University of Sussex
Informatics

Spring 2021

Limits of Computation
Feedback Exercises 3
Programs-As-Data, Self-Interpreter, and `hwhile`
(covers Lectures 3–6)
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1. Consider the programs `p1` in Figure 1 and `add` in Figure 2.

```
p1 read L {
  R := 0;
  X := hd L;
  Y := hd tl L;
  while X {
    R := <add> [ Y, R ];
    X := tl X
  }
}
write R
```

Figure 1: `WHILE`-program `p1`

```
add read L {
  X := hd L;
  Y := hd tl L;
  while X {
    Y := cons nil Y;
    X := tl X
  }
}
write Y
```

Figure 2: `WHILE`-program `add`

(a) What is $[\![\texttt{p1}]\!]^{\texttt{WHILE}}(\ulcorner[2,5,7,8]\urcorner)$ according to the definition of `p1` and `add` (from the last exercise sheet) according to $[\![\_]\!]^{\texttt{WHILE}}$?

Answer: Since `p2` is addition (on encodings of natural numbers), `p1` is multiplication, so $[\![\texttt{p1}]\!]^{\texttt{WHILE}}(\ulcorner[2,5]\urcorner) = \ulcorner 10\urcorner$. Note that only the first two elements are used in the input list.

(b) Translate the program `add` from above into its data representation (programs as data) using the definition of the encoding presented in Lecture 6. Encode the variables starting from number 0 in the order of appearance.

Answer:

```
[0,
[ [:=,1,[hd,[var,0]]],
  [:=,2,[hd,[tl,[var,0]]]],
  [while,[var,1],
           [ [:=,2,[cons,[quote,nil],[var,2]]],
             [:=,1,[tl,[var,1]]]
           ]
   ]
],
2]
```

Make sure that you have the right number of square brackets for all the blocks.

2. On our Canvas page you find the program `STEP_incomplete.while` in the *Programs* section – or also from this link

   `canvas.sussex.ac.uk/courses/12888/files/2022795`

   This program is macro-called in the self-interpreter for the `WHILE`-language with one variable, called `WH`^{1}`LE`. One case in the second switch construct is missing (for assignment). Fill in the missing lines.

   Answer:

   ```
   val:= arg ;
   DSt:= tl DSt;
   CSt:= tl CSt
   ```

   This follows directly from Lecture 6, Slide 20.

3. Run the program `p1` from Question 1 in `hwhile`. Which output flag is appropriate here?

   Please consult the Canvas page:

   `canvas.sussex.ac.uk/courses/12888/pages/while-programs-and-hwhile`

   on our Limits site for more info about `hwhile`. Ask the tutor in your seminar if you have problems with installation. Note that `hwhile` is also available on the SoftwareHub on the Chichester Lab machines (which are accessible remotely).

   Answer: The `-i` flag as the result is a number.