

# SVMRanker: A General Termination Analysis Framework of Loop Programs via SVM

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# Verification

Checking termination is necessary.

## Example

```
assume( True );  
int x = 1;  
while (x>0) x++;  
assertion (x<=0);
```

The assertion can be checked once the loop is terminating.  
However theoretically...

In the practice the program return UNKNOWN once we cannot prove or disprove the termination.

Our tool: focus on the synthesis ranking function.

What is **ranking function**?

# Ranking Function

```
assume(True);  
int x = 5;  
while(x > 0) x--;  
assertion(x<=0);
```

ranking function is the function used for proof of termination.

$$\Omega(x, x') := x > 0 \wedge x' = x - 1$$

Ranking function:

$$f(x) = x$$

- ▶ Informally:  $f : S \rightarrow \mathbb{R}$  where  $S$  is the set of states and  $\mathbb{R}$  is a well-founded ordered set.
- ▶ strictly decreases at each iteration.
- ▶ has a lower bound in the loop state space.

# More Powerful Ranking Functions

- ▶ Linear ranking function:  $f(x) = ax + b$ .
- ▶ Polynomial ranking function.
- ▶  $k$ -phase- nested or multiphase ranking function:

$$\langle f_1, \dots, f_k \rangle$$

# Synthesis of Ranking Function

- ▶ Prove the termination is UNDECIDABLE.
- ▶ Synthesis of a certain class of ranking function is DECIDABLE.

# State-of-the-Art Tools

Termination problem is essential and basic to program verification.  
State-of-the-art tools:

- ▶ LASSORANKER in ULTIMATE AUTOMIZER.
- ▶ IRANKFINDER: A tool for ranking function inferring.
- ▶ LOOPSTER: A static loop termination analyzer.
- ▶ CPACHECKER
- ▶ ...

Competition SV-COMP also has a termination track for this problem.

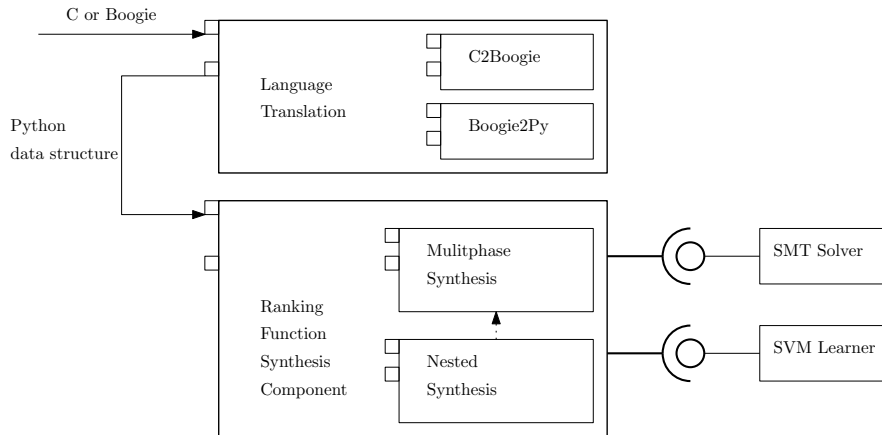
# SVMRANKER: Synthesize Ranking Function via SVM

Technique previous tools use.

We reduce the synthesis of ranking functions  
into the SVM problem.

Advantage? Disadvantage?

# SVMRanker: Architecture





# Experimental Results: Nonlinear Loops

Cases are adapted from SV-COMP.

Case ID	SVMRANKER	iRANKFINDER	LASSORANKER	CPACHECKER
116	U	U	U	U
148	Y	U	U	F
149	Y	U	U	U
151	Y	U	U	F
152	Y	U	U	F
153	Y	U	U	F
154	U	U	U	F
155	Y	U	U	F
157	Y	U	U	U
158	Y	U	U	TO
159	Y	U	U	F
160	Y	U	U	TO
161	U	U	U	F
162	Y	U	U	F
163	Y	U	U	F
164	Y	U	U	U
167	Y	U	U	E
171	Y	U	U	E
DoubleNeg	U	U	U	U

# Experimental Results: Linear Loops