CS-205: Welcome (to functional programming)

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30/09/24

Who?

Cécilia Pradic (she/her)

- Lecturer
- Theory group
- Research: proof/automata theory, ...
- `c.pradic@swansea.ac.uk`
- Office: CoFo 410

Monika Seisenberger (she/her)

- Associate Professor, deputy HoD
- Theory group (head of the)
- Research: formal methods, XAI,...
- `m.seisenberger@swansea.ac.uk`
- Office: CoFo 405

What?

Functional programming

- Haskell
- Lectures by Cécilia
- Weeks 1-5

Logic programming

- Prolog
- Lectures by Monika
- Weeks 6-10

Why?

- Get some more programming experience
- Explore new programming **features** and **styles**
  - higher-order functions, algebraic datatypes, recursion, ...
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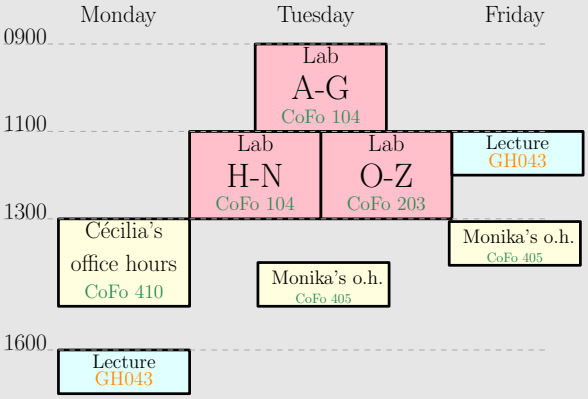
  (interesting exercises: write algorithms seen in CS-270?)

How?



- $2 \times$ 1h lecture weekly
- 2h of labs
- which lab session do I go to?
  $\rightarrow$ first letter of (whatever canvas thinks is) your surname
- $\exists$ computers but **do feel free to bring your own**
- up-to-date info on canvas

Lab rules

- Don't cheat/share solutions
- Not homework, doable within two hours (except maybe challenge tasks)
- Sign-off at the end of session/beginning of the next
- Half-marks afterwards unless an EC/exemption
  (you can request for up to 2 labs being exempted if ill)
  (slack to deal with illness/unavailability of TAs)
- Drop me an email if you **need** to change session
  (and preferrably arrange to swap with someone)

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- Computer science advisory sessions

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15% Labs

- 85%: sign-off of non-challenge lab tasks
- 15%: further engagement with the module

(e.g. signing-off the challenge lab tasks, excellent coursework, ...)

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- Probably individual, on autograder

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70% Pen-and-paper exam in January

- **Significant coding portion**
- Some questions about the implementation of Haskell/Prolog

Learning resources for Haskell

`https://wiki.haskell.org/Learning_Haskell`

- Textbook for the module: Programming in Haskell by Graham Hutton
- Thanks to him for letting us use and modify his slides!
- `https://www.cs.nott.ac.uk/~pszgmh`

That's all for the admin!

Pressing questions of general interest?

Next: finally some Haskell/functional programming

Let us get to know Haskell

Strong recommendation

Install Haskell on your own machine!

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- You will have IDE support! (and all other obvious benefits!)
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To follow along right now (if you have it already installed)

Launch `ghci`

Demo time!

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- more complex function composition
  - `drop 2 [1..5] ++ reverse [4,13]`
  - `fromIntegral (10 / 3)`
- checking and inferring types `(77 :: Int)^77`

(Spooky. Try not to be distressed)

(But worth saying, everything is secretly statically typed)

Still demo time!

Our first function definition!

```
sumOfInverses :: Float -> Float -> Float -- type declaration
sumOfInverses x y = 1 / x + 1 / y        -- function declaration
```

Let me explain, show how to load it and play with it

The same function in Java

```
public static float sumOfInverses(float x, float y)
{
  return 1/x + 1/y;
}
```

Now, for an advanced example

```
aFunction [] = []
aFunction (x : xs) = aFunction pre ++ x : aFunction post
             where pre  = filter (> x) xs
                   post = filter (<= x) xs
```

Can you guess what is the value of `aFunction [2,5,4,3,7]`?

First lab: to get started!

- You will familiarize yourselves with the interpreter
- You will write a few functions yourselves
- You will familiarize yourselves with basic list and arithmetic functions

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To look up documentation

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End of demo! Questions?

So what's a functional programming language (PL)?

Vibes[1] surrounding certain PL features such as

- algebraic datatypes
- parametric polymorphism
- anonymous **higher-order functions**
- implicit memory management
- static type inference
- type classes

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- you can find some of these among "dysfunctional" PLs
- complicated socio-technical history
- but Haskell has all of these features

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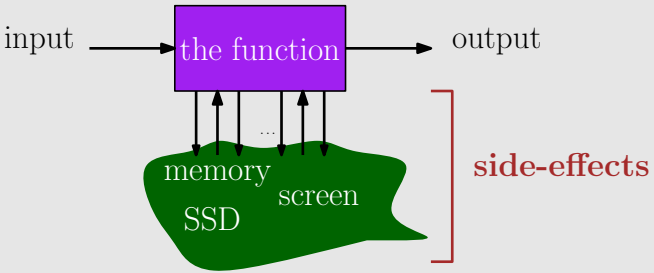
Haskell: a different point of view on functions

Peculiarity of Haskell

No way to do **side-effects**



Examples of side-effects:

- Reading/writing a file
- Printing to the screen
- Changing a value in memory

⇒ **no mutable variables, no loops!**

Example of a side effect in Java

```
static public void sumSuffixes(int[] arr)
{
  for(int i = arr.length-2; i >= 0; --i)
    arr[i] += arr[i+1];
}
```

- A single return value
- Operation: alter the global memory (depending on arguments)
- An auxiliary mutable variable `i`

Functions in Haskell

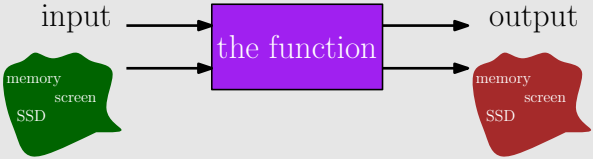
- Closer to mathematical functions
- Constrain the programming style in interesting ways

  (easier to reason about code)
- No loss of expressiveness: recursion instead of loops

But using side-effects is possible!

It is even necessary sometimes (people do want to write files)

The Haskell way: treat "real world states" as data to pass around



- ∃ *very* nice abstractions to deal with that
- so all is well

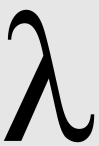
Some modern functional PLs

Legacy from three big academic traditions

ML

Haskell

LISP dialects



- Different set of features/design philosphies
- Big inspiration for new features in more mainstream languages
- Influenced greatly the design of
  - Rust
  - depedently typed languages/proofs assistants

Some examples of big Haskell projects

Some that were somehow relevant to me

- Pandoc - “a universal document converter”
- xmonad - a tiling windows manager (similar to the one I am using right now)
- hakyll - a static blog generator

More at `https://wiki.haskell.org/Applications_and_libraries`