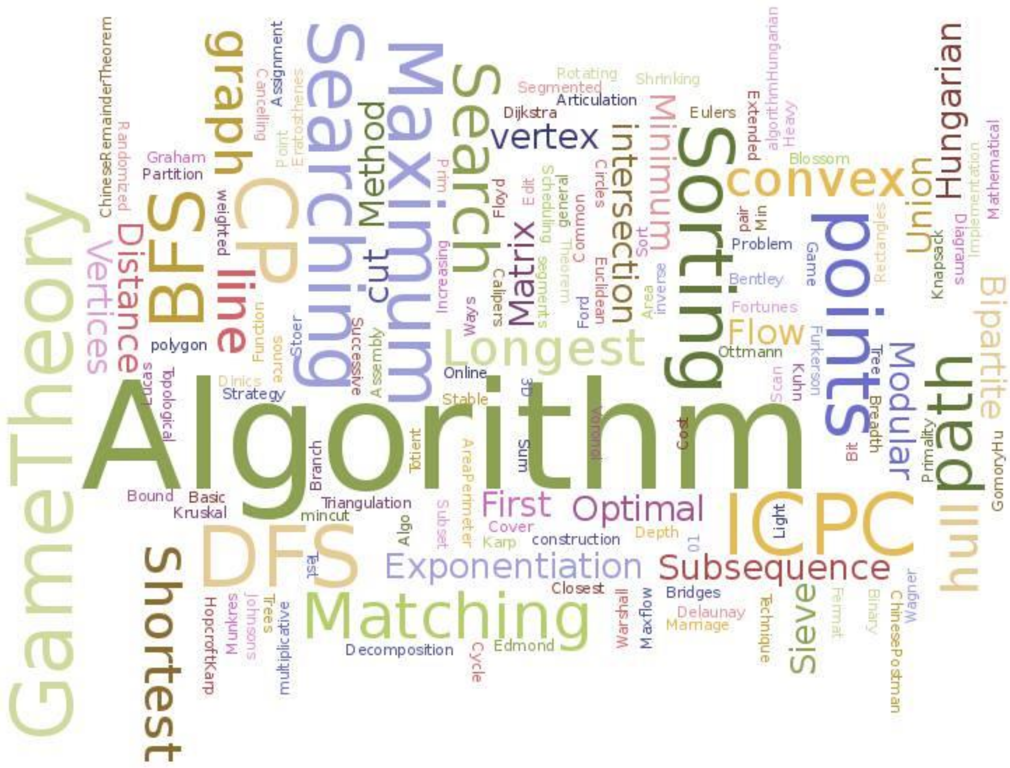
Advanced Algorithms
– Course Presentation –

Joaquim Madeira

Version 0.7 – September 2024

Overview

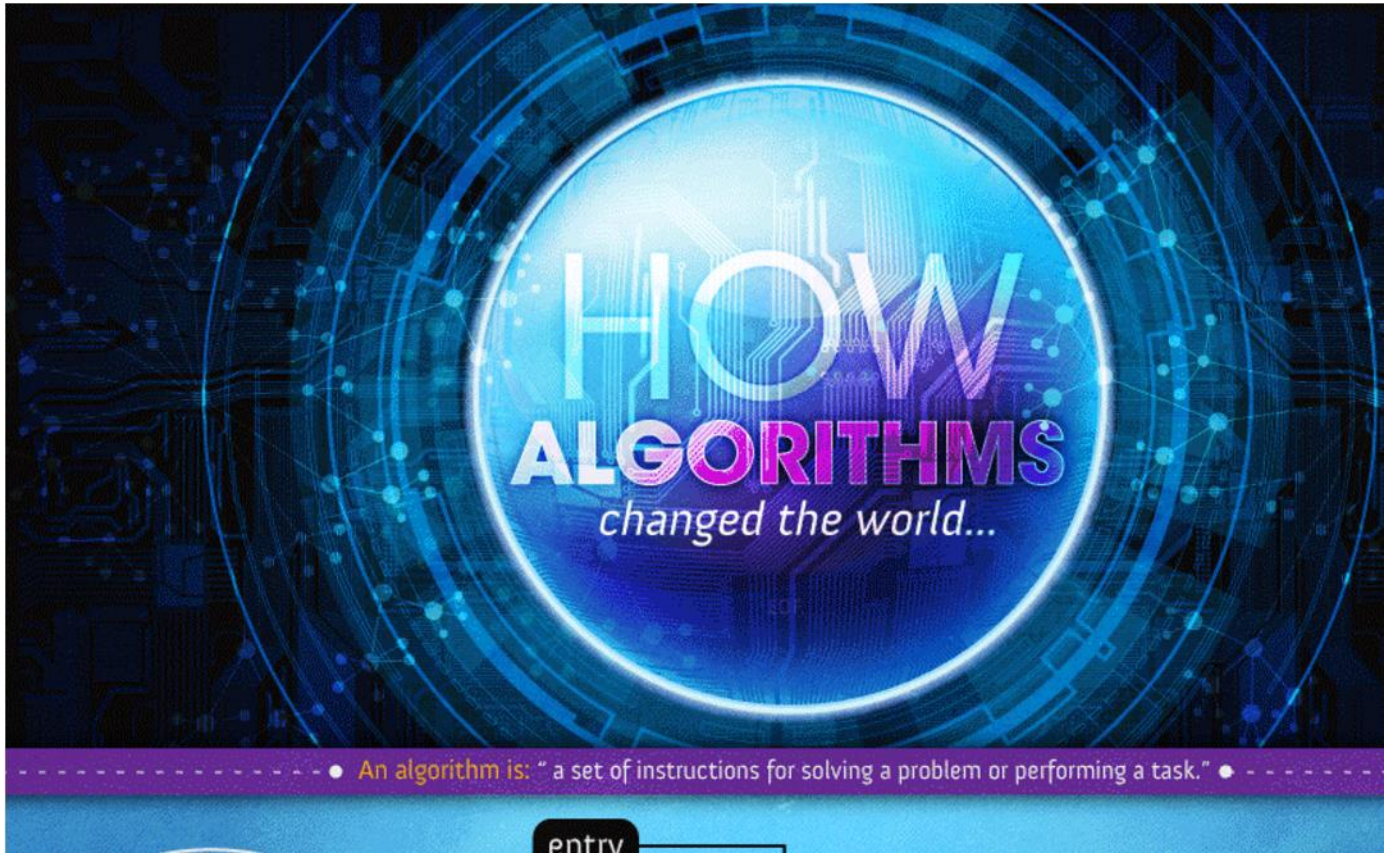
- Motivation
- Goals
- Tentative syllabus
- Evaluation
- Class organization
- Some useful books



[geeksforgeeks.org]

MOTIVATION

Algorithms have changed the world !

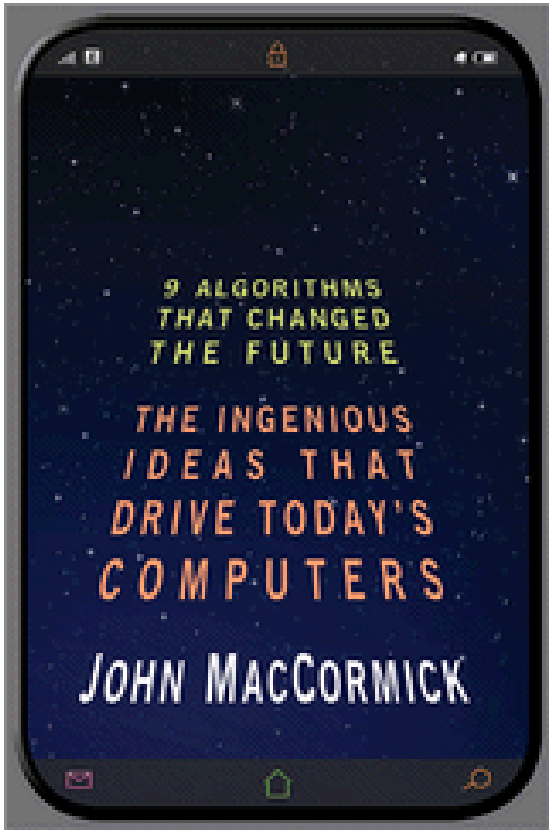


Check the infographic on the Web

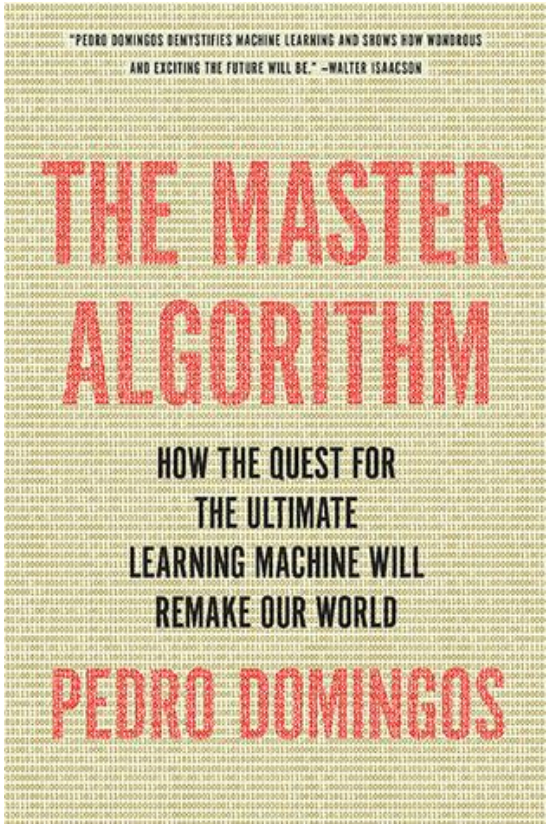
Top 10 algorithms of the 20th century

Special issue of IEEE CiSE, Jan/Feb 2000

There are even best-sellers !!

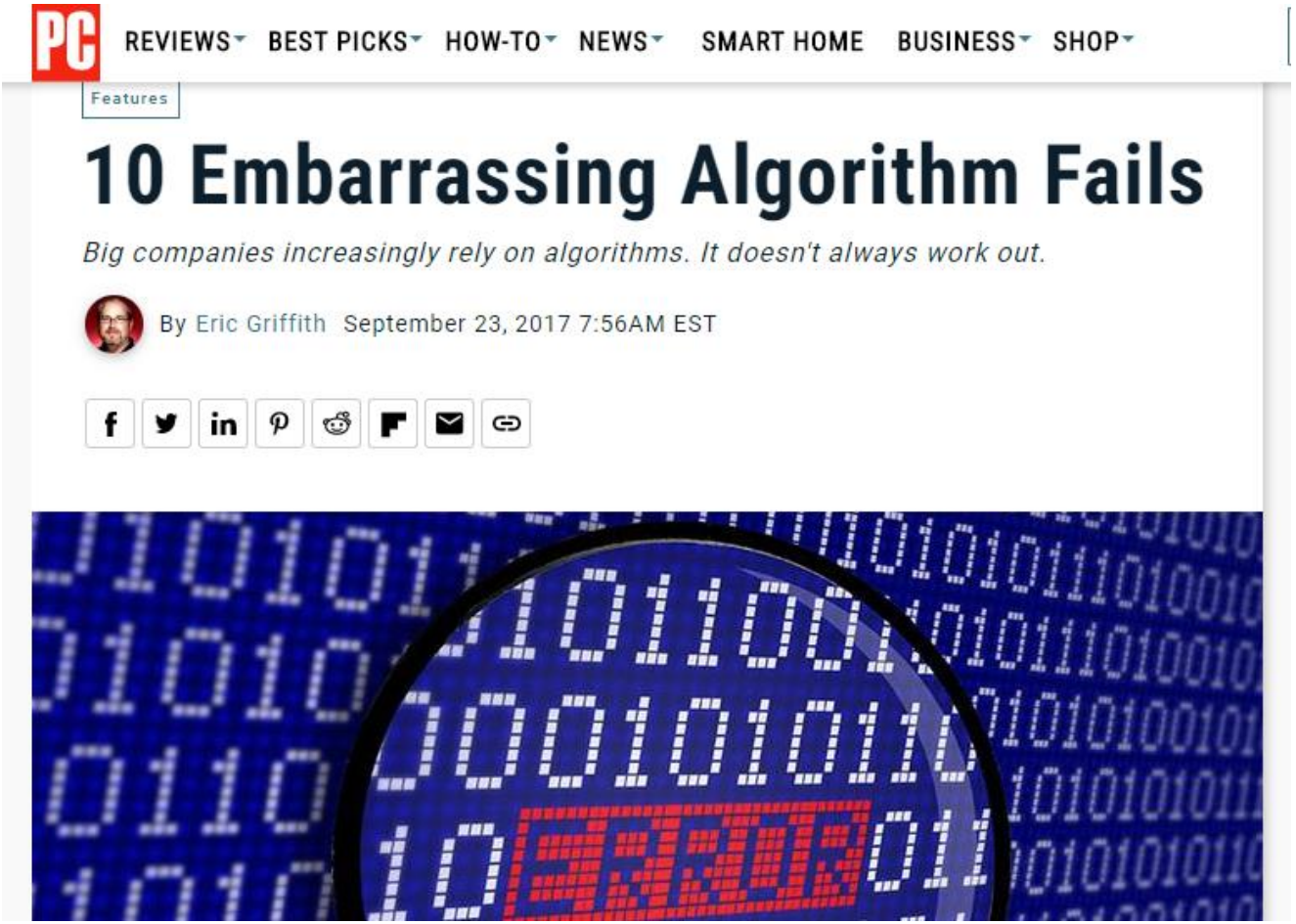


[2012]



[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]

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 !!

IEEE SPECTRUM Engineering Topics Special Reports Blogs Multimedia The Magazine P

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

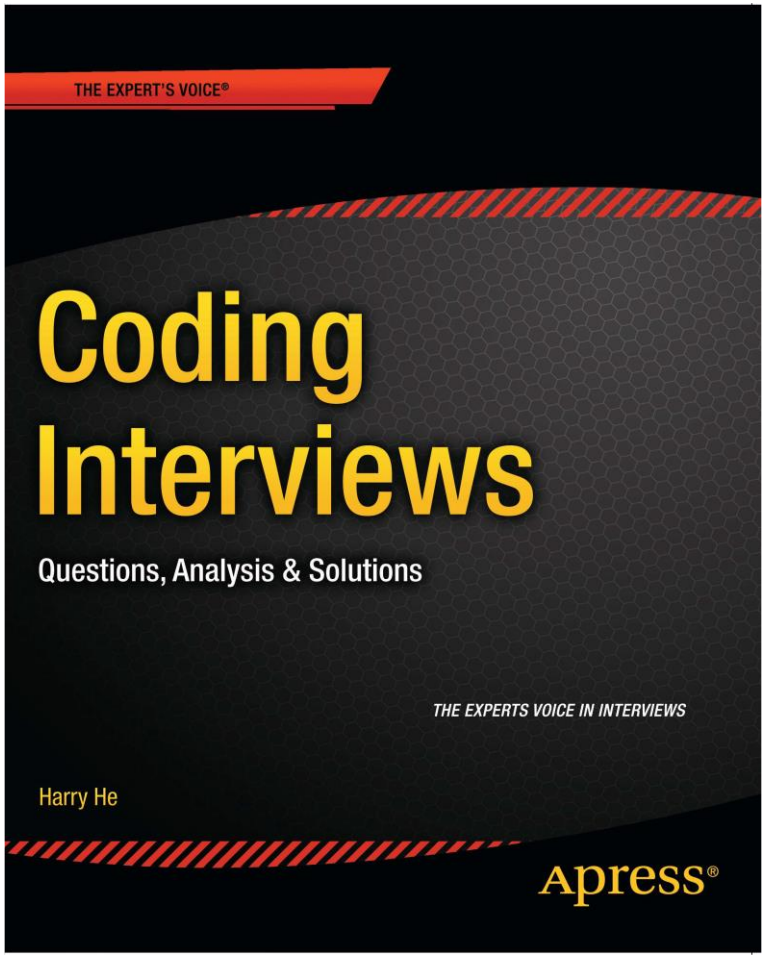
Will Thursday 13 August 2020 be remembered as a pivotal moment in democracy's relationship with digital technology? Because of the coronavirus outbreak, A-level and GCSE examinations had to be cancelled, leaving education authorities with a choice: give the kids the grades that had been predicted by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

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 a
languages are similar and different, and to aid a person with a grounding in one approach to a problem in learning another. Rosetta C

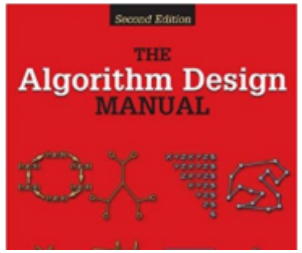
Stony Brook Algorithm Repository

Steven Skiena | Dept. of Computer Science | Stony Brook University | Books | By Language | By Problem

The Stony Brook Algorithm Repository

Steven Skiena

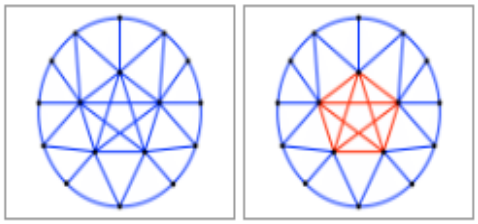
This page provides a comprehensive collection of algorithm implementations for seventy-five of the most fundamental problems in combinatorial algorithms. The problem taxonomy, implementations, and supporting material are all drawn from my book The Algorithm Design Manual. Since the practical person is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



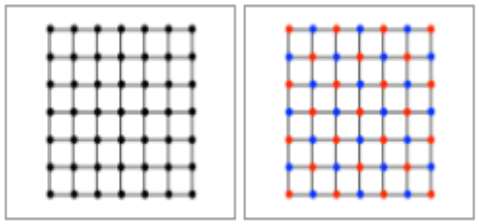
http://algorist.com/algorist.html

Stony Brook Algorithm Repository

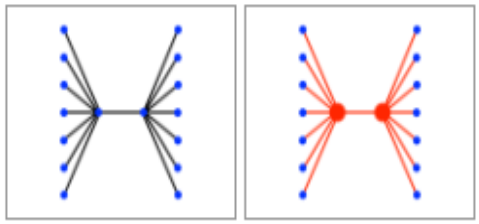
Graph: Hard Problems



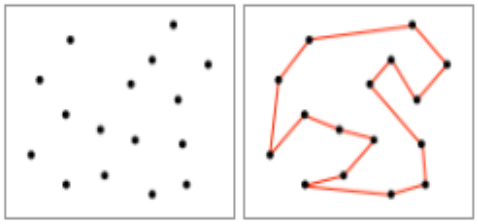
Clique



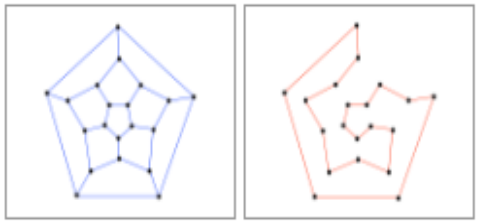
Independent Set



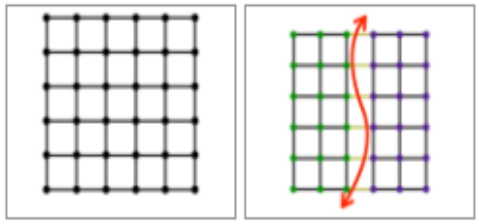
Vertex Cover



Traveling Salesman Problem



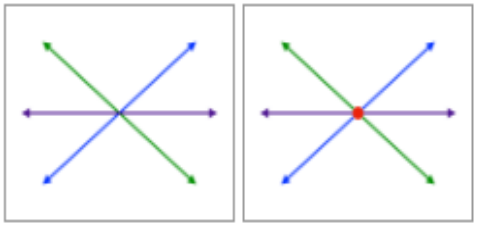
Hamiltonian Cycle



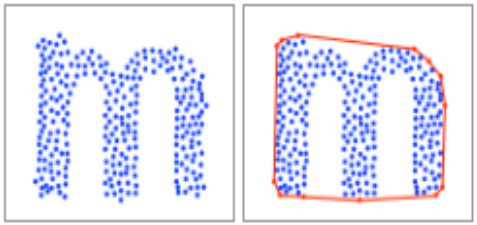
Graph Partition

Stony Brook Algorithm Repository

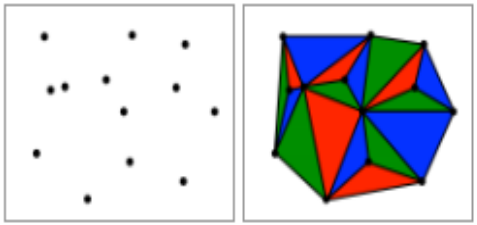
Computational Geometry



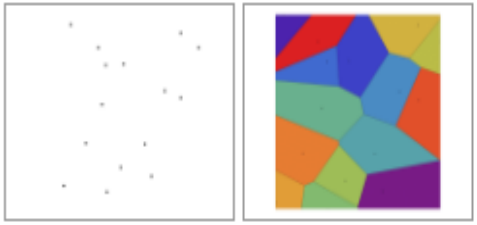
Robust Geometric Primitives



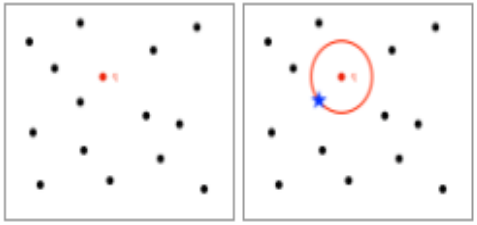
Convex Hull



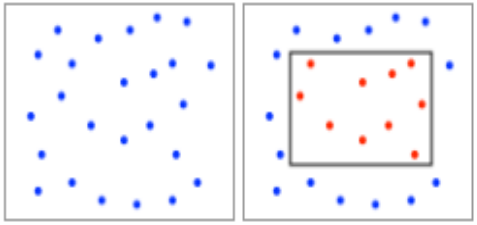
Triangulation



Voronoi Diagrams

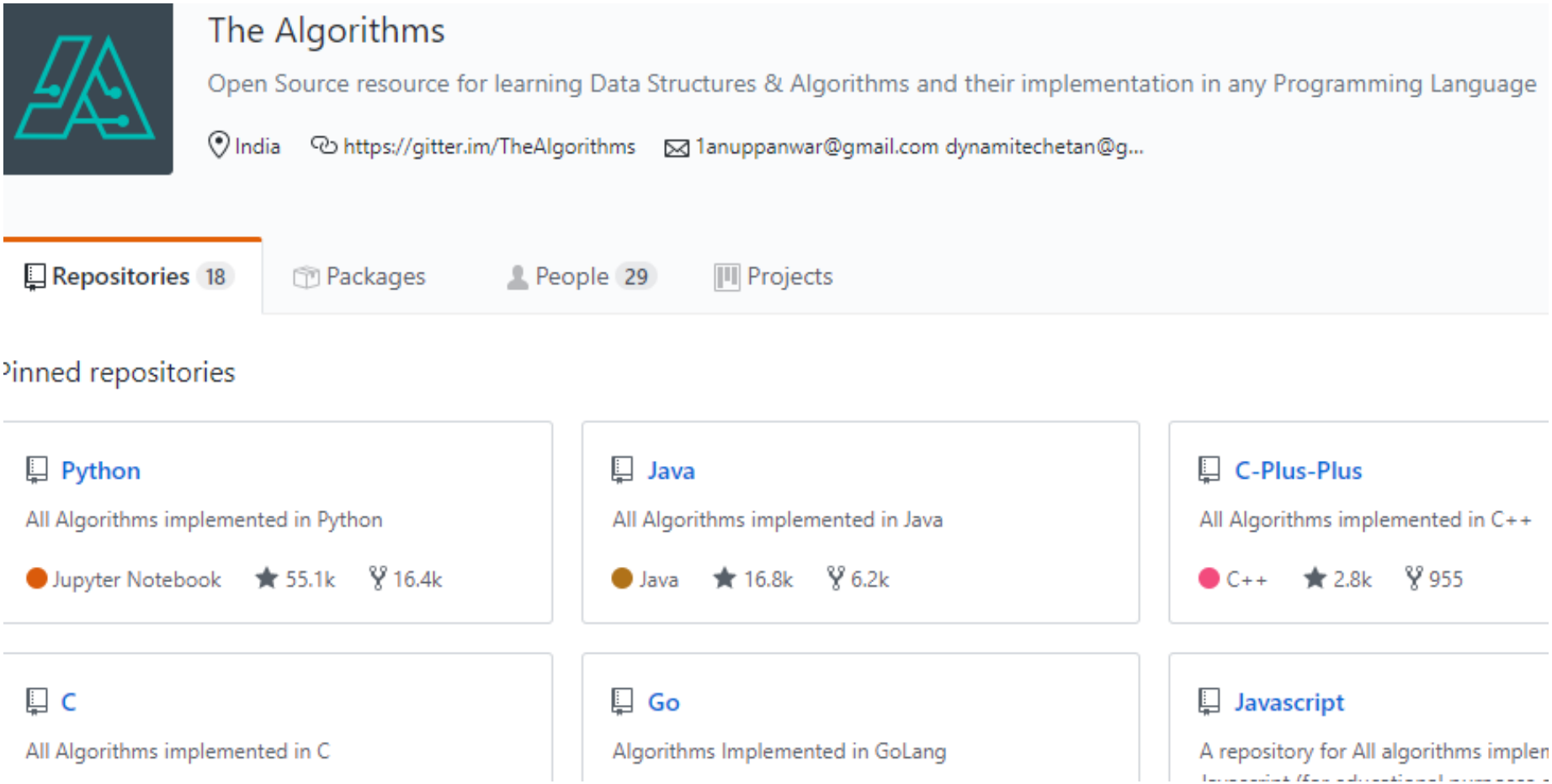


Nearest Neighbor Search



Range Search

github.com/TheAlgorithms



[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…

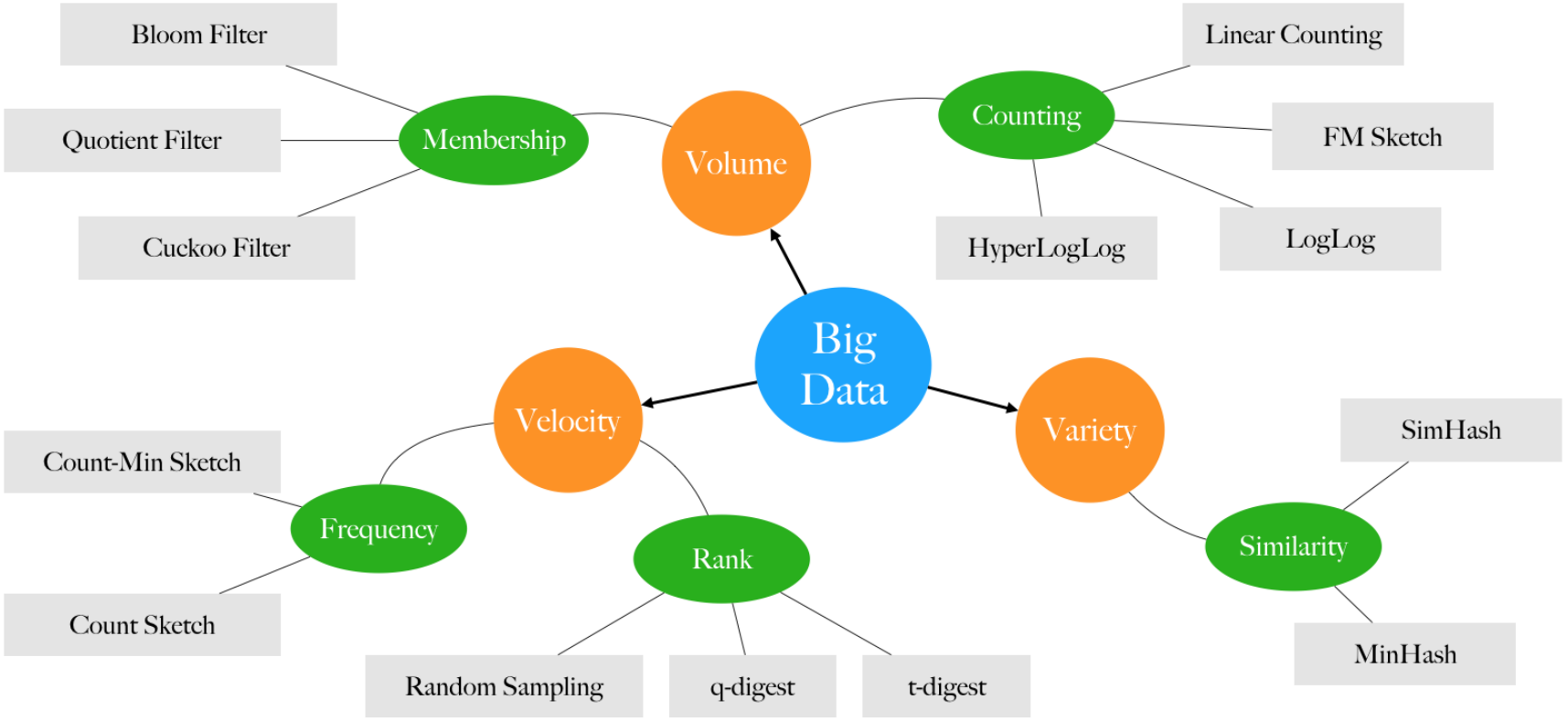
- Today's lecture and the first weeks should show us how we can proceed…

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

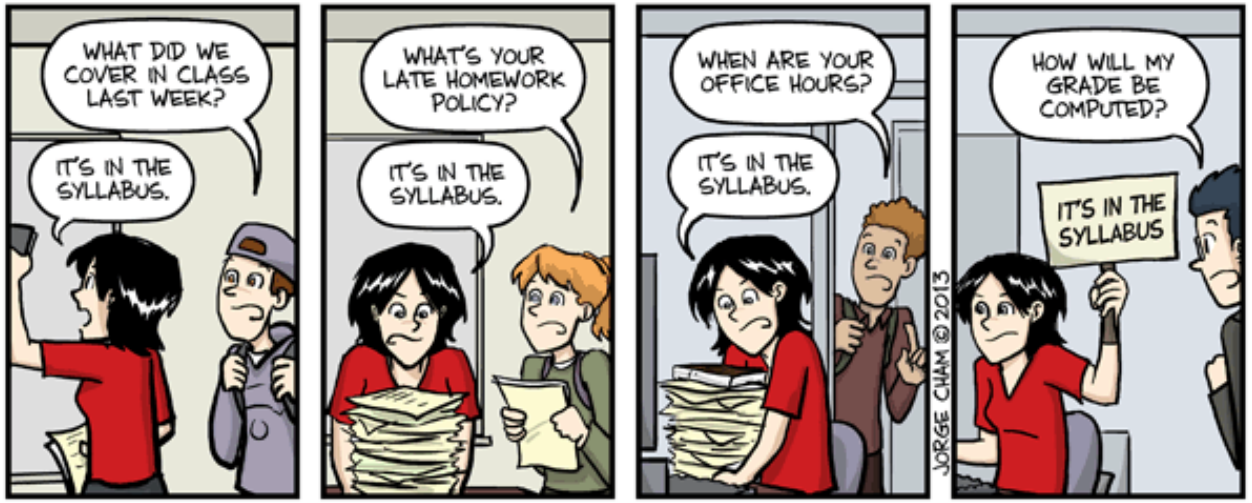
Problems Solved by PDSA



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

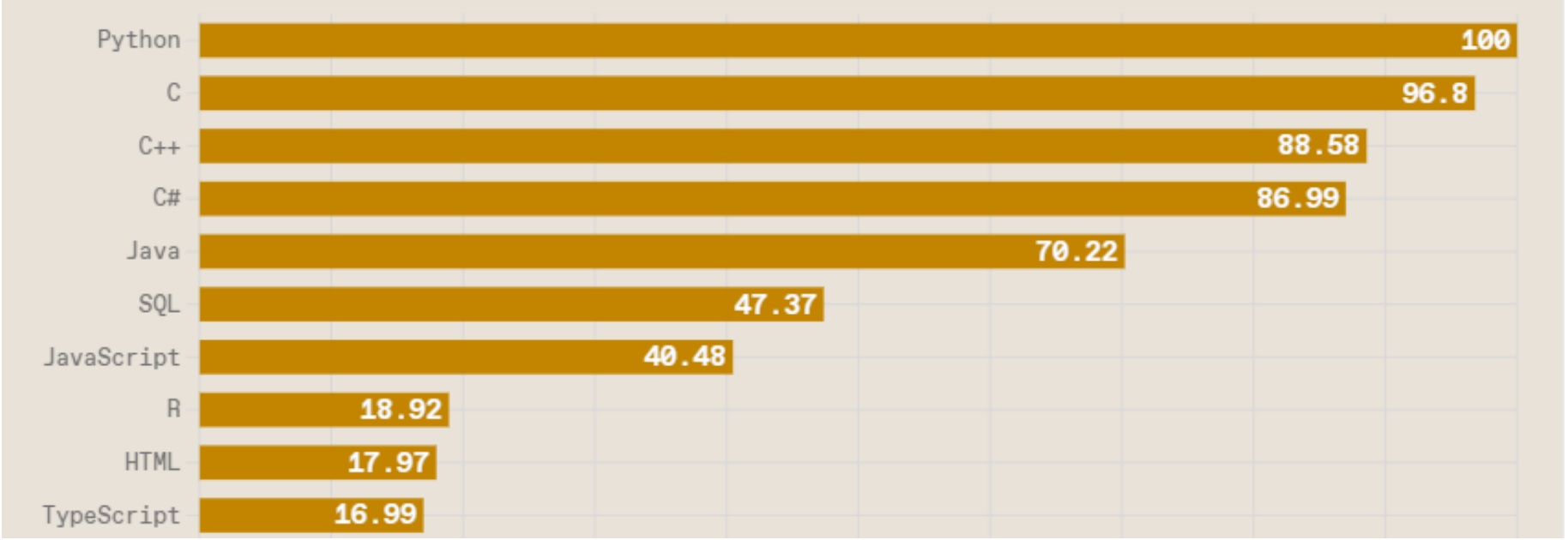
Programming Language

- 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

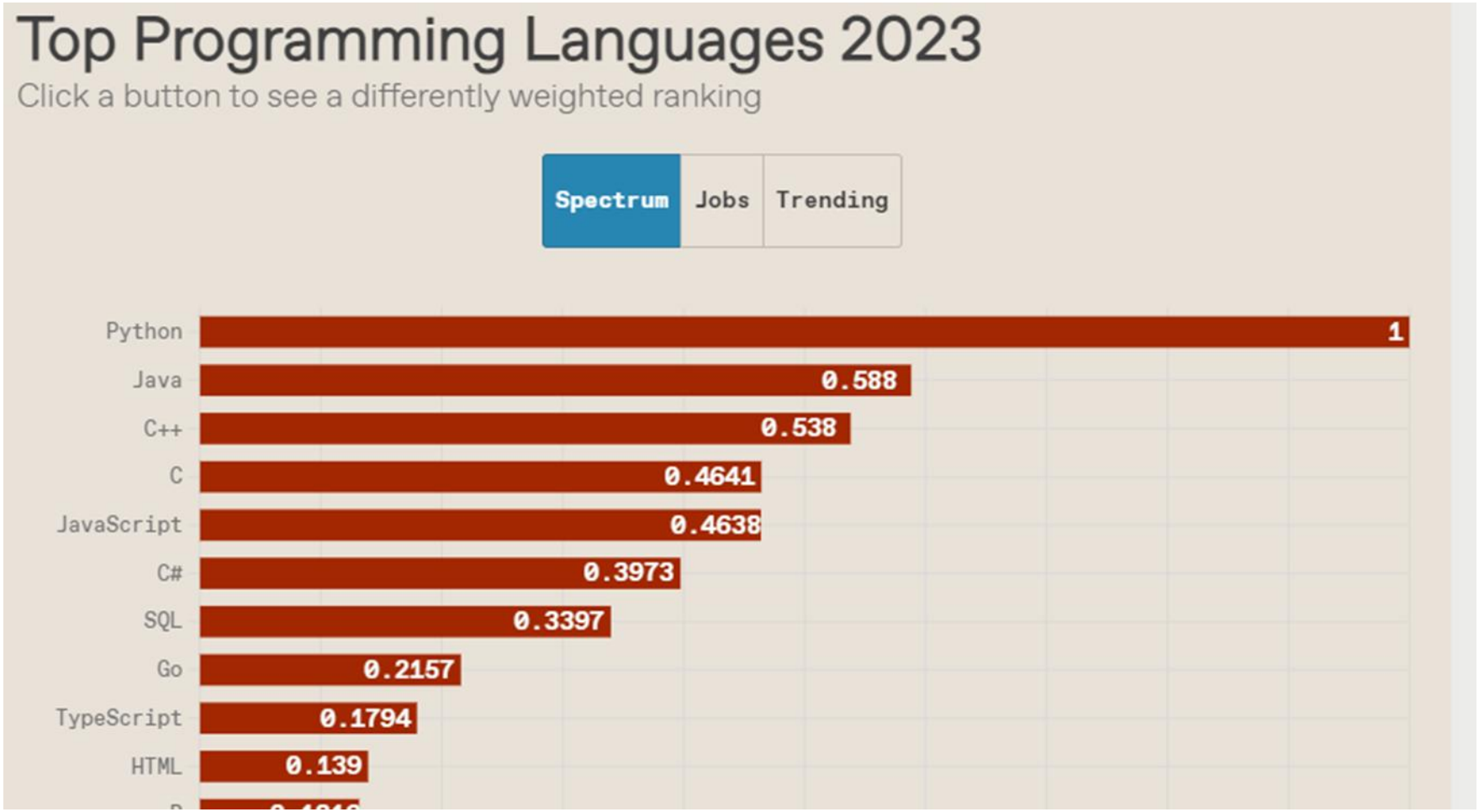
Top Programming Languages 2022 › Python's still No. 1, but employers love to see SQL skills

BY STEPHEN CASS | 23 AUG 2022 | 4 MIN READ |



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

IEEE Spectrum – Top prog. languages



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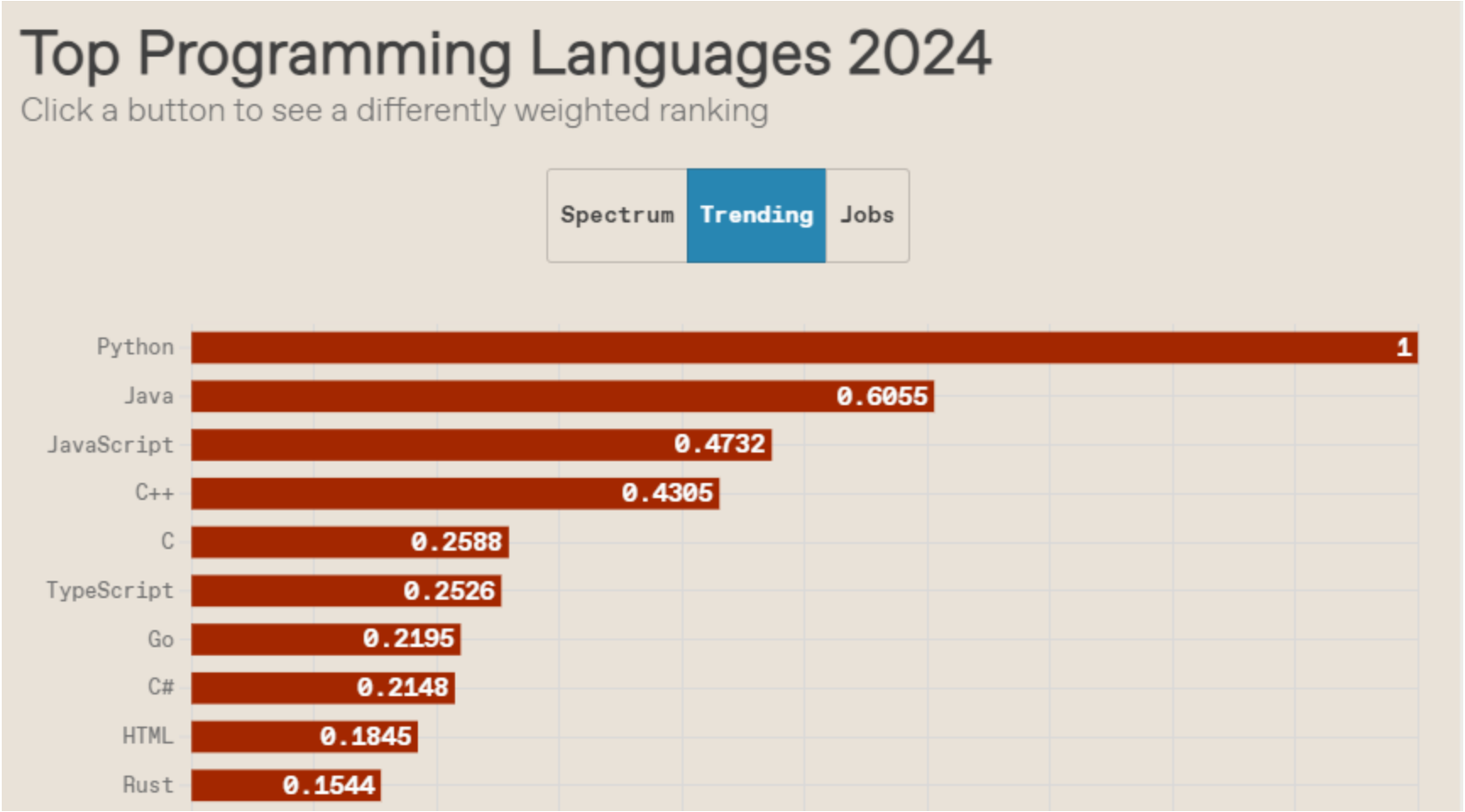
IEEE Spectrum – Top prog. languages



[https://spectrum.ieee.org/top-programming-languages-2024]

[irinstitutes.org]

EVALUATION

Grading

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

Grading

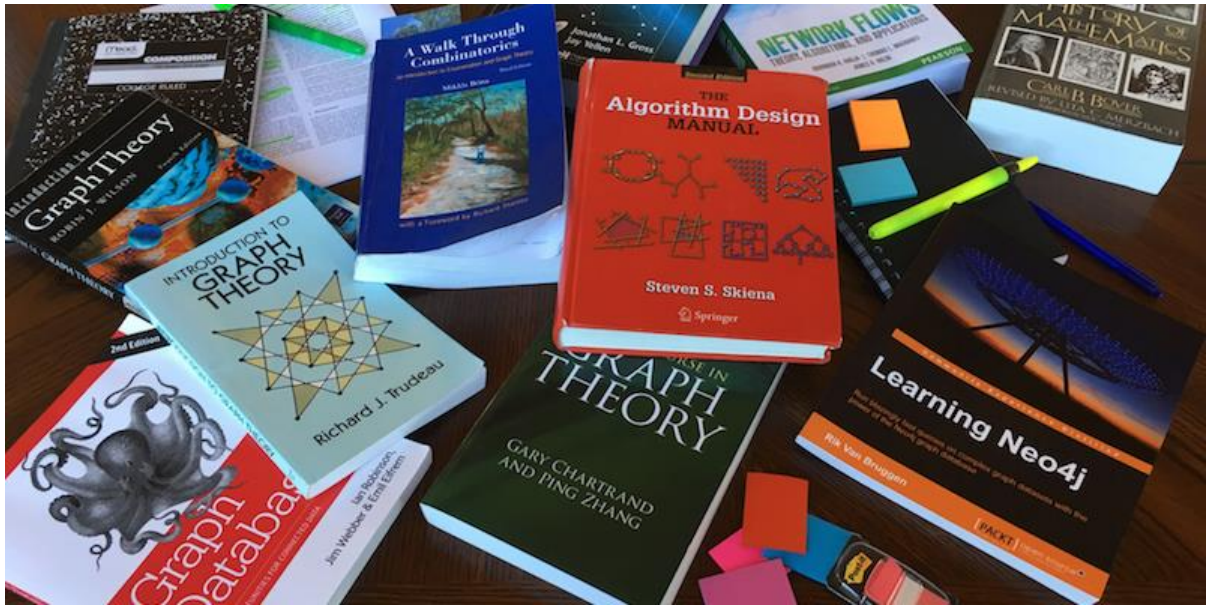
- Final grading
  - 65% – 1 final, aggregate project
    - Code + Report + Presentation / Analysis
  - 35% – Final written examination
    - Multiple-choice + True / False questions

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
- …