

The Beauty and Joy of Computing

Lecture #3 : Creativity & Abstraction



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LEARN LANGUAGE FREE!
Luis von Ahn's recent project is Duolingo, which is simultaneously allowing its users to learn a second language free, while also providing a cost-effective way to get documents translated on the web.

PREVENTING ADDICTION!
Researchers in the UK said that some gamers play up to 90 hrs a session, developing a "pathological" addiction. They say game makers need to do more, to get "sensible gaming"

www.duolingo.com
www.bbc.co.uk/news/uk-wales-south-east-wales-23576035

Computing is a Creative Activity


- "Creativity and computing are prominent forces in innovation; the innovations enabled by computing have had and will continue to have far-reaching impact.
- At the same time, computing facilitates exploration and the creation of knowledge.
- This course will emphasize these creative aspects of computing.



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Computing enables people...


- ...to translate intention into computational artifacts.
- A computational artifact is created by human conception using software tools.
- Examples of computational artifacts include
 - digital music, videos, images
 - documents
 - combinations of these. E.g.,
 - infographics
 - presentations
 - web pages.



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Computing enables people...


- ...to create digitally!
- **Creating...**
 - knowledge
 - tools
 - expressions of ideas
 - solutions to problems.
- **Creating digitally...**
 - requires understanding and using software tools.
 - can be done by...
 - combining and modifying existing artifacts
 - creating new artifacts.



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Collaboration is an essential part...


- ...of creating computational artifacts.
- Collaboration facilitates multiple perspectives in developing computational artifacts.
- A computational artifact can reflect collaborative intent.



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We can analyze computational artifacts...


- ...for correctness, functionality, and suitability.
- A computational artifact may have weaknesses, mistakes, or errors depending on the type of artifact.
 - For example, music created by a program may not have an error but may simply be hard to listen to.
- The functionality and suitability (or appropriateness) of a computational artifact may be related to how it is used or perceived.



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Computing extends traditional forms...


- ...of human expression and experience.
- Computer music can be created by synthesizing sounds, by sampling existing music, or by recording and manipulating sounds.
- Creating digital effects, images, and animations has impacted and transformed the movie industry.
- Computing enables creative exploration of real and synthetic phenomena.



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Programs can be developed...

- ...for creative expression or to satisfy personal curiosity.
- A program developed for creative expression or to satisfy personal curiosity may have visual, audible, or tactile results; or the program may affect a computer or system without such results.
- Programs developed for creative expression or to satisfy personal curiosity may be developed with different standards or methods than programs developed for widespread distribution.
- A program or the results of running a program may be shared with others.



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Programs can be developed...

- ...to solve problems, create new knowledge, or help people, organizations, or society.
 - however, the goals may be realized independently of the original purpose of the program.
- Computer programs and the results of running the programs have widespread impact on individuals, organizations, and society.



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Numbers: Positional Notation

- Number Base B \Rightarrow B symbols per digit:
 - Base 10 (Decimal): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
 - Base 2 (Binary): 0, 1 (In binary digits are called "bits")
 - Base 16 (Hexadecimal): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Number representation:
 - $d_{31}d_{30} \dots d_1d_0$ is a 32 digit number
 - value = $d_{31} \times B^{31} + d_{30} \times B^{30} + \dots + d_1 \times B^1 + d_0 \times B^0$
- Binary 0b11010 = $1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$
 = $16 + 8 + 2$
 = 26
- Hex 0x1A = $1 \times 16^1 + 10 \times 16^0$
 = $16 + 10$
 = 26
- One hex digit (four bits) is a "nibble". Two (eight bits) is a "byte" (values 0-255)
- N bits \Leftrightarrow at most 2^N things

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Abstraction (revisited): Numbers

- Number bases, including binary and decimal, are used for reasoning about digital data.
- Bits represent binary data using base two digits: zero and one.
- Hexadecimal, or base-16, is often used in reasoning about data such as colors in images.
- Different bases help in reasoning about digital data; digital data is stored in bits.

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Abstraction (revisited): Digital Data


- A combination of abstractions is used to represent digital data.
- At the lowest level all digital data are represented by bits.
 - Said another way, bits can represent anything!
- Bits are grouped to represent higher-level abstractions including numbers and characters.
 - Logical values? 0 \rightarrow False, 1 \rightarrow True
 - Colors? 00 \rightarrow Red, 01 \rightarrow Green, 10 \rightarrow Blue
 - Characters? 00000 \rightarrow 'a', 00001 \rightarrow 'b', ...
- Higher-level abstractions such as Internet protocol (IP) packets, images, and audio files are comprised of groups of bits that represent different parts of the abstractions.



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Binary Sequences to Represent Data

- A finite representation is used to model the infinite mathematical concept of a number.
- In many programming languages the fixed number of bits used to represent integers limits the range of integer values, and mathematical operations can result in overflow or other errors.
- In many programming languages the fixed number of bits used to represent real numbers (represented as "floating-point numbers") limits their range, and mathematical operations can result in round-off and other errors.




The image shows a screenshot of a news article from the A.M. Turing Institute. The article is titled "WILLIAM ('VELVEL') MORTON KAHAN" and discusses his contributions to computer science, particularly in the area of floating-point arithmetic. It mentions his work on the IEEE 754 standard and his book "The Art of Computer Programming".

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Interpretation of a Binary Sequence...

- ...depends on how it is used (e.g., as instruction, number, text, sound, or image).
- The sequence of bits that represents...
 - ...an instruction may also represent data processed by that instruction.
 - ...a character/letter may also represent a number.
 - ...a color in an image may also represent a sound in an audio file.

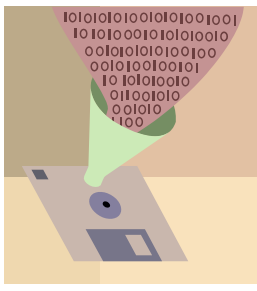


The image shows the cover of the book "being digital" by Nicholas Negroponte. The title is written in a stylized, lowercase font, and the author's name is at the bottom.

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SW and HW built on multiple abstractions!

- Software is built using low- and high-level abstractions...
 - such as expressions, statements, data types, functions, and libraries.
 - that represent hardware, such as device drivers and game controllers.
- Hardware is built using low- and high-level abstractions such as chips, memory, and storage.




The diagram shows a laptop with a green light emanating from it. Above the laptop, there is a large, stylized representation of a chip or component, with binary code (0s and 1s) floating around it. The background is a gradient of colors.

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Binary Data is processed by...

- ...physical layers of computing hardware, including gates, chips, and components.
- A logic gate is a hardware abstraction that models a Boolean function.
 - and
- A chip is an abstraction composed of low-level components and circuits that performs a specific function such as memory, CPU, encryption, and more.
- A hardware component can be low level like a transistor or high level like a video card.

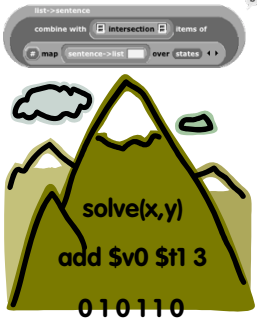


The diagram shows a laptop with a blue light emanating from it. Above the laptop, there is a large, stylized representation of a chip or component, with binary code (0s and 1s) floating around it. The background is a gradient of colors.

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Programming languages, from low to high level...

- ...are used in developing software.
- Low-level programming languages, such as assembly, are closer to the machine level and provide fewer abstractions for the programmer.
- High-level programming languages provide more abstractions for the programmer and are easier for humans to use for reading and writing code.
- Code in a high-level programming language is typically automatically translated into code in a lower-level language to be executed on a computer; this is done by a compiler or an interpreter.



The diagram shows a mountain with a green peak and a yellow base. On the mountain, there is a search bar with the text "solve(x,y)" and "add \$v0 \$f1 3". Below the mountain, there is a binary sequence "010110". Above the mountain, there is a search bar with the text "sentence->list" and "items of".

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Abstractions everywhere!

- Applications and systems are designed, developed, and analyzed using levels of hardware, software, and conceptual abstractions.
 - E.g., Mobile applications and systems
 - E.g., Web services (both an application and a system)



The image shows a woman with long blonde hair, smiling and looking at her smartphone. She is wearing a white top.

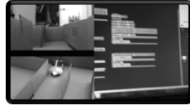
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Summary

▪ Creativity

- You will create interesting and relevant artifacts with the tools and techniques of computer science.



▪ Abstraction

- This course will include examples of abstractions used in modeling the world, managing complexity, and communicating with people as well as with machines.
- You will learn to work with multiple levels of abstraction while engaging with computational problems and systems.

