University of Arizona, Department of Computer Science

CSc 520 — Assignment 5 — Due noon, Wed Apr 20 — 5%

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1 Introduction

The purpose of this assignment is learn more about structural operational semantics.

Every function should be commented. At the very least, the comments should state what the function does, which arguments it takes, and what result it produces.

This assignment is graded out of 100. It is worth 5% of your final grade.

2 Lambda Calculus [35 points]

Solve the following problems from Chapter 8 of *Syntax and Semantics of Programming Languages*, by Ken Slonneger and Barry Kurtz:

1. Problem 1 on page 244.   [5 points]

2. Problem 1 on page 252.   [5 points]

3. Problem 2a on page 252.   [5 points]

4. Problem 8 on page 252.   [5 points]

5. Problem 9 on page 253.   [5 points]

6. Problem 1a on page 262.   [5 points]

7. Problem 3a on page 262.   [5 points]

Hand in your results in as a text file called `theory`.

3 Operational Semantics Evaluator [65 points]

On the class web page is an operational semantics evaluator for Wren expressions: `http://www.cs.arizona.edu/~collberg/Teaching/520/2005/Assignments/wren-handout.hs` written in Haskell. Extend this to also handle Wren commands, as described in Chapter 8 of Slonneger and Kurtz.

In particular, you should define the function

```
derive :: Command -> [Int] -> Store -> ([Int], Store)
derive cmd stdin sto = ...
```

which takes a Wren command, an input list (a list of integers), and a store as input, and returns a pair consisting of the output (a list of integers) and the resulting store.

For example, given the following definitions:

```
a1 = updateSto "b" (BVal True) (updateSto "a" (IVal 5) emptySto)
c3 = derive (IAssign "a" (Ibin Add (Ilit 1) (Ilit 2))) [] a1
c4 = derive (IfThenElse
        (Brel Lt (Iid "a") (Ilit 5))
        (IAssign "a" (Ilit 7))
        (IAssign "a" (Ilit 9))
     ) [] a1
c5 = derive (While
        (Brel Lt (Iid "a") (Ilit 7))
        (IAssign "a" (Ibin Add (Iid "a") (Ilit 1)))
     )
     [] a1
c6 = derive (Seq
        (IAssign "a" (Ibin Add (Iid "a") (Ilit 1)))
        (IAssign "a" (Ibin Add (Iid "a") (Ilit 2)))
     ) [] a1
c7 = derive (Read "a") [12] a1
c8 = derive (Write (Iid "a")) [] a1
```

we expect the following results:

```
> a1
[b->True,a->5]
> c3
([],[a->3,b->True,a->5])
> c4
([],[a->9,b->True,a->5])
> c5
([],[a->7,a->6,b->True,a->5])
> c6
([],[a->8,a->6,b->True,a->5])
> c7
([],[a->12,b->True,a->5])
> c8
([5],[b->True,a->5])
```

Note that, in our simplistic implementation of the Store, earlier mappings override later ones.

The abstract syntax of Wren commands has been defined for you:

```
data Command = Skip |
               IAssign String IntExpr |
               BAssign String BoolExpr |
               Read String |
               Write IntExpr |
               IfThen BoolExpr Command |
               IfThenElse BoolExpr Command Command |
               While BoolExpr Command |
               Seq Command Command
```

Note that you can learn much about how to proceed with the implementation of commands by studying how expressions are handled.

4   Submission and Assessment

The deadline for this assignment is noon, Wed Apr 20. You should submit the assignment (a text-file containing the function definitions) electronically using the `Unix` command ⌜`turnin cs520.5 theory wren.hs`⌝. This assignment is worth 5% of your final grade.

> **Don't show your code to anyone, don't read anyone else's code, don't discuss the details of your code with anyone. If you need help with the assignment see the instructor or TA.**