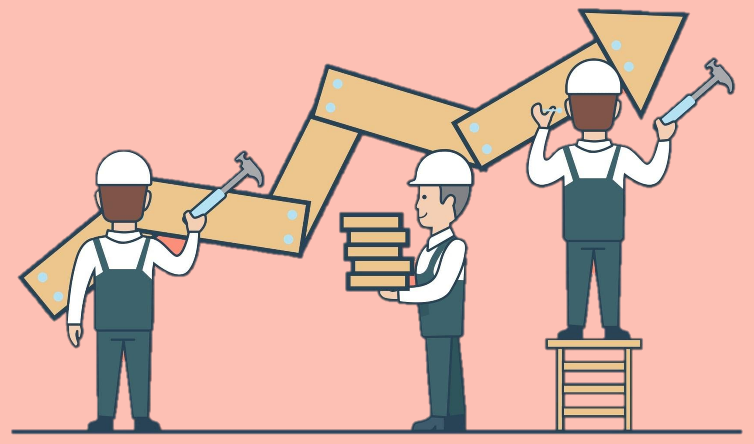
Learn Your Program

Hadar Frenkel, Orna Grumberg, and Sarai Sheinvald
Computer Science Department, Technion — Israel Institute of Technology



Goal

- **Synthesis** framework for **first-order LTL formulas** over program variables
- Infer program states using **automata learning**
- Infer program statements using **abduction**

Specifications

Quantifier-free first-order LTL formulas:

$$spec = (x = 0) \wedge Globally\big((x = 0) \rightarrow Finally(x > 0)\big)$$

x is the program variable

Program Alphabet

We infer program statements in two ways:

1. Syntactic inference of program statements out of the specification:
   $x := 0$ from $x = 0$
   $x := 1$ from $x > 0$
   $if\ (x > 0) \dots else$ from $x > 0$
2. Semantic inference using abduction, in case the statements obtained in (1) are not enough.
   Q: Are there cases in which (1) is not enough?

L* Algorithm [Angluin 1987]

Learns an automaton for a regular language L using **membership queries:** is $w \in L$?
and **equivalence queries:** dose $\mathcal{L}(C) = L$ for candidate C?

Symbolic L*

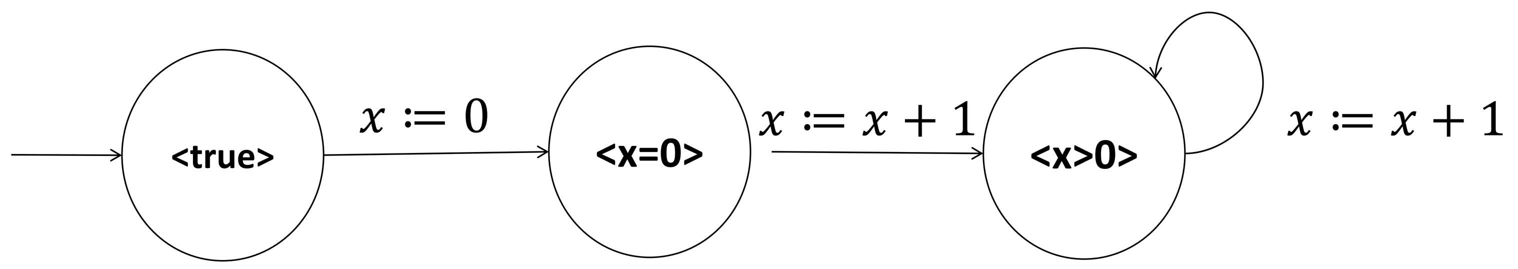
Membership queries:

Is the predicates sequence <p_1><p_2>... <p_n> in T_{spec} ?

<⊥>	No
<⊥> x:=0 **<x=0>**	No
<⊥> x:=0 **<x=0>** **<x=0>** x:=x+1 **<x>0>**	yes

Equivalence queries:

For a candidate program P, we check if $\mathcal{L}(P) \subseteq \mathcal{L}(\varphi)$



Q: How do we obtain "interesting" programs?

Q: How do we avoid vacuous results?

Work in progress...

Termination: when does the process converge into a candidate automaton?
Hoare triplets inference: how do we infer predicates?