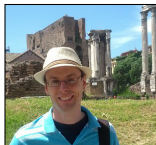
Detecting Ambiguity in Programming Language Grammars

Naveneetha Krishnan Vasudevan



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Non-deterministic ambiguity detector

Simpler

Yet performs 11% better

- New approaches to generating grammars

Other Contributions

- New approaches to generating grammars
- Breadth-over-depth non-deterministic approach outperforms more complex heuristics

I. Ambiguity

What is Ambiguity?

- Undecidable problem
- Undesirable

Multiple Parses

```
E -> E '+' E  |  E '*' E
```

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```
4 + 3 * 2
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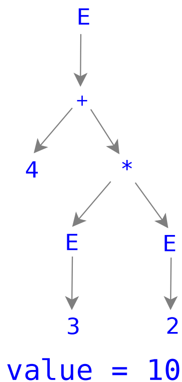
Tree 1



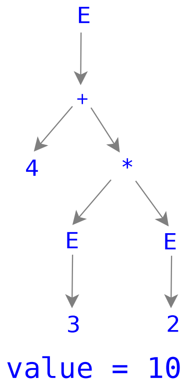
value = 10

Multiple Parses

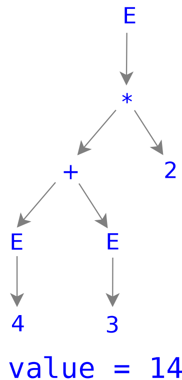
```
E -> E '+' E  |  E '*' E
```

$4 + 3 * 2$

Tree 1



Tree 2

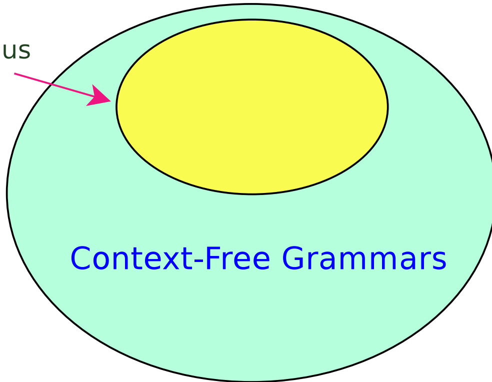


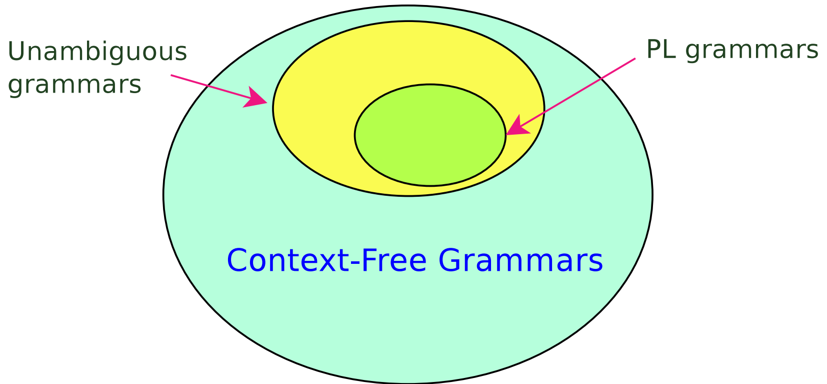
value = 10

value = 14

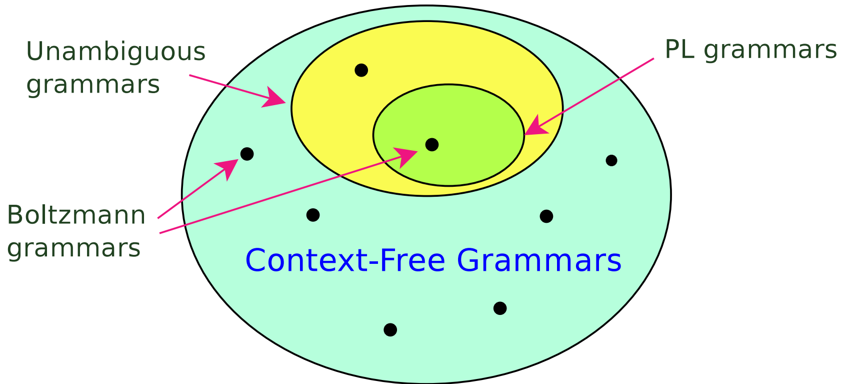
Context-Free Grammars

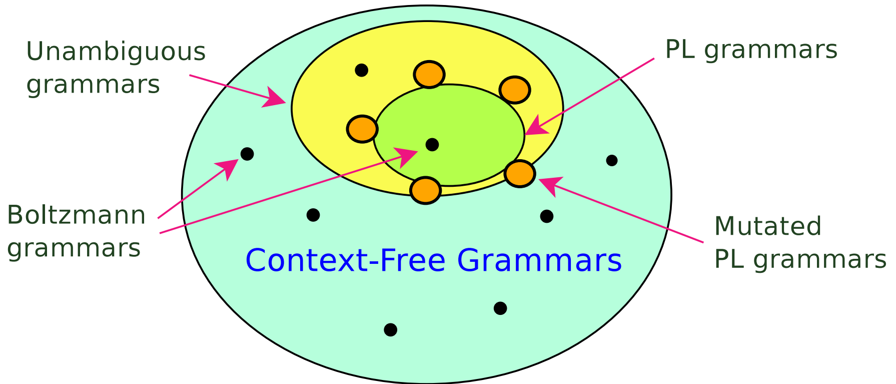
CFGs




Unambiguous grammars
PL grammars
Context-Free Grammars

CFGs




Unambiguous grammars
PL grammars
Boltzmann grammars
Mutated PL grammars
Context-Free Grammars

SinBAD

Search Based Ambiguity Detection

Search-Based

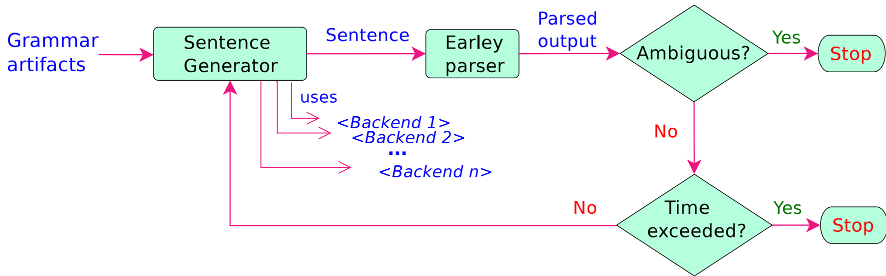
=

aim to find **good enough** solutions

Pure random
=
simple + scan randomly

Heuristics
=
fitness function + guided search

SinBAD



dynamic1

non-deterministic approach
to ambiguity detection

generate(G, *rule*, d, D, *sentence*):

```
if (d > D)
    alt ← favour-alternative(rule)
else
    alt ← pick an alternative randomly
for α ∈ alt
    if α ∈ non-terminals
        alt → generate(..,d+1,..)
    else
        sentence.append(α)
Keep count of rule.entered and rule.exited
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Favour Alternative

```
favour-alternative(rule):
    scores ← [ ]
    for alt ∈ rule
        score ← 0
        for α ∈ alt
            if α ∈ non-terminals
                score += (1 - (α.exited/α.entered))
        scores ← score
    alts ← { alternatives of rule whose score = min(scores) }
    return random(alts)
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II. Grammar Generation

Random grammars

based on Boltzmann sampling

Boltzmann Specification for CFGs

Cfg = Cfg Rule ... Rule

Rule = SingleAlt Alt | RuleAlts1 Rule Alt

Alt = EmptyAltSyms | SingleAltSyms1 Symbol | AltSyms1 Alt Symbol

Symbol = NonTerm NonTerm | Term Term

NonTerm = NonTerm1 | NonTerm2 | ... | NonTermN

Term = Term1 | Term2 | ... | TermN

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Mutated grammar

=

unambiguous grammar

+

single mutation

Types of Mutations

- Add empty
- Mutate symbol
- Add symbol
- Delete symbol

Ambiguity is statically undecidable: so how do we evaluate a tool?

III. Experiment

Experiment Methodology

- Comparative study
- Grammar sets
- Sub-experiments: mini, main and verification

Tools Selected

Tools:

- ACLA (approximation)
- AMBER (exhaustive search)
- AmbiDexter (filtering + search)
- dynamic1 (non-deterministic)

Various tools and options

+

lots of grammars

$\triangleq$

mini experiment

- 400 random grammars

Mini Experiment

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Best options → main experiment

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- 160 mutated PL grammars
- 20 manually modified PL grammars
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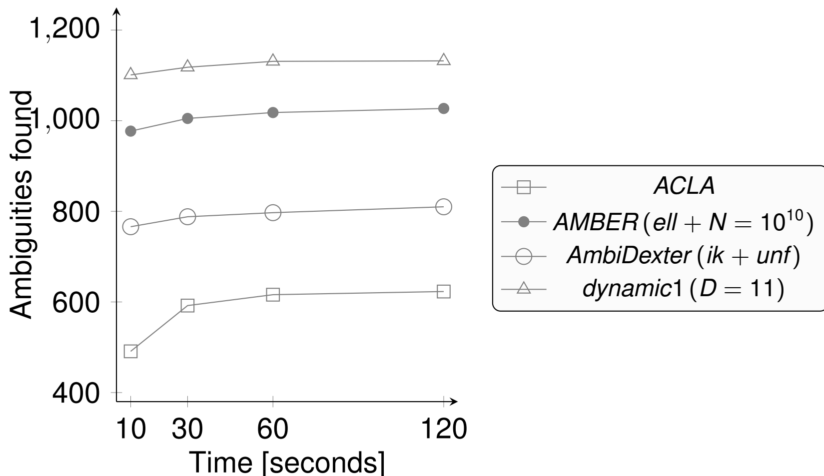
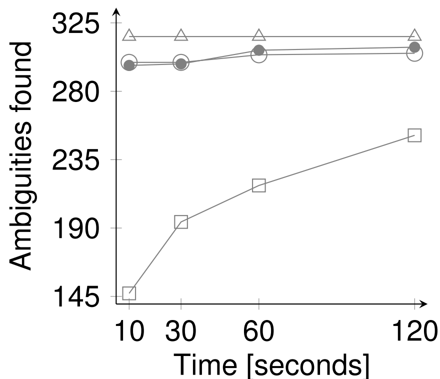
Best options $\rightarrow$ main experiment

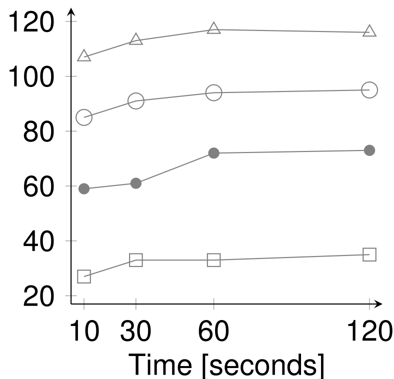
$$\text{Main experiment} = \text{mini experiment} \times 7$$

Boltzmann sampled grammars (1600)



Results





ACLA
AMBER (*len* = 15)
AmbiDexter (*k* = 15 + *SLR*1)
*dynamic*1 (*D* = 17)

Verification experiment

=

main experiment $\times$ 5

dynamic1:

- Simple heursitic

Summary

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http://soft-dev.org/