Course Overview

Data Structures
C++ for C Coders

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Data Structures & C++ for C Coders

- Read Syllabus
  - Piazza
  - “git” and “GitHub Desktop“
  - Atom
  - MinGW-w64/MSYS2
  - g++ (GNU GCC C++ Compiler)
  - MS Visual Studio
- Overview
  - Why study data structures?

SHOW CANTILLATION MARKS ☐ Masoretic Text SHOW VOWEL POINTS ☑

1:2 כִּי אִם בְּתוֹרַת יְהוָה חֶפְצוֹ וּבְתוֹרָתוֹ יֶהְגֶּה יוֹמָם וָלָיְלָה׃

Reverse Interlinear

English (NASB) [?]		Strong's	Root Form (Hebrew)
But his delight	PHR	H2656	חֵפֶץ chephets
is in the law	PHR	H8451	תּוֹרָה towrah
of the LORD,	PHR	H3068	יְהוָה Yĕhovah
And in His law	PHR	H8451	תּוֹרָה towrah
he meditates	PHR	H1897	הָגָה hagah
day		H3119	יוֹמָם yowmam
and night.	PHR	H3915	לַיִל layil

[시1:1-2] **복 있는 사람**은 악인들의 꾀를 따르지 아니하며 죄인들의 길에 서지 아니하며 오만한 자들의 자리에 앉지 아니하고, 오직 여호와의 율법을 즐거워하여 그의 율법을 주야로 **묵상하는도다**

(Psalm1:1-2) **Blessed is the one** who does not walk in step with the wicked or stand in the way that sinners tak e or sit in the company of mockers, but whose delight is in the law of the LORD, and who **meditates** on his law day and night.

I. הָגָה fut. יֶהְגֶּה—(1) TO MURMUR, TO MUTTER, TO GROWL, (almost the same in meaning as הָמָה); used of the growl of a lion over his prey (Gr. ὑποβρυχάομαι: *to roar* is שָׁאַג, βρυχάομαι), Isa. 31:4; of low thunder (see הֶגֶה Job 37:2); of the muttering of enchanters (see HIPHIL); of the sound of a harp when struck (see הִגָּיוֹן Ps. 9:17; 92:4); of the cooing of doves, Isa. 38:14; 59:11; of the groaning and sighing of men (οἰμώζειν), Isa. 16:7; Jer. 48:31.

(2) poetically, *to speak*.—(*a*) absolutely (*to utter sound*), Ps. 115:7.—(*b*) with an acc. of the thing, Job 27:4; Ps. 37:30; Isa. 59:3; Pro. 8:7; hence *to sing, to celebrate* (like *to say*, אָמַר). Psal. 35:28, לְשׁוֹנִי תֶּהְגֶּה צִדְקֶךָ "my tongue shall celebrate thy righteousness;" Ps. 71:24.

(3) *to meditate* (prop. to speak with oneself, murmuring and in a low voice, as is often done by those who are musing, compare No. 1 and אָמַר, אָמַר בְּלִבּוֹ), followed by בְּ, to meditate on any thing (über etwas nachdenken). Josh. 1:8, וְהָגִיתָ בּוֹ יוֹמָם וָלַיְלָה "and thou shalt meditate thereon (on the law) day and night;" Ps. 1:2; 63:7; 77:13, וְהָגִיתִי בְכָל־פָּעֳלֶךָ "and I will meditate on all thy works;" Ps. 143:5. (Syn. שִׂיחַ).

B2B^{J} : Back to the Bible

매주 화요일 늦은 7시, NTH311

B2B(BackToTheBible)와 오석 공동체로 여러분을 초대합니다.

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Course overview

What does the data structure mean?

- **Data structures**:
  - **methods to store and organize** [redacted] in a computer so that it can be used efficiently.
  - A key to designing efficient [redacted]

Course overview

What does the data structure mean?

- **Data structures**:
  - **methods to store and organize** in a computer so that it can be used efficiently.
  - A key to designing efficient
- **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

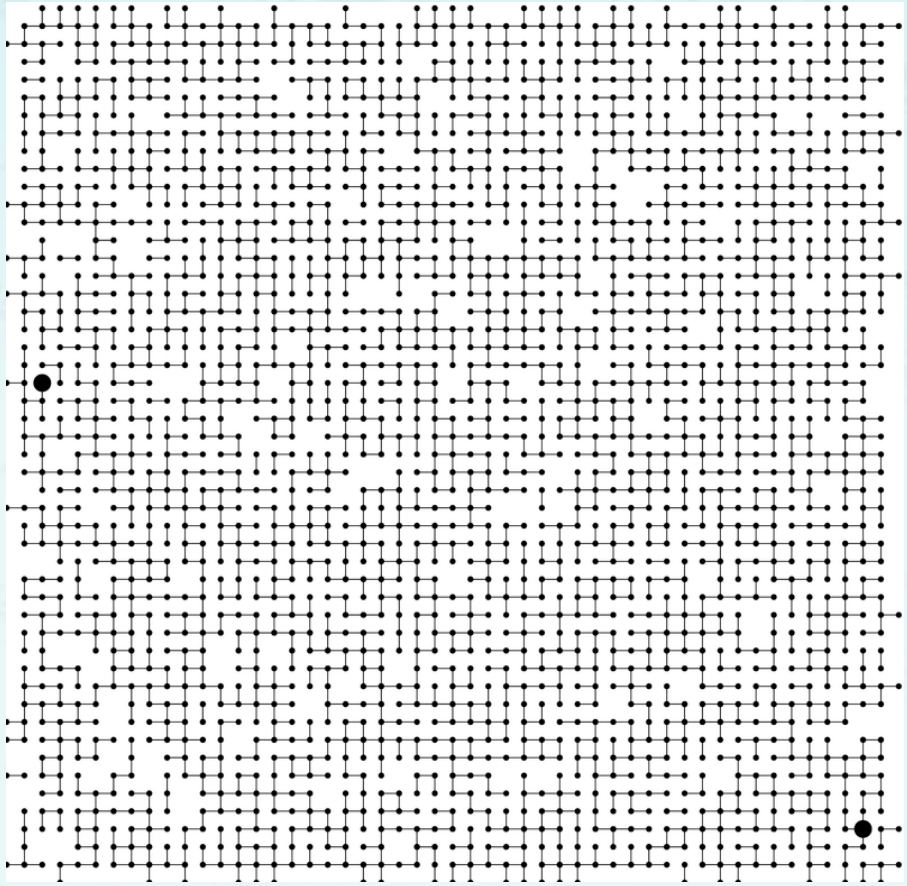
- **Internet** Web search, packet routing, distributed file sharing, ...
- **Social networks** News feeds, advertisements, ...
- **Computers** Circuit layout, file system, compilers, ...
- **Computer graphics** Movies, video games, virtual reality, ...
- **Multimedia** MP3, JPG, DivX, HDTV, face recognition, ...

- **Security** Cell phones, e-commerce, voting machines, ...
- **Biology** Human genome project, protein folding, ...
- **Physics** N-body simulation, particle collision simulation, ...

Why study data structures?

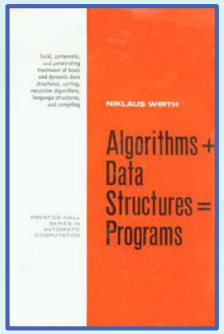
To solve problems that could not otherwise be addressed

- To work with **algorithms** to solve problems
- Ex. Network connectivity, navigation

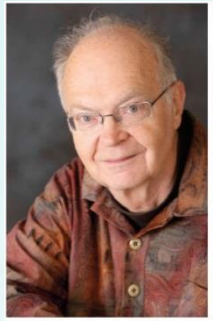


Why study data structures?

To become a proficient programmer.

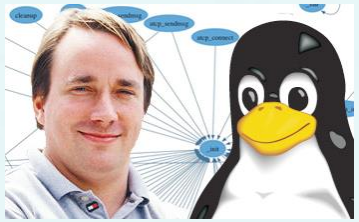


" *Algorithms + **Data Structures** = Programs.* " — *Niklaus Wirth*



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

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

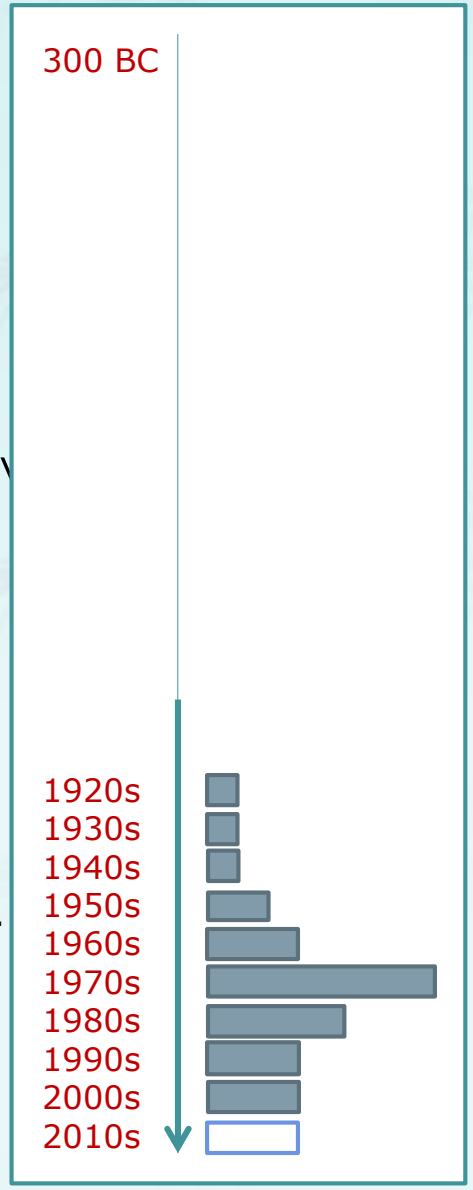


" *I will, in fact, claim that the difference between a bad programmer and a good one is whether he considers his code or his data structures more important. Bad programmers worry about the code. Good programmers worry about **data structures** and their **relationships**.* "
— *Linus Torvalds (creator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

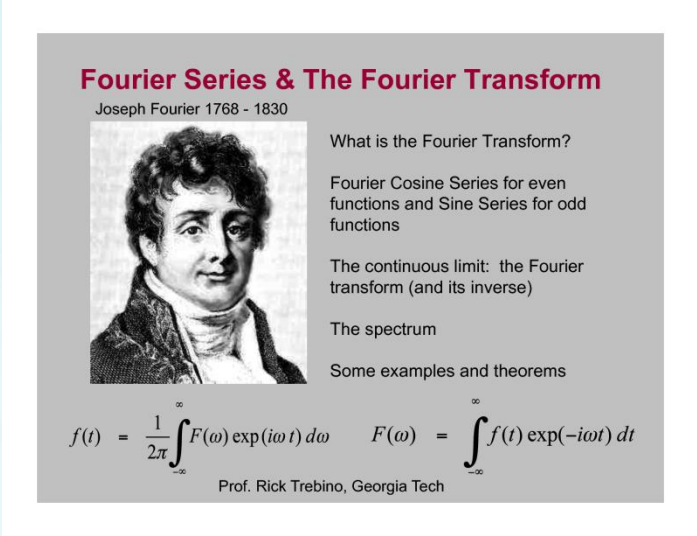
Why study data structures?

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




```
RECURSIVE-FFT(a)
n ← length[a]                    ▷ n is a power of 2.
if n = 1
   then return a
ω_n ← e^(2πi/n)
ω ← 1
a^[0] ← (a_0, a_2, ..., a_{n-2})
a^[1] ← (a_1, a_3, ..., a_{n-1})
y^[0] ← RECURSIVE-FFT(a^[0])
y^[1] ← RECURSIVE-FFT(a^[1])
for k ← 0 to n/2 − 1
      do y_k ← y_k^[0] + ω y_k^[1]
         y_{k+(n/2)} ← y_k^[0] − ω y_k^[1]
         ω ← ω ω_n
return y                         ▷ y is assumed to be column vector.
```

~ old century science
(formula based)

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..

ITP20001/ECE 20010 Data Structures

Data Structures

- *overview*
  - *pointers and dynamic memory allocation*
- *algorithm specification*
  - *recursive algorithm*
- *data abstraction*
- ***performance analysis - time complexity***
  - ***discrete math***

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