CSC4020Z: Functional Programming

Practical Assignment 1: Haskell

2021

Department of Computer Science
University of Cape Town, South Africa

DUE: Friday, 9th of April, 2021, 5.00 PM

Assignment Instructions and Description

The *Glasgow Haskell Compiler* (GHC) provides an interactive interpreter (GHCi), which will be the main Haskell tool used in this module. The usual way to write Haskell programs is to have two windows open: one for a text editor to write your code, and the other for GHCi so that you can regularly load and test your code. For example, a Haskell script defining the following function:

double x = x + x

And named: *script1.hs* can be compiled via typing:

ghci script1.hs

GHCi should load and you should see something like:

...

[1 of 1] Compiling Main (script1.hs, interpreted)
Ok, one module loaded.
∗Main>

In this case *script1* can then be tested via typing the function name and some value, for example:

double 7

Implement *Haskell* functions that provide solutions to the following computational problems given in each of the two (2) parts of this assignment:

Part A: Four (4) questions: 5 marks.

Part B: Six (6) questions: 15 marks.

Submit your scripts in a single ZIP file via VULA assignments tab, using your student number as the ZIP file name (e.g.: XYZZYX001.ZIP) and each script named according to the corresponding part and question number (e.g.: *partA-question1.hs*, *partB-question2.hs*, ...).

Part A [5 Marks]

1. Define a function product that produces the product of a list of numbers. For example: *product [2,3,4]*, should produce the solution: *24*.

   (1 Mark)

2. The library function *last* selects the last element of a non-empty list; for example: *last [1,2,3,4,5] = 5*. Write another definition for the *last* function in terms of the other library functions.

   (1 Mark)

3. Using library functions, define a function *halve :: [a] − > ([a],[a])* that splits an even length list into two halves. For example: *halve [1,2,3,4,5,6]*, should produce: *([1,2,3],[4,5,6])*.

   (1 Mark)

4. Consider a function *safetail :: [a] − > [a]* that behaves in the same way as the *tail* function except that it maps the empty list to itself rather than producing an error. Using *tail* and the function *null :: [a] − > Bool* that decides if a list is empty or not, define *safetail* using only: (1) a conditional expression, (2) guarded equations, and (3) pattern matching. Defining three different functions for solving these three different problems is an acceptable approach.

   (2 Marks)

Part B [15 Marks]

1. Suppose that arithmetic expressions built up from integers, addition and multiplication are represented using the following types:

   data Expr $=$ *Val Int* | *App Op Expr Expr*
   data Op $=$ *Add* | *Mul*

   Define functions:

   eval :: *Expr* $\rightarrow$ *Int*
   values :: *Expr* $\rightarrow$ *[Int]*

   that respectively evaluate an expression to its integer value, and return the list of integer values contained in an expression.

   (2 Marks)

2. Define a function:

   delete :: *Int* $\rightarrow$ *[Int]* $\rightarrow$ *[Int]*

   that deletes the first occurrence (if any) of a value from a list. For example, *delete* 2 [1, 2, 3, 2] should give the result [1, 3, 2].

   (2 Marks)

3. Using *delete*, define a function:

   perms :: *[Int]* $\rightarrow$ *[[Int]]*

   that returns all permutations of a list, given by all possible re-orderings of its elements. For example, *perms* [1, 2, 3] should return:

   [[1, 2, 3], [1, 3, 2], [2, 1, 3], [2, 3, 1], [3, 1, 2], [3, 2, 1]]

   (2 Marks)

4. Define a function:

   split :: *[Int]* $\rightarrow$ *[([Int], [Int])]*

   that returns all splits of a list into two non-empty parts that append to give the original list. For example, *split* [1, 2, 3, 4] should return:

   [([1], [2, 3, 4]), ([1, 2], [3, 4]), ([1, 2, 3], [4])]

   (3 Marks)

5. Using *split*, define a function:

   exprs :: *[Int]* $\rightarrow$ *[Expr]*

   that returns all expressions whose list of values is a given list. For example, *exprs* [1, 2, 3] should return all e for which *values* e = [1, 2, 3].

   (3 Marks)

6. Using your answers to the previous parts, define a function:

   solve :: *[Int]* $\rightarrow$ *Int* $\rightarrow$ *[Expr]*

   that returns all expressions whose list of values is a permutation of the given list and whose value is the given value.

   For example, *solve* [1, 2, 3, 4] 10 should return all expressions e for which *values* e is a permutation of [1, 2, 3, 4] and *eval* e = 10.

   (3 Marks)

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