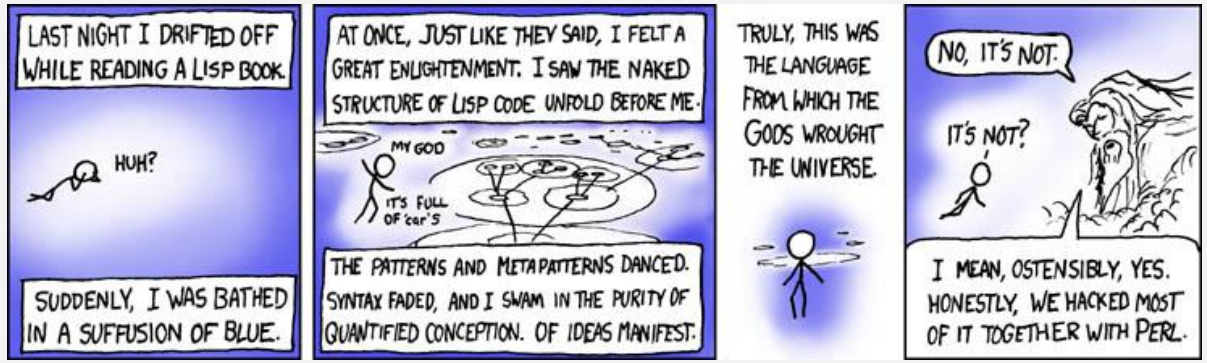
CS450 (section 2)

High Level Languages

UMass Boston Computer Science

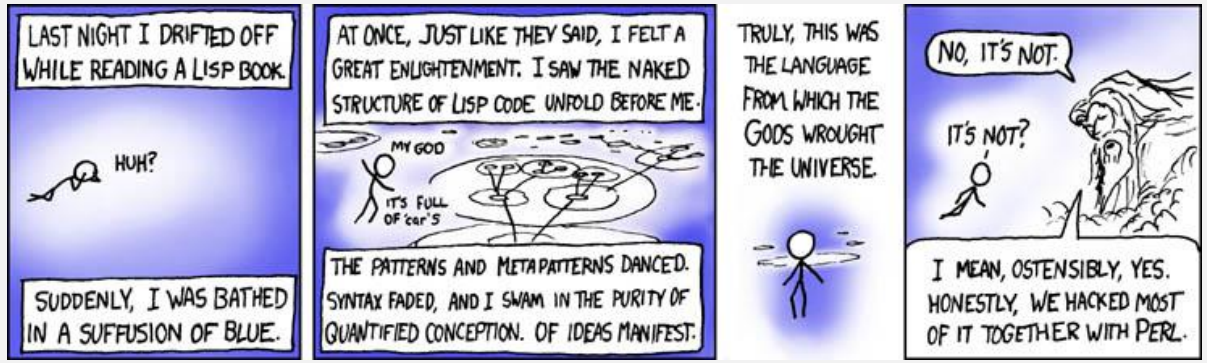
Tuesday, February 4, 2025



Logistics

- HW 0 in
  - ~~Due: Tue 2/4 11am EST~~
- HW 1 out
  - Due: Tue 2/11 11am EST
- Course web site:
  - Style: see “Racket Basics and Style”

`https://www.cs.umb.edu/~stchang/cs450/s25`



Last Week

Statements vs Expressions

Most other courses

Imperative programs are:
… sequences of (“low level”) **statements** / instructions
(C, Java, Python)

This course

Declarative programs are:
… (“high level”) **declarative expressions**, i.e., “arithmetic”
(Racket)

```
int add_one ( int x ) {
  return x + 1;
}
```

```
(define (add-one x)
  (+ x 1))
```

Last Week

Arithmetic … More Th

This position must be an (arithmetic expression that evaluates to a) **function value**

- Function call: **prefix notation** (fn name first)
  - **Easier to write multi-arity functions**

```
(+ 1 2 3 4)
```

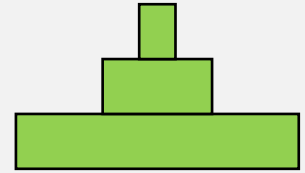
- (fundamental) programming model: **arithmetic** expressions
  - But **not just numbers!**
  - When **"run", arithmetic expressions evaluate** to an **answer** or **value**

```
(string-append "hi" "world")
```

➡ "hi-world"

```
(above                    )
```

➡



Programs Need Input

e.g., **students**

```
class Student {
  int ID;
  int year;
  string address;
  … }
```

Real World

"convert" into "data"

Input:
- Keyboard
- Mouse
- Gamepad
- Touchscreen
- Voice
- File

Program

Do a "real world" task

"run" (**evaluate**)

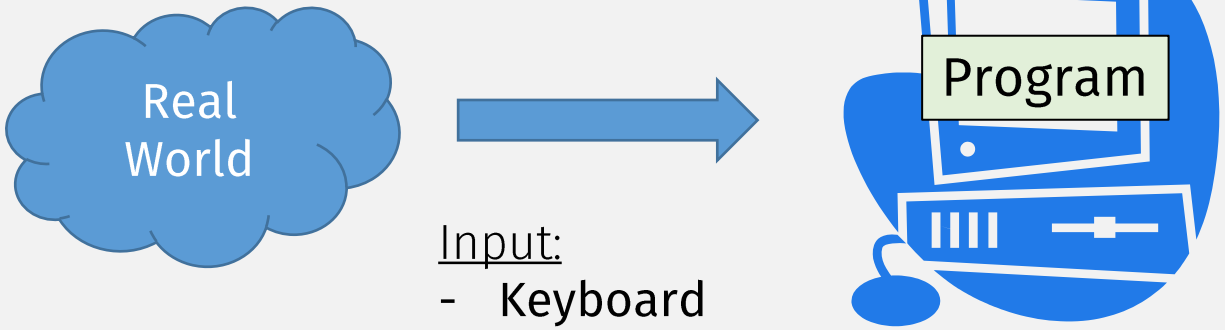
"answer", e.g., 42

Program vs Real World

Real World "things" ...

e.g., Temperature

... need a **data representation** in the program



Input:
- Keyboard
- Mouse

A **Data Definition** name

Specify possible values of the data

```
;; A TempC is an Integer
;; Interpretation: It represents a
temperature in degrees Celsius
```

Interpretation ... connects data to a real world concept

```
;; A TempF is an Integer
;; Interp: It represents a
temperature in degrees Fahrenheit
```

```
;; A TempK is an non-negative Integer
;; Interp: It represents a
temperature in degrees Kelvin
```

When programming,
choosing data representations must be the first task!
(way before writing any **code** ...
which **processes the data**)

Data Design Recipe

(Steps to follow)

A **Data Definition** name

Specify possible values of the data

```
;; A TempC is an Integer
;; Interpretation: It represents a
temperature in degrees Celsius
```

Interpretation … connects data to a real world concept

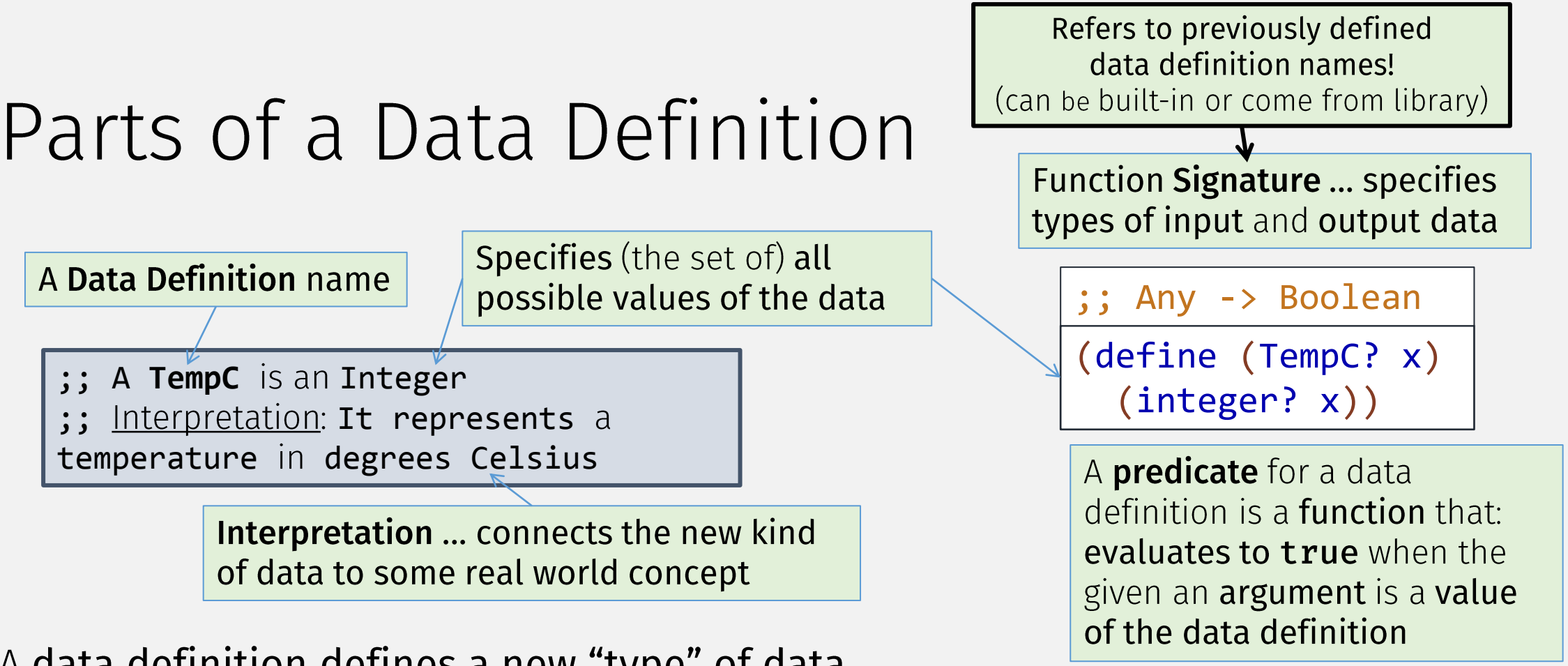
A **predicate** for a data definition is a **function** that: **evaluates to `true`** when the given an **argument** is a **value of the data definition**

```
(define (TempC? x)
  (integer? x))
```

- A **Data Definition** represents a **real world concept**
- It is what a **program's code computes "on"**
- It has the following components
  1. **Name**
  2. **Set of values specification** (using other data definitions)
  3. **Interpretation** that **explains** the **connection to the real world**
  4. **Predicate - code version** of **Set of Values** (step 2)

     A **predicate** is a **function** that **evaluates to `true`/`false`**

Parts of a Data Definition



A data definition defines a new "type" of data

- Different languages have different mechanisms to define new types of data:
  - `typedef`
  - `class`
  - `enum`
  - `struct`
- In this course, we use a combination of comments + code

Design Recipe(s)

(Steps to follow when writing a program)

- Data Design
- Function Design

Designing Functions

```
;; A TempC is an Integer
;; Interp: represents a temp in degrees Celsius
;; A TempF is an Integer
;; Interp: represents a temp in degrees Fahrenheit
```

1. Name
2. Signature
   - # of arguments and their data type
   - Output type
   - May only reference “defined” Data Definition names
3. Description

```
;; c2f: TempC -> TempF
;; Converts a Celsius temperature to Fahrenheit
```

Designing Functions

1. Name
2. Signature
   - # of arguments and their data type
   - Output type
   - May only reference "defined" Data Definition names
3. **Description** – shows how fn works, in English
4. **Examples** – shows how fn works, in code
5. Code
6. Tests

```
;; c2f: TempC -> TempF
;; Converts a Celsius temperature to Fahrenheit
```

```
; (c2f 0) => 32
; (c2f 100) => 212
; (c2f -40) => -40
```

```
(define (c2f ctemp)
  (+ (* ctemp (/ 9 5)) 32))
```

```
(check-equal? (c2f 1) (+ (/ 9 5) 32))
```

From testing framework (stay tuned!)

Designing Functions

```
;; A TempC is an Integer
;; Interp: represents a temp in degrees Celsius
;; A TempF is an Intege Rational
;; Interp: represents a temp in degrees Fahrenheit
```

1. Name
2. Signature
   - # of arguments and their data type
   - Output type
   - May only reference "defined" Data Definition names
3. **Description** – shows how fn works, in English
4. **Examples** – shows how fn works, in code
5. Code
6. Tests

```
;; c2f: TempC -> TempF
;; Converts a Celsius temperature to Fahrenheit
```

```
(define (c2f ctemp)
  (+ (* ctemp (/ 9 5)) 32))
```

```
(check-equal? (c2f 1) (+ (/ 9 5) 32))
```

Something is wrong!
- in Code?
- in Signature?
- in Data Definition?

Design Recipe(s)

(Steps to follow when writing a program)

- Data Design
- Function Design

Programming is an **iterative** process!

Iterative Programming

Other functions (“wish list”)

1. Name
2. Signature
   - # of arguments and their data type
   - Output type
   - May only reference “defined” Data Definition names
3. Description
4. Examples
5. Code
6. Tests

Programming is an **iterative** process!

Danger, Danger

This is not a license to “hack”

i.e., continually changing code, praying it will somehow “work”

Instead, **program incrementally**

Incremental Programming Pledge

At all times, all of the following should be **`true`** of your code:

1. Comments (**data defs, signatures**, etc) **match code**
2. Code has no syntax errors
    1. E.g., **missing / extra parens**
3. Runs **without runtime errors / exceptions**
    1. E.g., **use undefined variables, `div by zero`, call a "non function"**
4. All tests pass

When you **make a code edit** that **renders one of the above `false`, STOP …**

… and **don't do anything else** until **all the statements are true again.**

(this way, it's easy to revert back to a "working" program)

Incremental Programming, in Action

1. Name
2. Signature
   - # of arguments and their data type
   - Output type
   - May only reference “defined” Data Definition names
3. Description
4. Examples
5. Code
6. Tests

```
;; c2f: TempC -> TempF
;; Converts a Celsius temperature to Fahrenheit
```

2. Start with “placeholder” code
(do not submit this!)

```
(define (c2f ctemp)
  (case
   [(0) 32]
   [(100) 212]
   [(-40) -40]))
```

1. Make Examples runnable tests

```
; (c2f 0) => 32
; (c2f 100) => 212
; (c2f -40) => -40
```



```
(check-equal? (c2f 0) 32)
(check-equal? (c2f 100) 212)
(check-equal? (c2f -40) -40)
```

Incremental Programming, in Action

1. Name
2. Signature
   - # of arguments and their data type
   - Output type
   - May only reference “defined” Data Definition names
3. Description
4. Examples
5. Code
6. Tests

```
;; c2f: TempC -> TempF
;; Converts a Celsius temperature to Fahrenheit
```

1. Make Examples runnable tests

2. Start with “placeholder” code

3. Make small changes only (something easy to revert)

```
(define (c2f ctemp)
  (+ (* ctemp (/ 9 5)) 32))
```

4. Test each (small) **change** (before making another one)

Incremental Programming Tips Summary

1. Make Examples runnable tests
2. Start with “placeholder” code
3. Make small changes only → Write small functions!
4. Test each (small) change, before making another one

In this course, **all conditions** of the **Increment Programming Pledge** must be true at all times!

Conventional Wisdom: Write Small Functions

Write Short Functions

Google C++ Style Guide

Prefer small and focused functions.

We recognize that long functions are sometimes appropriate, so no hard limit is placed on functions length. If a function exceeds about 40 lines, think about whether it can be broken up without harming the structure of the program.

Even if your long function works perfectly now, someone modifying it in a few months may add new behavior. This could result in bugs that are hard to find. Keeping your functions short and simple makes it easier for other people to read and modify your code. Small functions are also easier to test.

You could find long and complicated functions when working with some code. Do not be intimidated by modifying existing code: if working with such a function proves to be difficult, you find that errors are hard to debug, or you want to use a piece of it in several different contexts, consider breaking up the function into smaller and more manageable pieces.

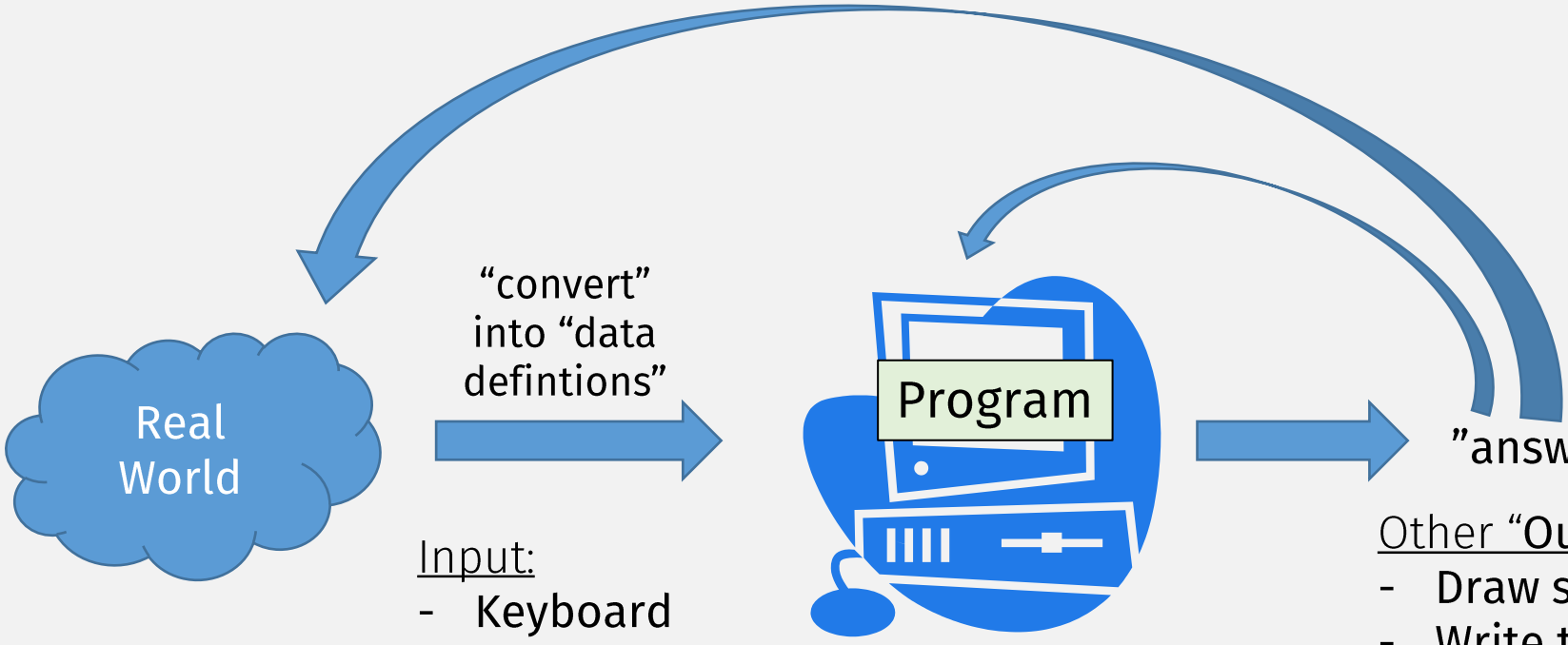
Small Functions Considered Awesome

Josh Saint Jacque · Follow
11 min read · Aug 22, 2017

Good rule of thumb:
A **function** should do **one, easily explainable task**

Programs can be Interactive

More fun to write and use!



Input:

- Keyboard
- Mouse
- Gamepad
- Touchscreen
- Voice
- File

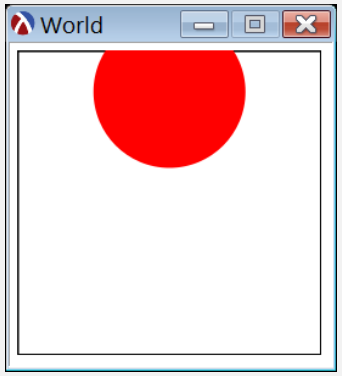
Other "**Output**" (**side effect**):

- Draw screen
- Write to file
- Play sound
- Change real world (unlock door)
- Changed computer state (game)

Interactive Programs (with **big-bang**)

```
(require 2htdp/universe)
```

- DEMO



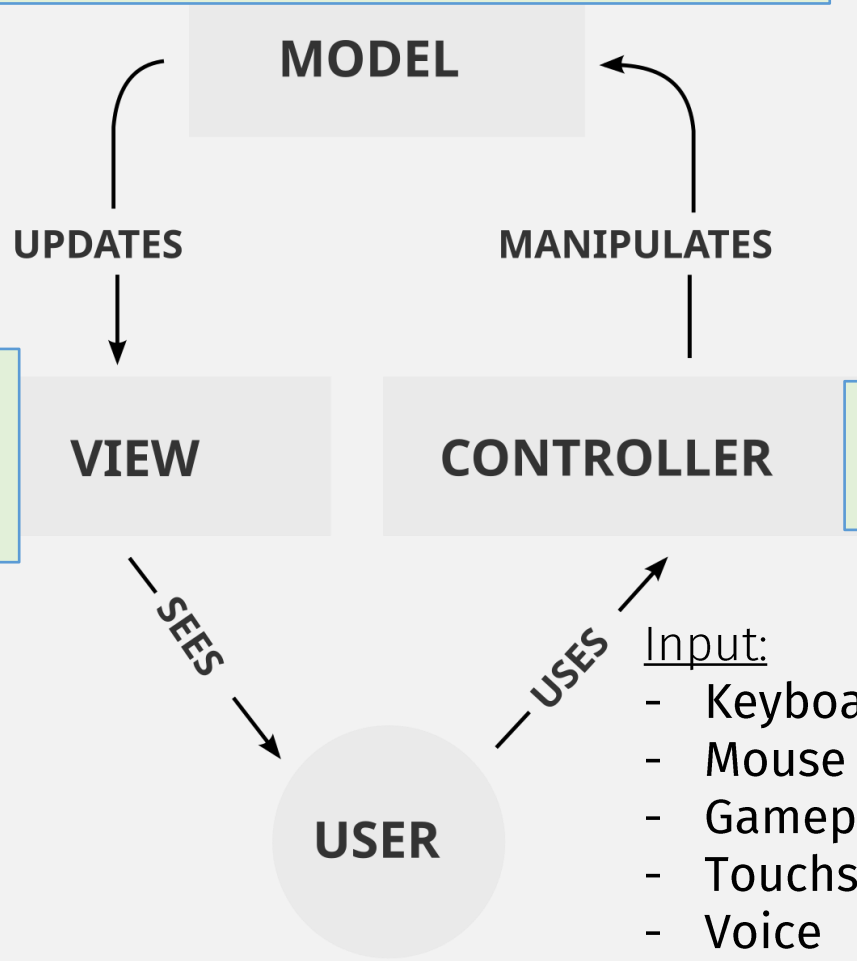
Interactive Programs (with **`big-bang`**)

```
(require 2htdp/universe)
```

- **`big-bang` starts an** (MVC-like) **interactive loop**

Model-View-Controller (MVC) Pattern

"world state" **data definition!**



Function that "converts" world state data ... into an **image**

Functions that "update" world state data

Input:
- Keyboard
- Mouse
- Gamepad
- Touchscreen
- Voice
- File

from: `wikipedia.org`

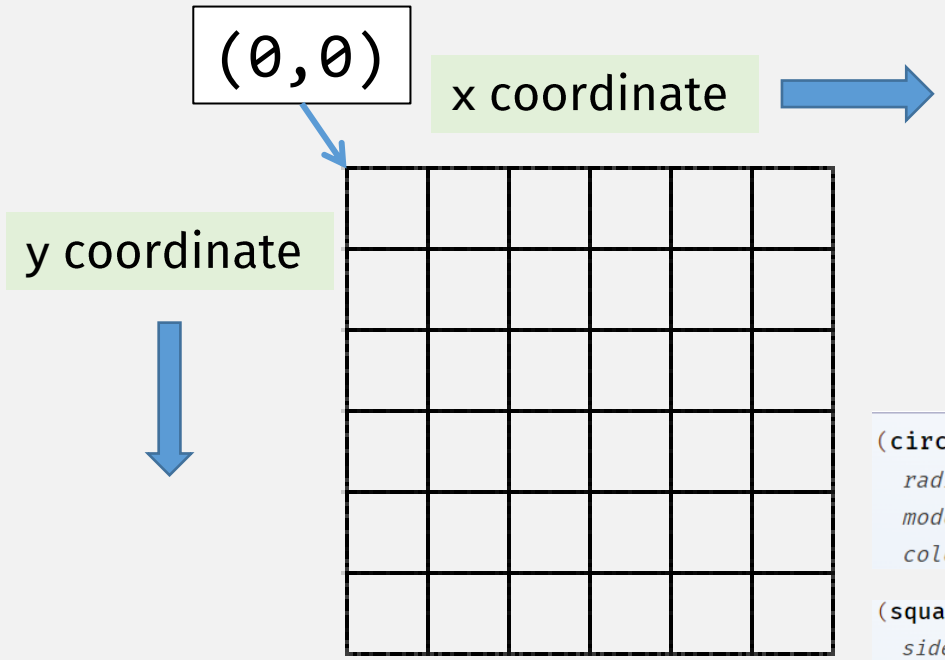
Interactive Programs (with **`big-bang`**)

```
(require 2htdp/universe)
```

- **`big-bang`** starts an (MVC-like) **interactive loop**
  - repeatedly updates a "world state"
  - Programmer must define what the "World" is …
  - … with a **Data Definition!**

```
;; A WorldState is a non-negative integer
;; Interp: represents y coordinate of a
circle center, in a big-bang animation
```

Interlude: htdp universe coordinates




```
(place-image image x y scene) → image?                    procedure
  image : image?
  x : real?
  y : real?
  scene : image?
```

Places *image* onto *scene* with its center at the coordinates (*x*,*y*) and crops the resulting image so that it has the same size as *scene*. The coordinates are relative to the top-left of *scene*.

```
(circle radius mode color) → image?
  radius : (and/c real? (not/c negative?))
  mode : mode?
  color : image-color?

(square side-len mode color) → image?
  side-len : (and/c real? (not/c negative?))
  mode : mode?
  color : image-color?
```

```
(place-image
 (circle 10 "solid" "red")
 0 0
 (square 40 "solid" "yellow"))
```

???

1 

2 

3 

4 

Interactive Programs (with `big-bang`)

```
(require 2htdp/universe)
```

- `big-bang` starts an (MVC-like) interactive loop
  - repeatedly updates a "world state"
  - Programmer must define what the "World" is …
  - … with a Data Definition!

```
;; A WorldState is a non-negative integer
;; Interp: represents y coordinate of a
circle center, in a big-bang animation
```

Next time

- Programmers specify "handler" functions to manipulate "World"
  - Render
  - World update
  - Input handlers