CS187 - Science Gateway Seminar for CS and Math

Fall 2013 – Class 3

Sep. 10, 2013

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- Network and system administration?
- Playing video games?
- Learning to use software packages?
- Using and fixing computers?
- Computer programming and code writing? (well, yes and no).

"Computer science is no more about computers than astronomy is about telescopes" (attributed to Edsger Dijkstra, 1970) The science of computation – theory and applications.

- Theory Algorithms, data structures, complexity, computability.
- Programming languages.
- Software engineering and design.
- Hardware design, compilers, operating systems (this is actually **about computers**!).
- Application: Bioinformatics, robotics, computer vision, graphics, databases...

- What we know as modern computer science was created in the mid-20th century.
- Often computer science did not exist as an independent department/school until fairly recently (at UMB – only since 2001).
- The term "Computer" was used to describe people until the 1920's!
- Humans used mechanical devices for calculations for thousands of years.

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Early History to 17th Century – First Mechanical Devices and Theoretical Developments



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Blaise Pascal (1623–1662), first mechanical adding and subtracting device.

Gottfried Wilhelm Leibniz (1646–1716), binary system, formal binary logic, "stepped reckoner" – first mechanical device capable of performing all 4 arithmetic operations.

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Abacus, 2700–2300 BC – predating written numbers, Middle East and Asia



John Napier (1550–1617), discovery of logarithms, decimal points, "Napier bones" – a calculating instrument

19th Century – First Attempt at a "Real" Computer

- The "difference engine" a mechanical computer for tabulating polynomial functions.
- The "analytical engine" a general-purpose mechanical computer containing a logic unit, conditional branching, loops, and integrated memory.
- Punched cards provided the input.
- Designed, never fully built.



Charles Babbage (1791–1871), invented the first computer. Ada Lovelace (1815–1852), first computer programmer.



Difference engine and analytical engine

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Turing and the Birth of Modern Computer Science

- 1930's the "Church-Turing thesis" – formalization of the algorithm, the notion of computability.
- Lambda calculus (Church) a framework for defining functions.
- The Turing machine (Turing) – a theoretical framework for a computer.



Alonzo Church (1903-1995)



Alan Turing (1912-1954)

The Turing Machine

- A (hypothetical) device representing a computing machine.
- Contains an infinite tape with a (finite) set of symbols from a finite alphabet – the input.
- A read/write head that can move to the left or right.
- A (finite) set of *state*, including an initial state and a set of final states.



 A (finite) list of instructions that tells us how to move from one state to another: Given a state q_i and a symbol s_i, move to state q_j, write symbol s_j and move the head to the left or right.

- This is a very simple model... right?
- Yet, it is as powerful as any computing device... even today.
- As a matter of fact, any task can be computed (performed by any computational device following a list of instructions, just like any of today's computer programs) if and only if it can be performed by a Turing machine.
- The Universal Turing machine A Turing machine that can simulate any Turing machine on any input.
- This is the foundation of modern day computers.

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Stored-Program Computers, the Von-Neumann Architecture

- A design that does not require "reprogramming" of a computer for every new task.
- Instead, the programs and instructions can be stored inside the computer.
- Sort of like the Universal Turing Machine...
- Modern computers are still based on this architecture.



A set of instructions/procedures to solve a given problem.



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A set of instructions/procedures to solve a given problem.

Input



Algorithm

Not.

Ready

Output

Recipe CHOCOLATE CAVE 4 oz. chocolate 3 eggs 1 cup butter 1 tap varilla 2 cup sugar 1 cup flour

Melt chocolate and butter. Stir augar into matted chocolate Stir in eggs and vanila. Mic inflour. Spread mic in greazed pan. Bake at 350, for 40 minutes or until inserted fork comes out almost clean. Cool in pan before eating.

Program Code

Declare variables: chocolate eggs mix butter vanilla sugar flour

mix = methed (4*Chooolate) + butter) mix = atir (mix + (2*Suga) + vanila) mix = atir (mix + flour spread (mix) VMH = not clean (fork) balse (mix, 350)





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What's in an Algorithm

- Must be unambiguous, solve the problem and terminate.
- One starting point and (one or more) end point(s).
- Input and output (both optional).
- Control flow we follow the instructions (not necessarily in the order of their appearance) and at any stage we're at some "block".
- Conditional branching if...then... (else...).
- Loops repeat some actions for a certain number of times or until some condition is filled.



- Print "Hello, world!" on the screen.
- Given a sequence of integers in no particular order, (-2, 17, 36, 29, 100, 10), find the smallest.
- Given a sequence of integers, sort them from the smallest to the biggest.
- Given a sequence of integers, calculate their sum.

How can you relate (2) and (3)?

Use Smaller Building Blocks to Build a Larger Algorithm

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- No. It can be mathematically shown that some problems are undecidable.
- In other words There are problems for which no algorithm can be constructed that will always answer yes/no.
- This concept is related to the Incompleteness theorems, stating that there cannot be a non-trivial, self-consistent set of mathematical axioms.
- Any non-trivial axiomatic system will always contains unprovable theorems.

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Computer Science is (also) About Computers

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- Wikipedia
- Ikea catalog
- Kevin Amaral, CS department.

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