

Course Overview

Data Structures
C++ for C Coders

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Course overview

What does the data structure mean?

- **Data structures:**
 - **methods to store and organize data** in a computer so that it can be used efficiently.
 - A key to designing efficient **algorithms**.
 - **Algorithms:**
 - methods for solving a problem
 - **Data structures & algorithms** are **the fundamentals of programming**.
 - To become a good computer scientist or engineering it is essential to master the **data structures and algorithms** and learn to apply them to the real world problems.
- ← which is complicated or complex.

Course overview

What is this course?

- Intermediate-level course.
- Programming **after** programming for problem solving with applications.

topic	data structures and algorithms
concepts	algorithms, time-complexity, array and structure
data types	linked list, array, stack, queue, trees, union-find, bag, priority queues
sorting	selection sort, quick sort, merge sort, heap sort
searching	binary search tree, hashing
graph	BFS, DFS

Why study data structures?

Their impact is broad and far-reaching

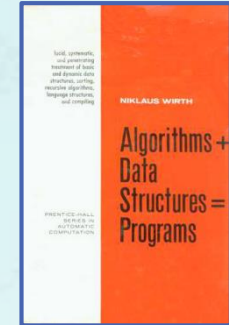
- **Internet** Web search, packet routing, distributed file sharing, ...
- **Social networks** News feeds, advertisements, ...
- **Computers** Circuit layout, file system, compilers, ...
- **Computer graphics** Movies, video games, virtual reality, ...
- **Multimedia** MP3, JPG, DivX, HDTV, face recognition, ...
- **Security** Cell phones, e-commerce, voting machines, ...
- **Biology** Human genome project, protein folding, ...
- **Physics** N-body simulation, particle collision simulation, ...



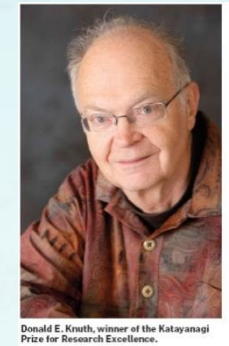
Why study data structures?

To become a proficient programmer.

" Algorithms + **Data Structures** = Programs. " — *Niklaus Wirth*

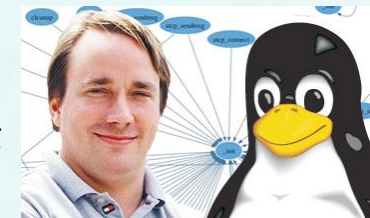


" An **algorithm** must be seen to be believed. " — *Donald Knuth*



" 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)



Why study data structures?

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.
- Then, why **data structures**?
It always comes with algorithms like its shadow.

Ex. Fast Fourier Transform(FFT) Algorithm

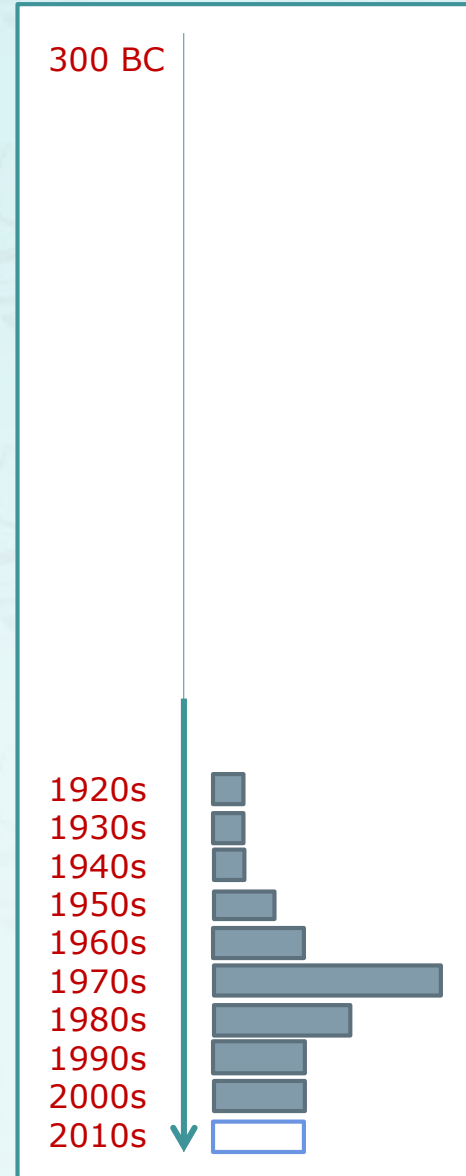
Joseph Fourier(1768-1830) used for heat-transfer computation.

1805 – invented by Carl Friedrich Gauss.

1965 – popularized by James Cooley(IBM) and John Tukey(Princeton).

1986 – JPEG(Joint Photographic Experts Group) was formed.

1992 – issued the first standard of JPEG using DCT
Discrete cosine transform – another form of FFT.



Why study data structures?

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

Computational models are replacing math models in scientific inquiry.

Ex. Fourier Transform → Fast FT algorithm → Image Processing → **JPEG/MPEG**

1805

1965

1992

Fourier Series & The Fourier Transform

Joseph Fourier 1768 - 1830



What is the Fourier Transform?

Fourier Cosine Series for even functions and Sine Series for odd functions

The continuous limit: the Fourier transform (and its inverse)

The spectrum

Some examples and theorems

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) \exp(i\omega t) d\omega \quad F(\omega) = \int_{-\infty}^{\infty} f(t) \exp(-i\omega t) dt$$

Prof. Rick Trebino, Georgia Tech

~ old century science
(formula based)

```
RECURSIVE-FFT(a)
1  n ← length[a]          ▷ n is a power of 2.
2  if n = 1
3    then return a
4  ωn ← e2πi/n
5  ω ← 1
6  a[0] ← (a0, a2, ..., an-2)
7  a[1] ← (a1, a3, ..., an-1)
8  y[0] ← RECURSIVE-FFT(a[0])
9  y[1] ← RECURSIVE-FFT(a[1])
10 for k ← 0 to n/2 - 1
11   do yk ← yk[0] + ω yk[1]
12     yk+(n/2) ← yk[0] - ω yk[1]
13     ω ← ω ωn
14 return y                ▷ y is assumed to be column vector.
```

21th century science
(algorithm based)

Why study data structures?

- 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..



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