Deriving Generic Functions by Example (+10 years)

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Guess the function

Input: aBc(

- (cBa
- bCd)
- ABC(
- aaBBcc((
- ac

Basic idea

$$f :: A \longrightarrow B$$

- I pick: $a \in A$
- You pick f, give me b (where b = f a)
- I infer f
  - Correct for a (b = f a)
  - Correct for all A (predictable)

Concrete example

Let’s derive ‘is’ functions for Haskell types

a: data MyType = Foo | Bar

b: isFoo Foo{} = True; isFoo _ = False

isBar Bar{} = True; isBar _ = False

You do not need to write down f.

Want to be sure f is what you wanted.

And the result…

MapCtor (App "FunBind" (List [List [App "Match" (List [App "Ident"(List [Concat (List [String "is",CtorName])]),List [App "PParen" (List [App "PRec" (List [App "UnQual" (List [App "Ident" (List [CtorName])]),List []])])],App "Nothing" (List []),App"UnGuardedRhs" (List [App "Con" (List [App "UnQual" (List [App"Ident" (List [String "True"])])])]),App "BDecls" (List [List []])]),App "Match" (List [App "Ident" (List [Concat (List [String "is",CtorName])]),List [App "PWildCard" (List [])],App "Nothing" (List[]),App "UnGuardedRhs" (List [App "Con" (List [App "UnQual" (List[App "Ident" (List [String "False"])])])]),App "BDecls" (List [List []])])]]))

Important to be *predictable* to treat f as a black box

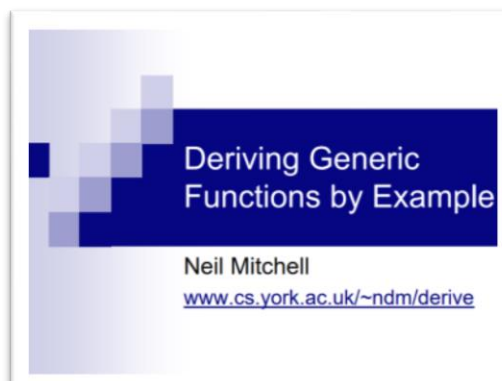
What happened to this work?

Where this work went

- 2007: York Doctoral Symposium (YDS) paper/talk
- 2008: York Programming Languages and Systems (PLASMA) talk
- 2009: Approaches and Applications of Inductive Programming (AAIP) keynote talk and reviewed post-publication
- 2007-2017: DERIVE open source project

2007: YDS

- My PhD involved learning to write English
  - With much thanks and credit to Colin Runciman
- YDS was a paper I wrote without Colin reading
  - Reading back, it's not too bad (6 small pages)
- All about an algorithm for inferring 'f' for one specific use case



Deriving Generic Functions by Example

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Abstract. A function is said to be generic if it operates over values of any data type. For example, a generic equality function can test pairs of booleans, integers, lists, trees etc. In most languages programmers must define generic functions multiple times, specialised for each data type. Alternatively, a tool could be used to specify the relationship between the data type and the implementation, but this relationship may be complex. This paper describes a solution: given a single example of the generic function on one data type, we can infer the relationship between a data type and the implementation. We have used our method in the Derive tool, allowing the implementation of 60% of the generic functions to be inferred.

1 Introduction

Haskell [10] is a modern functional programming language. In Haskell a generic function can be defined using a type class [12] (using the **class** keyword), and implementations can be provided for specific types (using the **instance** keyword). Generic equality is defined by the Eq class:

```
class Eq α where
  (≡) :: α → α → Bool
```

The Eq class has an operator, (≡). All types that are instances of the class Eq have the (≡) operator available. We can define a Haskell data type, along with an instance for Eq, as follows:

```
data WritingImplement = Pencil       -- a pencil
                      | Pen Colour   -- a pen, plus its colour

instance Eq WritingImplement where
  (Pencil) ≡ (Pencil) = True
  (Pen x)  ≡ (Pen y)  = x ≡ y
  _        ≡ _        = False
```

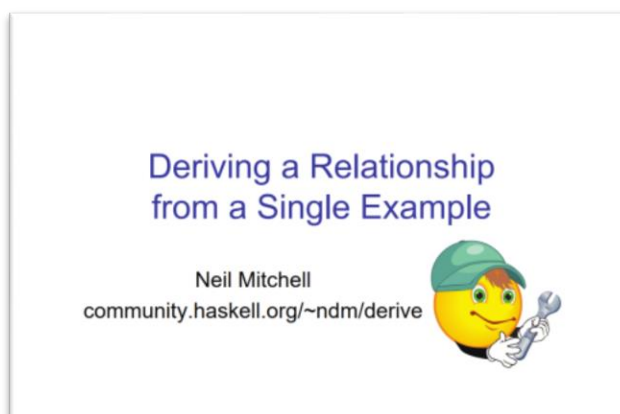
The data type we introduce is WritingImplement. A WritingImplement is either a pencil, or a pen with a colour. Pencil and Pen are referred to as data constructors. The first line of the Eq instance says that any two Pencil values are equal. The second line says that for two Pen values to be equal, their colour

2008: PLASMA

- More theory about how the algorithm worked, a bit more principled
  - f now quantified, can lift between quantifiers
- A sales pitch for the associated open-source DERIVE tool

2009: AAIP

- Invited to give a talk at a workshop
  - They'd seen my YDS work through my blog posts
- More formal and generic – less intuition
- Reviewed post-submission,
  12 pages in 2-column style



Formal setup

We pick all of:

- Input *the input type*
- Output *the output type*
- DSL *type of things describing functions*
- sample :: Input *chosen input*
- apply :: DSL ⟶ Input ⟶ Output *apply f*
- derive :: Output ⟶ Maybe DSL *guess f*

Correctness

$\forall o \in Output,$

$d \in derive\ o,$

$apply\ d\ sample \equiv o$

If derive succeeds,
it must work for the example

Predictability

$\forall i \in \text{Input},$

$d_1, d_2 \in \text{DSL},$

$\text{apply } d_1 \text{ sample} \equiv \text{apply } d_2 \text{ sample} \Rightarrow$

$\text{apply } d_1\ i \equiv \text{apply } d_2\ i$

If any input can distinguish two DSLs
it must be sample

Predictability not influenced
by derive!

Guess the function solved

Input: aBc(

Output: ac

Function: Pick odd indicies, filter isLower

Option 1: Change sample to aBcd(

Option 2: Only permit one of those in DSL

2007-2017: DERIVE tool

- Generates instances
  - 60% of instances defined by example
  - Some instances have been moved into GHC
- Moderately successful Haskell tool
  - https://github.com/ndmitchell/derive
  - 843 commits
  - 10 forks, 15 stars, 3 watchers
  - 14 contributors (most a couple of patches)

DERIVE: End of the line

- There are lots of newer instances it can’t do
  - Projects now ship an instance deriver with the instance, rather than centrally
- New way to define generic instances with GHC
- Examples define simple instances, which are the easiest ones anyway

- I don’t personally use it anymore

What happened to me?

Personal life

- -10Y Move to Cambridge
- -8Y Got married (Emily)
- -5Y Had child (Henry)

Hobby/Mission

Haskell

Jobs

- 3 month Google Summer of Code
- 3 month internship at Credit Suisse
- 8 years at Standard Chartered
- 1 year at Barclays

Expected to have to abandon Haskell, instead been programming it for a decade, and also learnt finance

Academic

- Supercompilation
  - Extension of my PhD, paper in ICFP 2010
  - Had a few PhD students follow my work
  - Mostly fizzled out (apart from Russia)
- Build systems (Shake)
  - Required by Standard Chartered
  - Papers at ICFP 2012, Haskell Symposium 2016
  - Going strong: GHC switching, companies use it
  - http://shakebuild.com/

Open Source

- Lots and lots of projects (too many)
  - Biggest: Hoogle, Shake, HLint, Ghcid
  - Recent: Hexml, Weeder, Profiterole
  - Contribute: Foundation, Alga
- All on GitHub https://github.com/ndmitchell/

Talks/Blog

- Still talk at user groups/conferences
  - 46 talks since 2004, recently 2-4 a year
  - All on http://ndmitchell.com
  - Where I got all the material for this talk from
- Blog with 307 posts
  - I write 4-8 posts a year (should do more)
  - 976,729 views (not including aggregator sites)
  - Initially just writing practice

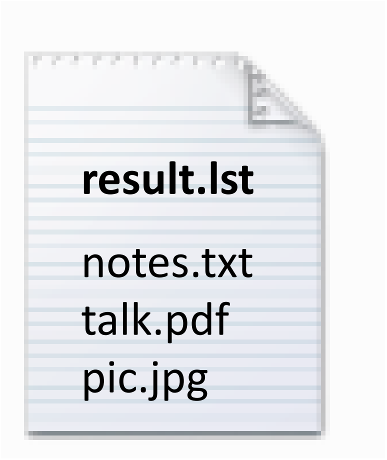
Shake overview

- Haskell EDSL for writing build systems – alternative to Make
  - Monadic dependencies
  - Unchanging dependencies
  - Non-file dependencies
  - Lots of engineering
- Vastly better for *generated* files

Shake example

```
import Development.Shake
import System.FilePath

main = shakeArgs shakeOptions $ do
    want ["result.tar"]
    "*.tar" %> \out -> do
        need [out -<.> "lst"]
        contents <- readFileLines $ out -<.> "lst"
        need contents
        cmd "tar -cf" [out] contents
```



Shake users

- **Standard Chartered** have been using Shake since 2009, 1000’s of compiles per day.
- **factis research GmbH** use Shake to compile their Checkpad MED application.
- **Samplecount** using Shake since 2012, producing several open-source projects for working with Shake.
- **CovenantEyes** use Shake to build their Windows client.
- **Keystone Tower Systems** has a robotic welder with a Shake build system.
- **FP Complete** use Shake to build Docker images.
- **Genomics Plc** use Shake for the build system, their first major use of Haskell in the company.

Conclusions

- YDS was fun, resulted in my first invited talk
- Suggestions:
  - Do lots of things that interest you
  - Make some of those things good
  - Tell people what you are doing (blogs, talk etc)
  - Be open about your work
  - Start your website/blog now