PROGRAM SYNTHESIS with LIVE BIDIRECTIONAL EVALUATION

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PROGRAM SYNTHESIS

Computer generation of programs ***satisfying*** a ***specification***

PROGRAMMING BY EXAMPLE

Specification

```
assert (sort [] == [])
assert (sort [3, 1, 2] == [1, 2, 3])
```

Satisfaction *Dynamic verification*
Test each input-output pair: ***evaluate and check***

MYTH

Examples

```
natMax : Nat -> Nat -> Nat

assert (natMax 0 0 == 0)
assert (natMax 0 1 == 1)
assert (natMax 0 2 == 2)
assert (natMax 1 0 == 1)
assert (natMax 1 1 == 1)
assert (natMax 1 2 == 2)
assert (natMax 2 0 == 2)
assert (natMax 2 1 == 2)
assert (natMax 2 2 == 2)
```

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Output

```
natMax n m =
  case n of
    Zero ->
      m

    Succ n' ->
      case m of
        Zero ->
          n

        Succ m' ->
          Succ (natMax n' m')
```

SKETCH-n-MYTH

Examples

```
assert (natMax 1 0 == 1)
assert (natMax 1 1 == 1)
assert (natMax 1 2 == 2)
```

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Sketch

```
natMax : Nat -> Nat -> Nat
natMax n m =
  case n of
    Zero ->
      m

    Succ n' ->
      ??
```

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LIVE EVALUATION

Program e

```
let
  greeting =
    “Hello!”
in
let
  x =
    (4, ??0)
in
  10 + 20 + snd x
```

Output

```
30 + env:[greeting=“Hello!”] ??0
```

$\varnothing \vdash e \Rightarrow 30 + {}^{\text{env:}}[\texttt{greeting=“Hello!”}]\ ??_0$

LIVE UNEVALUATION

$\varnothing \vdash e \Rightarrow 30 + [\ldots]\ ??_0 \Leftarrow 100 \dashv [\ldots]\ ??_0 \vDash 70$

$\varnothing \vdash e \Rightarrow \mathbf{fst}\ [\ldots]\ ??_1 \Leftarrow 8 \dashv [\ldots]\ ??_1 \vDash (8, \top)$

Program

```
natMax : Nat -> Nat -> Nat
natMax n m =
  case n of
    Zero    -> m
    Succ n' -> ??2

assert (natMax 1 2 == 2)
```

$\varnothing \vdash$ `natMax 1 2`
$\Rightarrow [\texttt{n=1, m=2, n'=0}]\ ??_2$
$\Leftarrow 2$
$\dashv [\texttt{n=1, m=2, n'=0}]\ ??_2 \vDash 2$

LIVE BIDIRECTIONAL EVALUATION

Satisfaction $\underbrace{E \vdash e \Rightarrow r}_{\text{Live evaluation}} \underbrace{\Leftarrow ex \dashv X}_{\text{Live unevaluation}}$