YuchiKaml

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Contents

1 Introduction

YuchiKaml is a toy language. and YuchiKaml interpreter is an implementation of interpreter of YuchiKaml. Both are created in order to get accustomed to Sprache, a C#Parser Combinator Library. In this article, I introduce both the language and the interpreter.

2 YuchiKaml Language

YuchiKaml is a dynamic typed language with-ML like surface grammar.

2.1 Syntax

Expressions of YuchiKaml are defined by the following BNF equations:

$$
\begin{aligned}
e ::= {} & () \mid x \mid n \mid \mathrm{true} \mid \mathrm{false} \mid s \mid (e) \\
& \mid e\ e \mid !\,e \\
& \mid e * e \mid e/e \\
& \mid e + e \mid e - e \\
& \mid e \leq e \mid e < e \mid e \geq e \mid e > e \\
& \mid e = e \mid e \neq e \\
& \mid e \,\&\&\, e \\
& \mid e \,||\, e \\
& \mid e \triangleright e \mid e \gg e \\
& \mid \mathrm{if}\, e\, \mathrm{then}\, e\, \mathrm{else}\, e \mid \mathrm{let}\, x\ \tilde{a} = e\, \mathrm{in}\, e \mid \mathrm{let\,rec}\, f\ a_1\ \tilde{a} = e\, \mathrm{in}\, e \mid \lambda x.\ e \\
& \mid e\,;\, e
\end{aligned}
$$

The operators defined in earlier rows have stronger precedences than the operators defined in later rows. For example, $1+2*3$ is not parsed as $(1+2)*3$, but $1+(2*3)$.

In real source codes, the symbols above are notated as follows:

$\leq$	$<=$
$\geq$	$>=$
$\neq$	$! =$
&&	&&
$\|\|$	$\|\|$
$\triangleright$	$\| >$
$\gg$	$>>$
$\lambda x.\ e$	$\backslash x- > e$

Example 2.1 (GCD)**.** This is an example of a YuchiKaml source code of a program which calculates the greatest common divisor of 120 and 45.

Listing 1: Samples/gcd

```
let rec gcd m n =
    if m > n then gcd (m - n) n
    else if m < n then gcd m (n - m)
    else m
in gcd 120 45
```

2.1.1 Syntax Sugar

Some of the expressions shown above are syntactic sugars. We show the list and syntax sugars and how they are desugared.

$$\begin{aligned}
e_1 \triangleright e_2 &::= e_2\ e_1 \\
e_1 \gg e_2 &::= \lambda x.\ g(fx) \\
\mathrm{let}\, f\ a_1 \cdots a_n = e_1 \,\mathrm{in}\, e_2 &::= \mathrm{let}\, f = \lambda a_1. \cdots \lambda a_n.\ e_1 \,\mathrm{in}\, e_2 \\
\mathrm{let\,rec}\, f\ a\ b_1 \cdots b_n = e_1 \,\mathrm{in}\, e_2 &::= \mathrm{let\,rec}\, f\ a = \lambda b_1. \cdots \lambda b_n.\ e_1 \,\mathrm{in}\, e_2 \\
e_1\, ;\, e_2 &::= \mathrm{let}\ _ = e_1 \,\mathrm{in}\, e_2
\end{aligned}$$

2.2 Semantics

Then we define the semantics of the expressions.

2.2.1 Value

Values of YuchiKaml is listed as below:

$$
\begin{aligned}
v(\text{value}) &::= n \mid b \mid s \mid \text{cl} \mid f_b \\
\rho(\text{valuation}) &\in \text{Var} \not\rightharpoonup \text{Val} \\
f_b(\text{built-in function}) &\in \text{Val} \not\rightharpoonup \text{Val} \\
\text{cl}(\text{closure}) &::= (x, e, \rho)
\end{aligned}
$$

Here Var is the set of the variables and Val is the set of the values.

2.2.2 Evaluation

We define the *evaluation* process of expression by a big-step semantics shown below.

An *evaluation relation* is a four-term relation of the form $\rho \vdash e_1 \longrightarrow e_2$.

The evaluation rules of YuchiKaml are shown below:

$$\frac{\rho(x) = v}{\rho \vdash x \longrightarrow v} \tag{E-Var}$$

$$\frac{\rho \vdash e_1 \longrightarrow e_1'}{\rho \vdash e_1\ e_2 \longrightarrow e_1'\ e_2} \tag{E-AppLeft}$$

$$\frac{\rho \vdash e_2 \longrightarrow e_2'}{\rho \vdash v_1\ e_2 \longrightarrow v_1'\ e_2'} \tag{E-AppRight}$$

$$\frac{\rho' \cup \{x \mapsto v\} \vdash e_1 \longrightarrow e_1'}{\rho \vdash (x, e_1, \rho')\ v_2 \longrightarrow (x, e_1', \rho')v_2} \tag{E-AppCls}$$

$$\frac{}{\rho \vdash (x, v_1, \rho')\ v_2 \longrightarrow v_1} \tag{E-AppCls2}$$

$$\frac{f_1 @ v_2 = v_3}{\rho \vdash f_1\ v_2 \longrightarrow v_3} \tag{E-AppBuiltIn}$$

$$\frac{\rho \vdash e_1 \longrightarrow e_1'}{\rho \vdash e_1 \operatorname{op} e_2 \longrightarrow e_1' \operatorname{op} e_2} \tag{E-BinOp-Left}$$

$$\frac{\rho \vdash e_2 \longrightarrow e_2'}{\rho \vdash v_1 \operatorname{op} e_2 \longrightarrow v_1 \operatorname{op} e_2'} \tag{E-BinOp-Right}$$

$$\frac{n_1 \llbracket * \rrbracket\, n_2 = n_3}{\rho \vdash n_1 * n_2 \longrightarrow n_3} \tag{E-Mul}$$

$$\frac{n_1 \llbracket / \rrbracket\, n_2 = n_3}{\rho \vdash n_1 / n_2 \longrightarrow n_3} \tag{E-Div}$$

$$\frac{n_1 \llbracket + \rrbracket n_2 = n_3}{\rho \vdash n_1 + n_2 \longrightarrow n_3} \quad \text{(E-PLUS)}$$

$$\frac{n_1 \llbracket - \rrbracket n_2 = n_3}{\rho \vdash n_1 - n_2 \longrightarrow n_3} \quad \text{(E-MINUS)}$$

$$\frac{n_1 \llbracket \leq \rrbracket n_2 = b_3}{\rho \vdash n_1 \leq n_2 \longrightarrow b_3} \quad \text{(E-LEQ)}$$

$$\frac{n_1 \llbracket < \rrbracket n_2 = b_3}{\rho \vdash n_1 < n_2 \longrightarrow b_3} \quad \text{(E-LT)}$$

$$\frac{n_1 \llbracket \geq \rrbracket n_2 = b_3}{\rho \vdash n_1 \geq n_2 \longrightarrow b_3} \quad \text{(E-GEQ)}$$

$$\frac{n_1 \llbracket > \rrbracket n_2 = b_3}{\rho \vdash n_1 > n_2 \longrightarrow b_3} \quad \text{(E-GT)}$$

$$\frac{b_1 \llbracket \&\& \rrbracket b_2 = b_3}{\rho \vdash b_1 \,\&\&\, b_2 \longrightarrow b_3} \quad \text{(E-AND)}$$

$$\frac{b_1 \llbracket || \rrbracket b_2 = b_3}{\rho \vdash b_1 \,||\, b_2 \longrightarrow b_3} \quad \text{(E-OR)}$$

$$\frac{(v_1 = v_2) = b_3}{\rho \vdash v_1 = v_2 \longrightarrow b_3} \quad \text{(E-EQ)}$$

$$\frac{(v_1 \neq v_2) = b_3}{\rho \vdash v_1 \neq v_2 \longrightarrow b_3} \quad \text{(E-NEQ)}$$

$$\frac{\rho \vdash e_1 \longrightarrow e_1'}{\rho \vdash \mathrm{if}\, e_1 \,\mathrm{then}\, e_2 \,\mathrm{else}\, e_3 \longrightarrow \mathrm{if}\, e_1' \,\mathrm{then}\, e_2 \,\mathrm{else}\, e_3} \quad \text{(E-IFCOND)}$$

$$\frac{}{\rho \vdash \mathrm{if}\,\mathrm{true}\,\mathrm{then}\, e_2 \,\mathrm{else}\, e_3 \longrightarrow e_2} \quad \text{(E-IFTRUE)}$$

$$\frac{}{\rho \vdash \mathrm{if}\,\mathrm{true}\,\mathrm{then}\, e_2 \,\mathrm{else}\, e_3 \longrightarrow e_3} \quad \text{(E-IFFALSE)}$$

$$\frac{\rho \vdash e_1 \longrightarrow e_1'}{\rho \vdash \mathrm{let}\, x = e_1 \in e_2 \longrightarrow \mathrm{let}\, x = e_1' \,\mathrm{in}\, e_2} \quad \text{(E-LETBODY)}$$

$$\frac{\rho \cup \{x \mapsto v_1\} \vdash e_2 \longrightarrow e_2'}{\rho \vdash \mathrm{let}\, x = v_1 \,\mathrm{in}\, e_2 \longrightarrow \mathrm{let}\, x = v_1 \,\mathrm{in}\, e_2'} \quad \text{(E-LETREM)}$$

$$\frac{}{\rho \vdash \mathrm{let}\, x = v_1 \,\mathrm{in}\, v_2 \longrightarrow v_2} \quad \text{(E-LetValue)}$$

$$\text{(E-LetRec)}$$

TODO: define it.

$$\frac{}{\rho \vdash \lambda x.\ e \longrightarrow (x, e, \rho)} \quad \text{(E-Abs)}$$

3 YuchiKaml Interpreter

3.1 Usage

3.2 Preprocess