Lisp
Functional Programming

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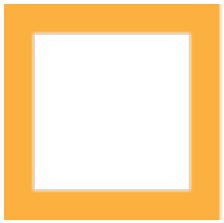

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Spring 2017

Outline

Lambda calculus

Lisp syntax
- Exercises 1

Higher order functions

Lisp syntax
- Exercises 2

Map and flat map
- Hand-in

Application as data

A computer is a thing that follows an algorithm = computation.

Application as data

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What can be computed?

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If we can treat functions as memory, they simply become data

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$f(5) = y \mapsto y^2 + 25$

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Higher order function 1/2

A function that either:

- Takes a function as an argument
- Returns a function as its result

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First part: Returning a function

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$$x \mapsto (y \mapsto x + y)$$

Lisp syntax

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Boolean	`T` and `nil`

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	`(body))`	`(let ((a 10)) a)`

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	`(body))`	`(let ((a 10)) a)`
Functions	`(defun name`	
	`(arguments) body)`	`(defun sum (a b) (+ a b))`
Lambda	`(lambda (arguments)`	
	`body)`	
		`(lambda (a b) (+ a b))`

Lisp syntax: Lambda

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Lambdas are simply just functions without a name

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To avoid confusing them with normal functions, use `funcall` to call them

```
(funcall (lambda a (+ a 2)) 5)
```

Lisp exercises

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Clone the `lisp-exercises` from `cphbus-functional-programming`

`https://github.com/cphbus-functional-programming/lisp-exercises`

Work on the `lambda.lisp` file

Imperative programming

- Series of instructions

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- Variables in memory

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- Series of instructions
- Variables in memory = global state

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Imperative programming

- Series of instructions
- Variables in memory = global state
- Seen in a CPU
- Interacts with side-effects

Side effects

State = The values in your memory

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Mutability = Changing state

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Side effects = Behaviour outside scope

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Mutability + **Concurrency** =

Side effects

State = The values in your memory

Mutability = Changing state

Side effects = Behaviour outside scope

Mutability + **Concurrency** = Disaster

Mathematical functions does not have

- State

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Functional programming

Mathematical functions does not have

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Data is changed using $\mapsto$ - immutably

Functional programming

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Immutability + concurrency =

Mathematical functions does not have

- State
- Side effects

Data is changed using $\mapsto$ - immutably

Immutability + **concurrency** = World domination

Higher order functions 2/2

Part two: Taking functions as input

Higher order functions 2/2

Part two: Taking functions as input

Where could this be useful?

```
interface DoSomething {
  void something(int i) { ...}
  }
```

Higher order functions in Java

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```
interface DoSomething {
  void something(Int i);
}
```

Higher order functions in Java

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```
interface DoSomething {
  void something(Int i);
}

interface List<T> {
  ...
  void foreach(DoSomething function)
  ...
}
```

Lisp syntax

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Lisp exercises

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Work on the `function.lisp` file

Map and flat map

What was common about the exercises?

Mapping from one side to the other.

$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix} \tag{1}$$

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$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 5 \\ 6 \\ 7 \end{bmatrix} \tag{2}$$

Flattening

Flattens a two dimensional list into one dimension

Flat map

Flattens a two dimensional list into one dimension, and uses `map` on the output

Hand-in

Clone the `lisp-exercises` from `cphbus-functional-programming`

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Work on the hand-in in the `flatmap.lisp` file.

- Implement a `map` function
- Implement a `flatten` function
- Implement a `flatmap` function