

## Program Synthesis Meets Machine Learning

### Assignment 2 (PBE/FlashMeta and Model Learning)

(Due on Mon 24st Feb 2020)

1. Consider a DSL for sum expressions in the FlashMeta framework, with the following grammar:

$$\begin{aligned} S &\rightarrow T \mid S + S \\ T &\rightarrow 0 \mid 1 \mid x \mid y \end{aligned}$$

The variables  $x$  and  $y$  are input variables with domain natural numbers  $\{0, 1, \dots\}$ , and a program (a sum expression derived from  $S$ ) outputs a natural number as the result of evaluating the expression on the input valuation for  $x$  and  $y$ . A specification  $\varphi$  is an input/output example of the form  $(1, 2) \rightsquigarrow 3$  (meaning that the program on the input valuation  $(x \mapsto 1, y \mapsto 2)$  evaluates to 3).

- (a) Consider the witness functions for first parameter of the production  $S \rightarrow S + S$  given by:

$$\omega_1((m, n) \rightsquigarrow k) = (m, n) \rightsquigarrow 1 \vee (m, n) \rightsquigarrow 2 \vee \dots \vee (m, n) \rightsquigarrow k - 1,$$

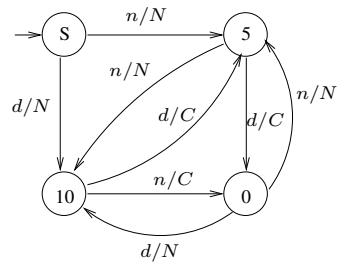
and a conditional witness function for the second parameter given by

$$\omega_2((m, n) \rightsquigarrow k \mid l) = (m, n) \rightsquigarrow k - l.$$

Is the witness function  $\omega_1$  precise? Is the conditional witness function  $\omega_2$  precise?

- (b) Using the witness functions above, show the step-by-step progression of the enumeration tree (as shown in Slide 28 of the lectures slides) for the specification  $(1, 2) \rightsquigarrow 3$ , till you obtain the enumeration tree representing *all* programs (modulo the specification of the witness functions) that satisfy  $\varphi$ .
  - (c) Represent the final tree above as a VSA structure. Assume that VSA nodes are labeled by their specification (in addition to the operator corresponding to the node), and unify nodes that have the same label.
  - (d) What is the size and volume of the VSA?
2. Consider the coffee vending machine (implemented as a Mealy machine) below. The machine accepts 10 paise (dime) and 5 paise (nickel) coins and gives out 1 cup of coffee whenever the balance is 15 paise or more. The inputs are  $n$  (for “nickel”) and  $d$  (for “dime”), and outputs of the machine are  $C$  (for “Coffee vended”) and  $N$  (for “Nothing vended”).

Given this as a black box implementation, use Angluin’s algorithm to learn an equivalent Mealy machine. Show the main steps in the learning process (i.e. the points whenever you reach a closed and consistent table).



3. Question on Prose (to be given).