Introduction to Haskell & some category theory

Wellington Functional Programming

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Introduction

Haskell is strange ?

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A functional programming language

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With lazy evaluation

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Pure, with no side effects

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Fairly old

Haskell is strange ?

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Pure, with no side effects

Fairly old, fairly odd

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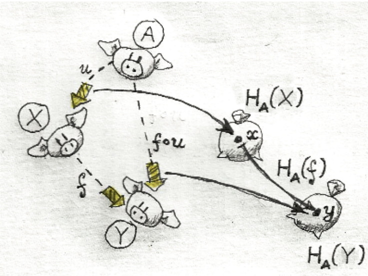
Huh ?



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Is Haskell impractical ?

- Hackage has thousands of libraries
- Haskell is fast, and getting faster

To learn Haskell,
it helps to learn a little category theory.

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Actually, I reckon you already know category theory!

Anatomy of a function

```python
def capitalise(name):
    f = name[0].upper()
    r = name[1:].lower()
    return f+r
```

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this is a function

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this is a function

```
def capitalise(name):   from text
    f = name[0].upper()
    r = name[1:].lower()
    return f+r
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```python
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from text

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def capitalise(name):
    f = name[0].upper()
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noise

to text

```haskell
capitalise :: String -> String
capitalise [] = []
capitalise (a:as)
  = (toUpper a : map toLower as)
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no noise now !

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A little category theory

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Between two objects, there are **arrows**.

There are some rules, more on that later.

Programming involves defining arrows.

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Writing functions in a programming language involves defining arrows between data types.

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Writing functions in a programming language involves defining arrows between data types.

Haskell emphasises category theory aspect of programming.

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A category defines some kind of objects, and the way we can transform these objects into each other. It is a very general concept, and so almost completely vacuous.

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As is often the case with mathematical concepts, there is nothing more than the definitions.

Definition

A category C consists of

- a class of objects $Obj(C)$,
- $\forall X, Y \in Obj(C)$, $\exists$ a class of arrows $C(X, Y)$.
- $\forall f : X \to Y$, and $g : Y \to Z$, $\exists g \circ f : X \to Z$.

$$\begin{tikzcd} X \arrow[r, "f"] \arrow[dr, "g \circ f"'] & Y \arrow[d, "g"] \\ & Z \end{tikzcd}$$

Such that

- $\forall X \in Obj(C)$, $\exists id_X : X \to X$,
- $\forall f : X \to Y$, then

$$f \circ id_X = f = id_Y \circ f$$

- $\forall f : X \to Y$, $g : Y \to Z$, and $h : Z \to W$, then

$$(h \circ g) \circ f = h \circ (g \circ f)$$

Programming in patterns

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Numerous patterns have emerged from mainstream object-oriented languages such as Java, C#, and C++.

Category theory provides Haskell with patterns.

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The Haskell community draws on category theory to provide programming patterns.

They *tend* to be good patterns, with good performance characteristics, and general enough to be useful.

Pattern: Functors

Functors are arrows between categories.

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Definition

A Functor $F : C \to D$ consists of

- A map $F : Obj(C) \to Obj(D)$,
- $\forall X, Y \in Obj(C)$, a map $F : C(X, Y) \to D(FX, FY)$

Such that

- $\forall X \in C$, then $F(id_X) = id_{FX}$
- $\forall f : X \to Y, g : Y \to Z$, then $F(g \circ f) = F(g) \circ F(f)$

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User defined data types in Haskell

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For example, the maybe type allows for “nullable” types.

```haskell
-- Maybe :: a -> Maybe a
data Maybe a = Just a | Nothing
```

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```
class Functor m where
    fmap :: (a -> b) -> m a -> m b
```

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```
class Functor m where
    fmap :: (a -> b) -> m a -> m b
```

```
instance Functor Maybe where
    fmap f (Just x) = Just (f x)
    fmap _ Nothing  = Nothing
```

```haskell
-- Take a name, and capitalise the words in it
formatName :: String -> String
formatName = unwords . map capitalise . words

-- Now allow for names that might not be there
-- for example from an optional input html field
fn = fmap formatName

fn (Just "haskell CURRY")   -- > Just "Haskell Curry"
fn Nothing                  -- > Nothing
```

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Separately, define a Functor instance for a wrapper data type.

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Separately, define a Functor instance for a wrapper data type.

Use the wrapped values as if they were not wrapped!

Further reading

The official Haskell website is good
`https://www.haskell.org/`

Newish book all about the Maybe data type
`https://gumroad.com/l/maybe-haskell/`

Good series of blog posts on category theory
`http://bartoszmilewski.com/2014/10/28/category-theory-for-programmers-the-preface/`