

Data Structures and Algorithms

Lesson 1. Introduction: Algorithms, Data Structures and Cognitive Science

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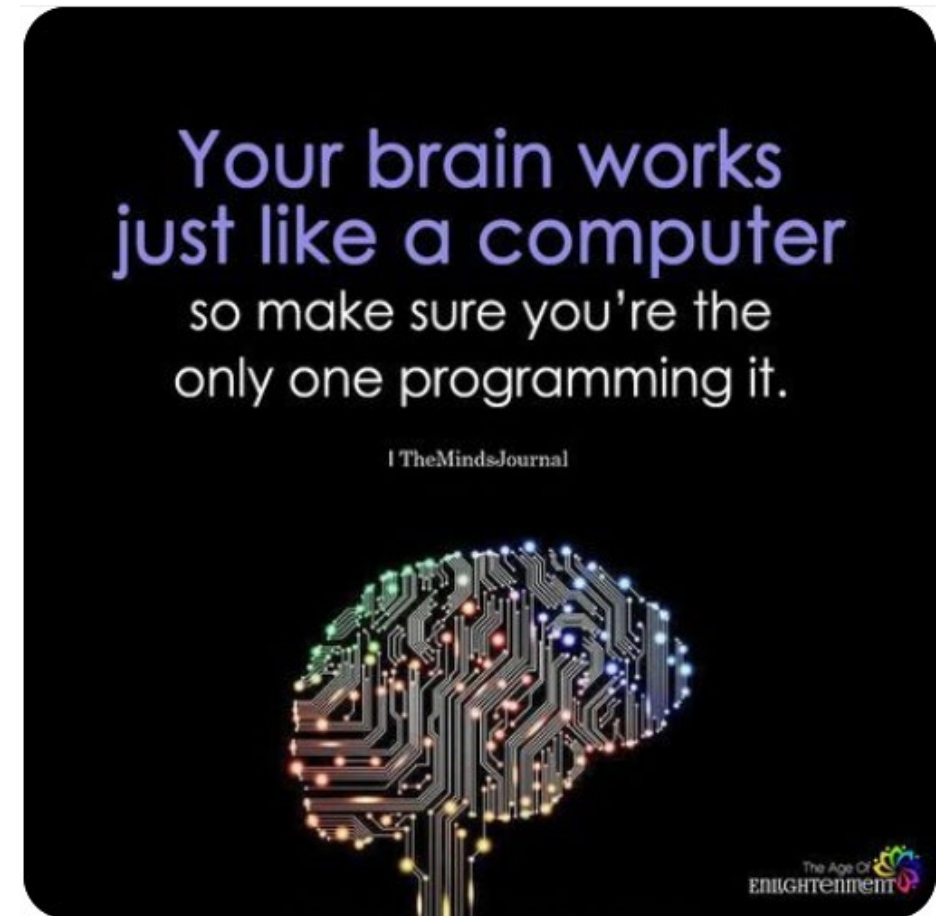
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Syllabus

- Lesson 1. Introduction: Algorithms, Data Structures and Cognitive Science.
- Lesson 2. Python Data Types and Structures.
- Lesson 3. Principles of Algorithm Design.
- Lesson 4. Lists and Pointer Structures.
- Lesson 5. Stacks and Queues.
- Lesson 6. Trees.
- Lesson 7. Hashing and Symbol Tables.
- Lesson 8. Graphs and Other Algorithms.
- Lesson 9. Searching.
- Lesson 10. Sorting. Mid-term evaluation quiz (30%)
- Lesson 11. Selection Algorithms.
- Lesson 12. String Algorithms and Techniques.
- Lesson 13. Design Techniques and Strategies.
- Lesson 14. Implementations, Applications and Tools.
- Lab (20%) + Project (50%).

Introduction

- One would say that data structures and algorithms don't have much in common with the brain, right?
- Well, that's simply not true! The brain is the main processing unit of our body, as it works pretty much like a computer does – or even more, like 100 billion mini-computers working together (source: <https://www.newscientist.com/article/2182987-your-brain-is-like-100-billion-mini-computers-all-working-together/>)



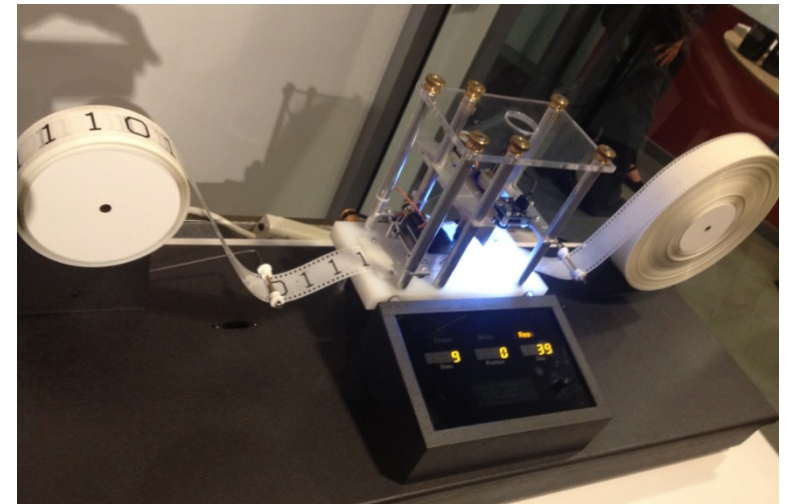
Source: <https://ro.pinterest.com/pin/787144841101524642/>

The Brain Is Like a Computer, yes

- <https://medium.com/the-spike/yes-the-brain-is-a-computer-11f630cad736>
- The Church-Turing thesis: any problem we have a means of solving using only a finite set of instructions and no insight, will turn out to be implementable by a Turing machine, thus, an algorithm is anything that a Turing machine can do.
- Turing machines are not real machines, they are abstract mathematical constructs that can operate with infinite memory and no time restrictions.
- A Turing machine is a mathematical model of computation that defines an abstract machine that manipulates symbols on a strip of tape according to a table of rules.

Turing machines

- “A Turing machine is a finite-state machine associated with a special kind of environment -- its tape -- in which it can store (and later recover) sequences of symbols” [A.M.Turing, 1937].
- Although the models were originally designed to be technically feasible, Turing machines were not intended to be practical computational technologies, but a mental experiment on the limits of mechanical computation.



Definitions

- A *data structure* is a particular way of organizing data in a computer so that it can be used effectively (<https://www.geeksforgeeks.org/data-structures/>)
- An *algorithm* is anything a Turing machine can do,
- Computable *functions* are defined as those functions that we have algorithms for,
- A *computer* is anything which physically implements algorithms in order to solve computable functions (tasks).

The macroscopic laws of physics are computable functions (a parabolic path is computable), therefore every snowflake, grain of sand, etc., can be viewed as a computer, implementing algorithms to solve the functions that describe that object's evolution through time.

Turing completeness

- Some Turing machines can be used to implement any other Turing machines – these are called *universal Turing machines*.
- A mathematical tool that can be proven to be capable of implementing an algorithm is called “Turing complete”, because it can be proven that any algorithm can be programmed with these languages.
- Thus, the computers we use every day are a much more powerful form of computer than a stone or a snowflake, which are limited to computing only the functions of physics that apply to their movement. Your laptop is an “**uber-computer**”, as it were, and therefore, arguably deserves the title “computer” much more than any other object in your house (except maybe you). (source: <https://medium.com/the-spike/yes-the-brain-is-a-computer-11f630cad736>)

Brains are also uber-computers...

- ... they just work in a different manner

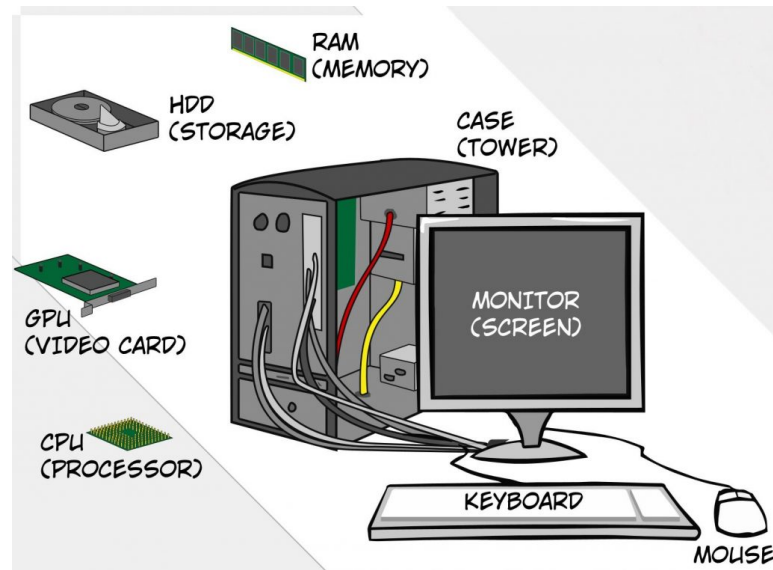


- <https://youtu.be/rjnRiEaud0Y>
- While scientists can use cognitive science to replicate intelligence in AI, eventually AI will be using cognitive science to understand humans better.

A trivial way of thinking may be:

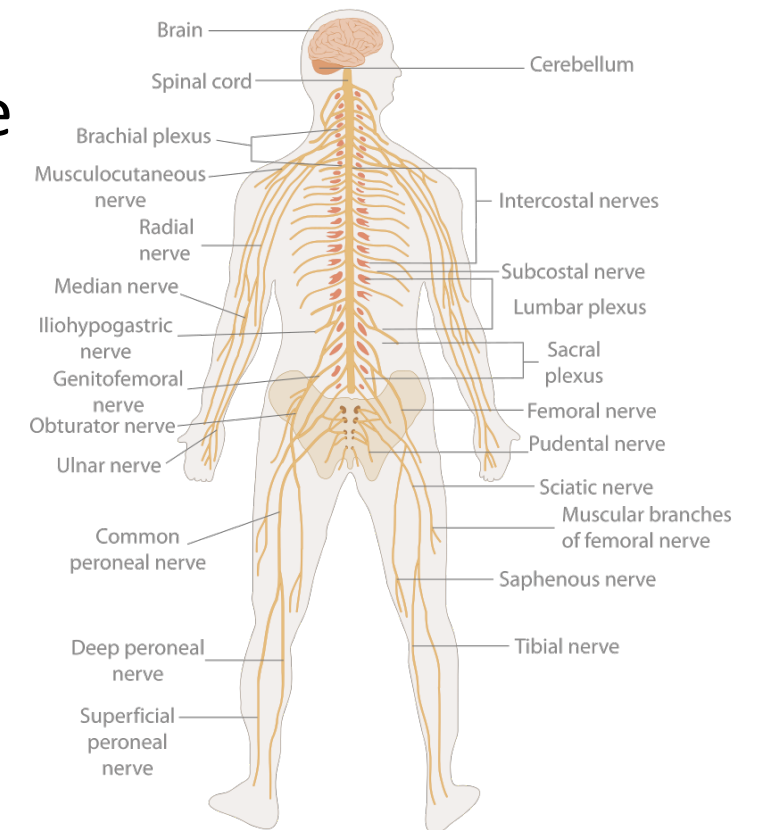
Computer

- Hardware



Human

- Hardware

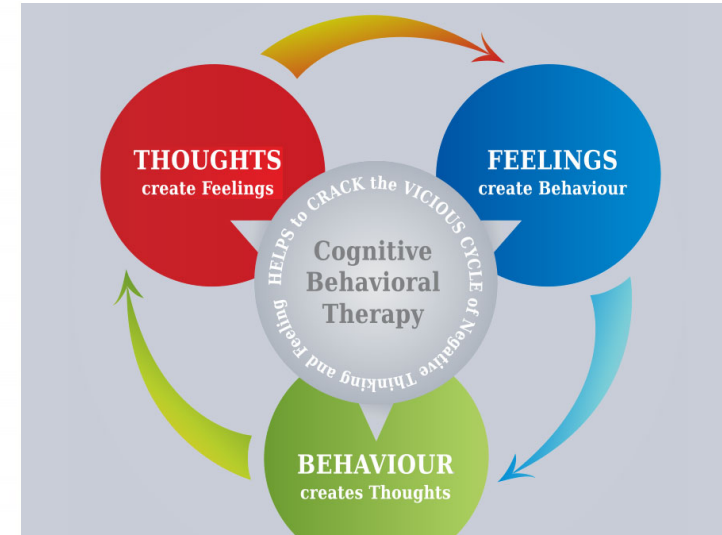


So a trivial way of thinking may be:

Computer Programming Software



Human Programming Software?



If Brains are Computers, Who Designs the Software?

Daniel Dennet: <https://youtu.be/TTFoJQSd48c>

Thank you!