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The Beauty and Joy of Computing

Lecture #4 : Functions

Quest (first exam) in **in 14 days!!**

THE FUTURE OF VIDEO GAMES?

Valve (video game makers of Half-Life) believes the future of video games may not be in the *input* device (ala the Wii remotes or your body ala Kinect), but the output device! What is shown on the right is an *augmented reality* device, layering 3D content onto the real world.

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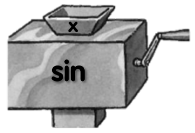
http://www.nytimes.com/2012/09/09/technology/
valve-a-video-game-maker-with-few-rules.html
```

Generalization (in CS10) REVIEW

- **You are going to learn to write functions, like in math class:**

  y = sin(x)

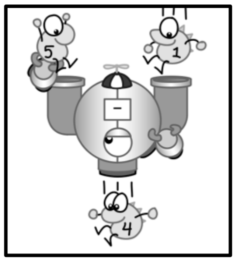
  - sin is the function
  - x is the input
  - It returns a single value, a number



"Function machine" from *Simply Scheme* (Harvey)

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

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

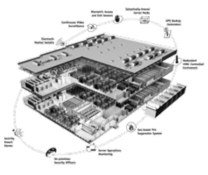
- **Range**
  - All the possible return values of a function
- **Examples**
  - Sqrt of
    - Non-negative numbers
  - Length of
    - Non-negative integer
  - _ < _
    - Boolean (true or false)
  - _ and _
    - Boolean (true or false)
  - Letter _ of _
    - Letter

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 (to be "SNAP!")**
  - Based on Scratch code
  - Maintained by jens & Cal
  - Growing community
  - No sharing (yet) ☹
  - Functions! ☺ … "Blocks"
  - BYOB 4.0 in HTML5
    - All devices ☺
  - byob.berkeley.edu

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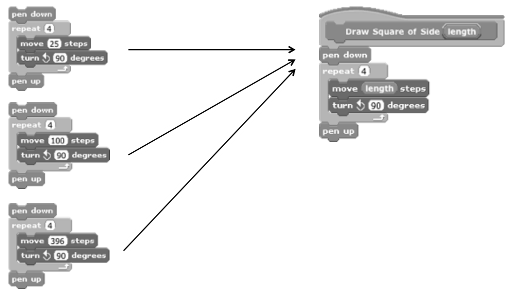
Why use functions? (1)



```
pen down
repeat 4
  move 25 steps
  turn ↻ 90 degrees
pen up

pen down
repeat 4
  move 100 steps
  turn ↻ 90 degrees
pen up

pen down
repeat 4
  move 396 steps
  turn ↻ 90 degrees
pen up
```

```
Draw Square of Side (length)
pen down
repeat 4
  move (length) steps
  turn ↻ 90 degrees
pen up
```

The power of generalization!

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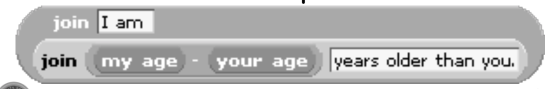
Why use functions? (2)

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



```
join [I am] (join ((my age) - (your age)) [years older than you.])
```

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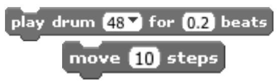
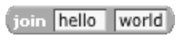
Types of Blocks

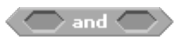
- **Command**
  - No outputs, meant for side-effects
  - Not a function…
- **Reporter (Function)**
  - Any type of output
- **Predicate (Function)**
  - Boolean output
    - (true or false)



```
play drum (48 ▾) for (0.2) beats
move (10) steps
```



```
join [hello] [world]
```



```
< < > and < > >
```

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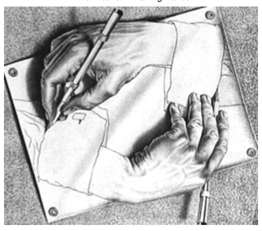
Quick Preview: Recursion

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*



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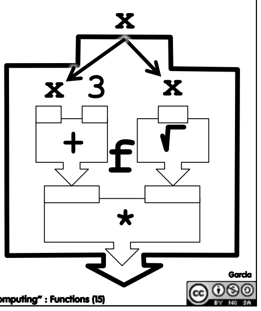
en.wikipedia.org/wiki/Functional_programming

Functional Programming Summary

- **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 not Scratch**

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



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