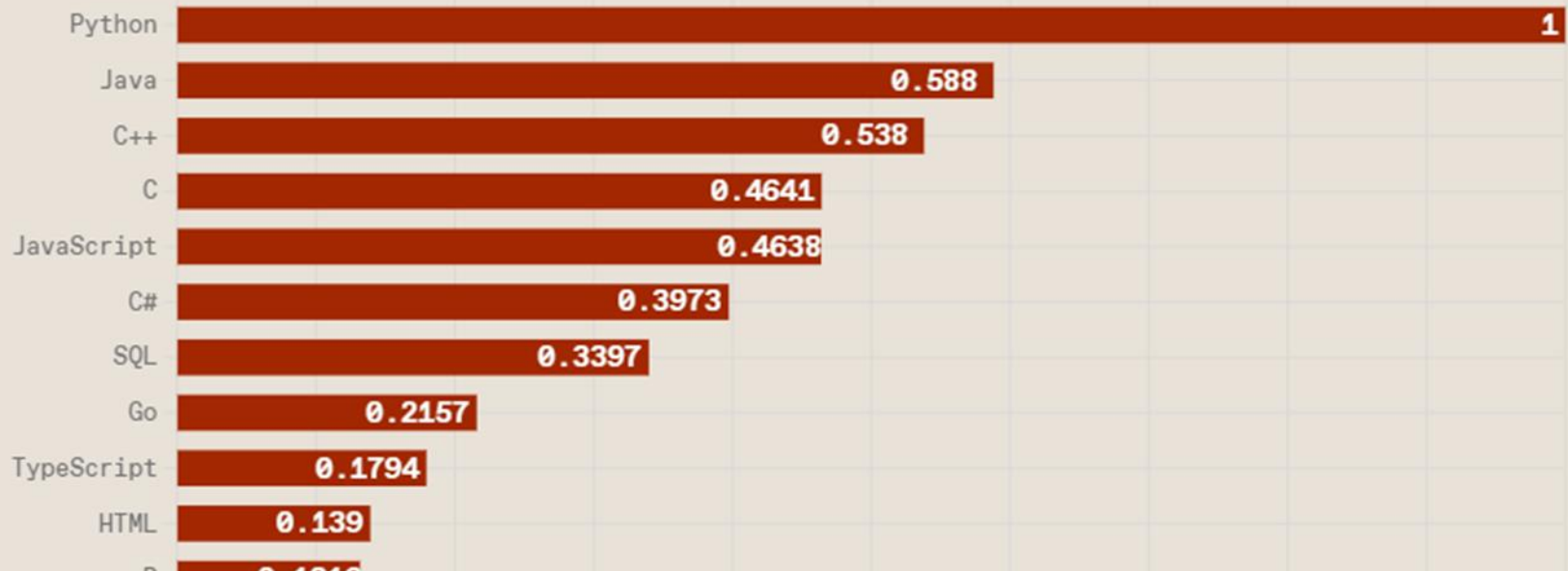
Top Programming Languages 2023

Click a button to see a differently weighted ranking

Spectrum

Jobs

Trending



[\[https://spectrum.ieee.org/top-programming-languages-2023\]](https://spectrum.ieee.org/top-programming-languages-2023)



[irinstitutes.org]

EVALUATION

Grading

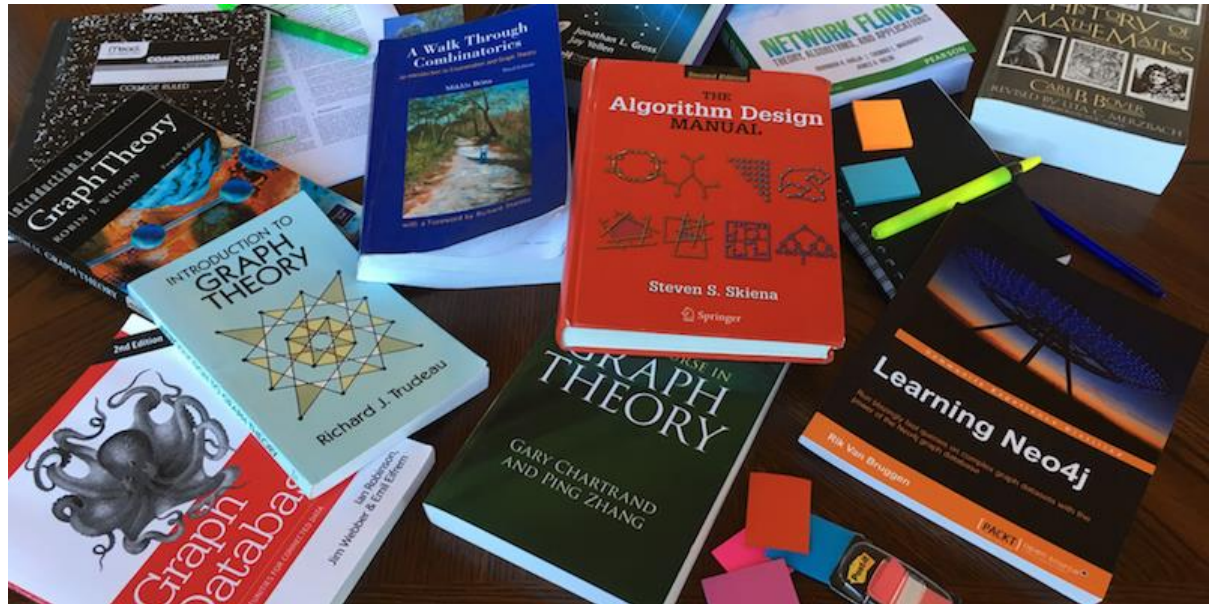
■ Mixed grading

- 65% – Individual assignments / projects
 - Code + Report + Presentation / Analysis
- 35% – Final written examination
 - Multiple-choice + True / False questions

ORGANIZATION

Class Organization

- 1st part (approx. 1 hour) : Lecture / presentation
- (Very) Short break 😊
- 2nd part : Design / programming / testing
- Bring your own computer !
- Individual work during classes !



[hackernoon.com]

USEFUL BOOKS

Bibliography – The basics

- T. H. Cormen et al., *Introduction to Algorithms*, 3rd Ed., MIT Press, 2009
- J. Kleinberg and E. Tardos, *Algorithm Design*, Pearson, 2006
- D. Vrajitoru and W. Knight, *Practical Analysis of Algorithms*, Springer 2014
- ...

Bibliography

- J. Hromkovic, *Design and Analysis of Randomized Algorithms*, Springer, 2005
- J. Leskovec, A. Rajaraman and J. D. Ullman, *Mining of Massive Datasets*, 2nd Ed., C. U. Press, 2014
- ...