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(Breadth First Search), DFS(Depth First Search)

Why study data structures?

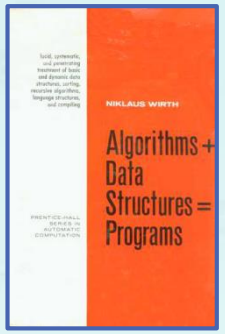
Their impact is broad and far-reaching

- **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, MP4, 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, ...

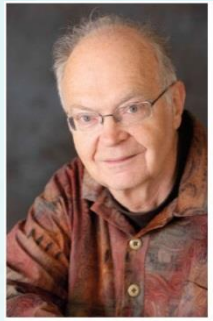
Why study data structures?

To become a proficient programmer.

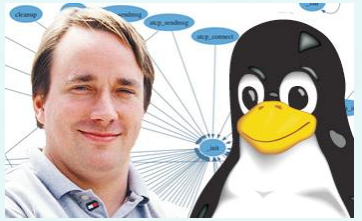


" *Algorithms +* ***Data Structures*** *= Programs.* " — *Niklaus Wirth*

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


Donald E. Knuth, winner of the Katayanagi Prize for Research Excellence.

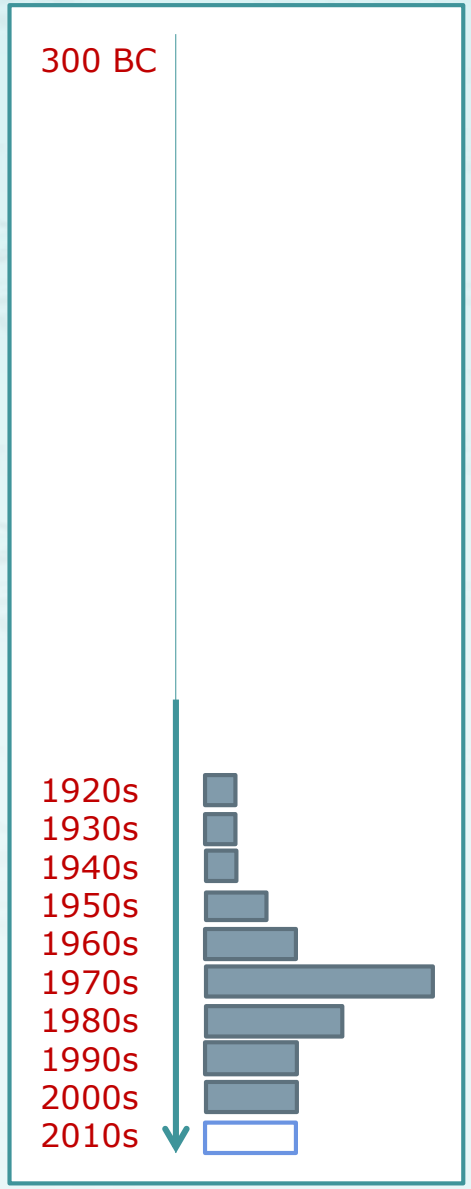
" *I will, in fact, claim that the difference between a bad programmer and a good one is whether he considers his code or his data structures more important. Bad programmers worry about the code. Good programmers worry about* ***data structures*** *and their* ***relationships****.* "
— *Linus Torvalds (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).

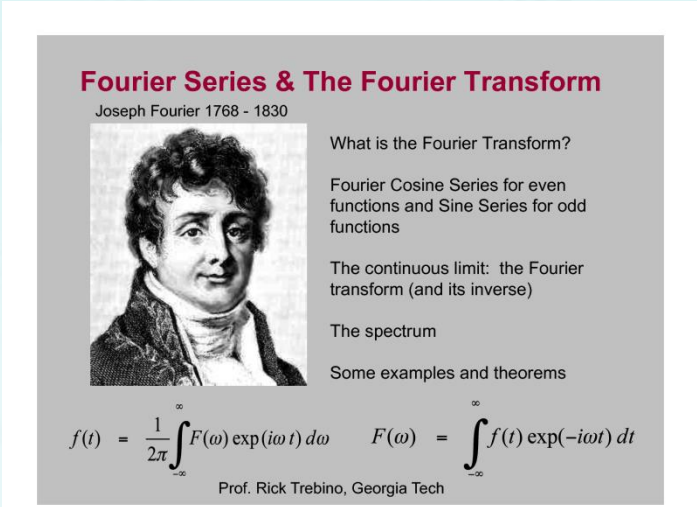
1986 – JPEG(Joint Photographic Experts Group) was formed.
1992 – issued the first standard of JPEG using DCT
Discrete cosine transform – another form of FFT.

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



~ 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  ω_n ← e^(2πi/n)
 5  ω ← 1
 6  a^[0] ← (a_0, a_2, ..., a_{n-2})
 7  a^[1] ← (a_1, a_3, ..., a_{n-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 y_k ← y_k^[0] + ω y_k^[1]
12           y_{k+(n/2)} ← y_k^[0] − ω y_k^[1]
13           ω ← ω ω_n
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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