The Beauty and Joy of Computing

Lecture #2 : Functions

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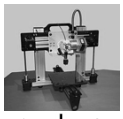


3D PRINTING… WOW!

Cheap 3D Printers are making it possible for designers, tinkerers, students, etc. to render their designs in physical space. It's reduced the design-test-debug cycle time by a hundred fold!

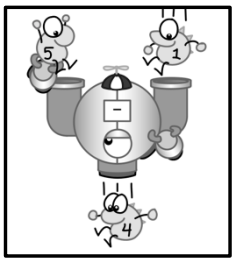
3D PRINTING… IP?!

Have they considered how much work it is to design a 3D model? The current technology "gives" it all away when sent to another to print. If I sell it to you, you get my intellectual property!

www.technologyreview.com/news/518591/copy-protection-for-3-d-printing-aims-to-prevent-a-piracy-plague/

Function basics

- **Functions take in 0 or more inputs and return exactly 1 output**
- **The same inputs MUST yield same outputs.**
  - Output function of input only
- **Other rules of functions**
  - No state (prior history)
  - No mutation (no variables get modified)
  - No side effects (nothing else happens)



CS Illustrated function metaphor

Which is NOT a function?

a) pick random ▢ to ▢

b) ▢ < ▢

c) length of ▢

d) sqrt of ▢

e) true

More Terminology (from Math)

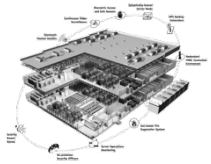
- **Domain**
  - The "class" of input a function accepts
- **Examples**
  - Sqrt of
    - Positive numbers
  - Length of
    - Sentence, word, number
  - _ < _
    - Both: Sentence, word, number
  - _ and _
    - Booleans
  - Letter _ of _
    - Number from 1 to input length
    - Sentence, word, number
- **Range**
  - All the possible return values of a function
- **Examples**
  - Sqrt of
    - Non-negative numbers
  - Length of
    - Non-negative integer
  - _ < _
    - Boolean (true or false)
  - _ and _
    - Boolean (true or false)
  - Letter _ of _
    - Letter

Types of input (there are more)

Sentences	• Words separated by N spaces, N ≥ 0 • E.g., CS 10 is great
Word	• Length ≥ 1, no spaces • Cal, 42, CS10
Character	• Length = 1 • E.g., A, 3, #
Digit	• 0-9 only • E.g., 7

Why functions are great!

- **If a function only depends on the information it gets as input, then nothing else can affect the output.**
  - It can run on any computer and get the same answer.
- **This makes it incredibly easy to parallelize functions.**
  - Functional programming is a great model for writing software that runs on multiple systems at the same time.

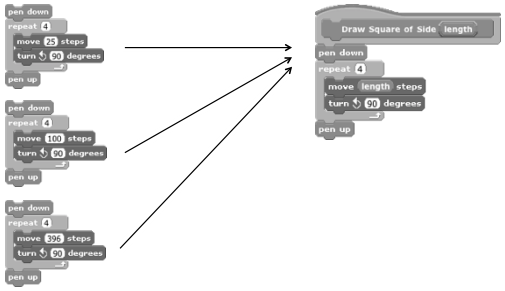


Datacenter

Scratch → BYOB (Build Your Own Blocks)

- **Scratch**
  - Invented @ MIT
  - Maintained by MIT
  - Huge community
  - Sharing via Website
  - No functions ☹
  - Scratch 2.0 in Flash
    - No iOS devices. ☹
  - scratch.mit.edu
- **BYOB (and *SNAP!*)**
  - Based on Scratch code
  - Maintained by jens & Cal
  - Growing community
  - No sharing (yet) ☹
  - Functions! ☺ … "Blocks"
  - Snap! Is in HTML5
    - All devices ☺
  - snap.berkeley.edu/run

Why use functions? (1)



The power of generalization!

Why use functions? (2)

They can be composed together to make even more magnificent things.

They are literally the building blocks of almost everything that we create when we program.

We call the process of breaking big problems down into smaller tasks functional decomposition

Types of Blocks

- **Command**
  - No outputs, meant for side-effects
  - Not a function…

- **Reporter (Function)**
  - Any type of output

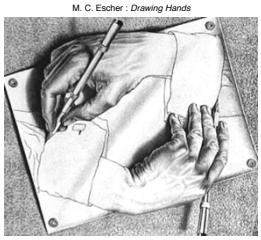
- **Predicate (Function)**
  - Boolean output
    - (true or false)

Quick Preview: Recursion

Recursion is a technique for defining functions that use themselves to complete their own definition.

We will spend a lot of time on this.

M. C. Escher : *Drawing Hands*



Functions Summary

en.wikipedia.org/wiki/Functional_programming

- **Computation is the evaluation of functions**
  - Plugging pipes together
  - Each pipe, or function, has exactly 1 output
  - Functions can be input!
- **Features**
  - No state
    - E.g., variable assignments
  - No mutation
    - E.g., changing variable values
  - No side effects
- **Need BYOB/Snap!, and not Scratch 1.x**

$$f(x) = (x+3) * \sqrt{x}$$