The Definition of Snail Programming Language

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1 Snail の構文定義

EBNF 記法を用いて Snail の具象構文を以下に示す.

$$\begin{aligned}
\mathit{toplevel} &::= \mathit{let}\ [\mathit{rec}]\ \mathit{var}\ \{\mathit{var}\ [\ :\ \langle \mathit{type} \rangle]\}\!: \langle \mathit{type} \rangle = \langle \mathit{term} \rangle\ \{\langle \mathit{mutual\text{-}recursion\text{-}top\text{-}let} \rangle\} \\
&\quad\mid\ \ \mathit{typedef}\ \mathit{cons}\ \{\mathit{var}\} = [\ |\ ]\ \{\langle \mathit{type\text{-}dec} \rangle\ |\ \}\ \langle \mathit{type\text{-}dec} \rangle\ \{\langle \mathit{mutual\text{-}recursion\text{-}type} \rangle\}
\end{aligned}$$

$$\mathit{mutual\text{-}recursion\text{-}type} ::= \mathit{and}\ \mathit{cons}\ \{\mathit{var}\} = [\ |\ ]\ \{\langle \mathit{type\text{-}dec} \rangle\ |\ \}\ \langle \mathit{type\text{-}dec} \rangle$$

$$\mathit{mutual\text{-}recursion\text{-}top\text{-}let} ::= \mathit{and}\ \mathit{var}\ \{\mathit{var}\ [\ :\ \langle \mathit{type} \rangle]\}\ :\ \langle \mathit{type} \rangle = \langle \mathit{term} \rangle$$

$$\mathit{type\text{-}dec} ::= \mathit{cons}\ [\mathit{of}\ \langle \mathit{type} \rangle]$$

$$\begin{aligned}
\mathit{type} &::= \langle \mathit{type} \rangle \to \langle \mathit{type} \rangle \\
&\quad\mid\ \ !\ '['\ \langle \mathit{expmod} \rangle\ ']'\ '\{'\ \langle \mathit{type} \rangle\ '\}' \\
&\quad\mid\ \ \langle \mathit{simple\text{-}type} \rangle \\
&\quad\mid\ \ \langle \mathit{type} \rangle\ \langle \mathit{simple\text{-}type} \rangle
\end{aligned}$$

$$\begin{aligned}
\mathit{expmod} &::= \mathit{int} \\
&\quad\mid\ \ \infty
\end{aligned}$$

$$\begin{aligned}
\mathit{simple\text{-}type} &::= '('\ \langle \mathit{type} \rangle\ ')' \\
&\quad\mid\ \ \mathit{var} \\
&\quad\mid\ \ \mathit{cons} \\
&\quad\mid\ \ ()
\end{aligned}$$

$$\begin{aligned}
\mathit{pattern} &::= \langle \mathit{simple\text{-}pattern} \rangle \\
&\quad\mid\ \ \langle \mathit{pattern} \rangle\ \langle \mathit{simple\text{-}pattern} \rangle \\
&\quad\mid\ \ \langle \mathit{simple\text{-}pattern} \rangle\ \mathit{binop}\ \langle \mathit{simple\text{-}pattern} \rangle
\end{aligned}$$

$$
\begin{aligned}
\mathit{simple\text{-}pattern} ::= &\ '(' \ \langle \mathit{pattern} \rangle \ ')' \\
|\ & \mathit{var} \\
|\ & \mathit{cons}\ '[' \ \langle \mathit{simple\text{-}pattern} \rangle \ ']' \\
|\ & [\,] \\
|\ & \_
\end{aligned}
$$

$$
\mathit{mutual\text{-}recursion\text{-}let} ::= \mathit{and}\ \mathit{var}\ \{\mathit{var}\ [\ :\ \langle \mathit{type} \rangle]\}\ :\ \langle \mathit{type} \rangle = \langle \mathit{term} \rangle
$$

$$
\begin{aligned}
\mathit{term} ::= &\ \langle \mathit{simple\text{-}term} \rangle \\
|\ & \langle \mathit{term} \rangle \ \langle \mathit{simple\text{-}term} \rangle \\
|\ & \mathit{let}\ [\mathit{rec}]\ \mathit{var}\ \{\mathit{var}\ [\ :\ \langle \mathit{type} \rangle]\}\!: \langle \mathit{type} \rangle = \langle \mathit{term} \rangle \ \{\langle \mathit{mutual\text{-}recursion\text{-}let} \rangle\}\ \mathit{in}\ \langle \mathit{term} \rangle \\
|\ & \mathit{fun}\ \{\mathit{var}\ [\ :\ \langle \mathit{type} \rangle]\}\ \rightarrow \langle \mathit{term} \rangle \\
|\ & \mathit{match}\ \langle \mathit{term} \rangle\ \mathit{with}\ [\ |\ ]\ \{\langle \mathit{pattern} \rangle \rightarrow \langle \mathit{term} \rangle \ |\ \}\ \langle \mathit{pattern} \rangle \rightarrow \langle \mathit{term} \rangle \\
|\ & \mathit{if}\ \langle \mathit{term} \rangle\ \mathit{then}\ \langle \mathit{term} \rangle\ \mathit{else}\ \langle \mathit{term} \rangle
\end{aligned}
$$

$$
\begin{aligned}
\mathit{simple\text{-}term} ::= &\ '(' \ \langle \mathit{term} \rangle \ [\ :\langle \mathit{type} \rangle]\ ')' \\
|\ & !\ \langle \mathit{term} \rangle \\
|\ & \mathit{int} \\
|\ & \mathit{float} \\
|\ & \mathit{string} \\
|\ & \mathit{bool} \\
|\ & \mathit{var} \\
|\ & \mathit{cons}\ [\langle \mathit{simple\text{-}term} \rangle] \\
|\ & () \\
|\ & [\,] \\
|\ & \mathit{list}
\end{aligned}
$$

終端記号の意味を以下のように定義する.

- var 先頭が小文字で始まる文字列.
- cons 先頭が大文字で始まる文字列.
- list 組み込みリストの構文糖衣,[1,2,3] など.
- string 文字列リテラル.
- int 整数リテラル.
- float 小数リテラル.
- bool 真偽値リテラル.
- その他 予約語.

2　Snail の型システム

Snail は次のような型付け規則を持つ.

$$\frac{}{\vdash int : Int} \ (\textsc{Int})$$

$$\frac{}{\vdash float : Float} \ (\textsc{Float})$$

$$\frac{}{\vdash string : String} \ (\textsc{String})$$

$$\frac{}{\vdash bool : Bool} \ (\textsc{Bool})$$

$$\frac{}{x : A \vdash x : A} \ (\textsc{id})$$

$$\frac{\Gamma, x : A \vdash e : B}{\Gamma, x : [A]_1 \vdash e : B} \ (\textsc{der})$$

$$\frac{[\Gamma] \vdash e : B}{r * [\Gamma] \vdash !e : !_r B} \ (\textsc{pr})$$

$$\frac{\Gamma, x : A \vdash e : B}{\Gamma \vdash fun\ x \to e : A \multimap B} \ (\textsc{fun})$$

$$\frac{\Gamma, x : [A]_r \vdash e : B}{\Gamma \vdash fun\ (!x : !_r A) \to e :\ !_r A \multimap B} \ (\textsc{fun-exp})$$

$$\frac{\Gamma \vdash e : A \multimap B \quad \Delta \vdash e' : A}{\Gamma + \Delta \vdash e\ e' : B} \ (\textsc{app})$$

$$\frac{\Gamma \vdash e : Bool \quad \Delta \vdash e_1 : A \quad \Delta \vdash e_2 : A}{\Gamma + \Delta \vdash if\ e\ then\ e_1\ else\ e_2 : A} \ (\textsc{if})$$

$$\frac{\Gamma \vdash e : A \quad \Delta, x : A \vdash e' : B}{\Gamma + \Delta \vdash let\ x = e\ in\ e' : B} \ (\textsc{let})$$

$$\frac{\Gamma \vdash e : !_r A \quad \Delta, x : [A]_r \vdash e' : B}{\Gamma + \Delta \vdash let\ !x = e\ in\ e' : B} \ (\textsc{let-exp})$$

$$\frac{[\Gamma], x : [A]_p \vdash e :\ A \quad \Delta, x :\ [A]_\infty \vdash e' :\ B}{\infty * [\Gamma] + \Delta \vdash let\ rec\ x = e\ in\ e' : B} \ (\textsc{let-rec})$$

$$\frac{\Delta \vdash e :\ B \quad \Gamma <: \Delta}{\Gamma, \Theta \vdash e : B} \ (\textsc{sub})$$