Next Syntactic-Unit Code Completion and Applications

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Introduction

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2  while (textFile.hasNextLine())
3  {
4     String line;
5  }
```

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2  while (textFile.hasNextLine())
3  {
4     String line;
5     if (CondExpr) break;
6  }
```

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- In this work, we specifically focus on synthesizing *syntactic units* at ***any*** location.
- This is especially useful for other general program synthesis tasks such as *automated program repair*, *test generation in automated testing*, etc., which make use of one such code completion (CC) engine.

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- Code statements are project-specific, thus rendering code mining and information retrieval (IR)-based approaches ineffective.
- More recent large language model (LLM)-based approaches
  - can recommend syntactically incorrect or undefined code
  - can invoke functions/methods outside the scope of the codebase.

Our Approach: ASTCC

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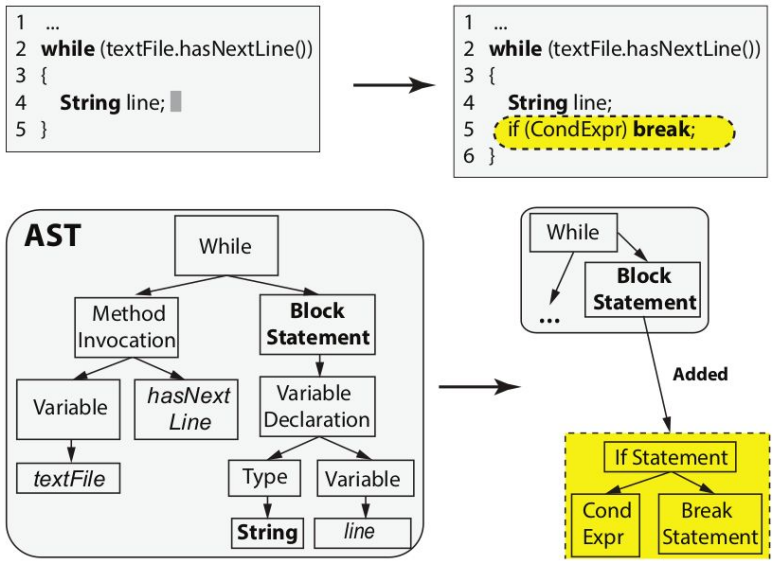

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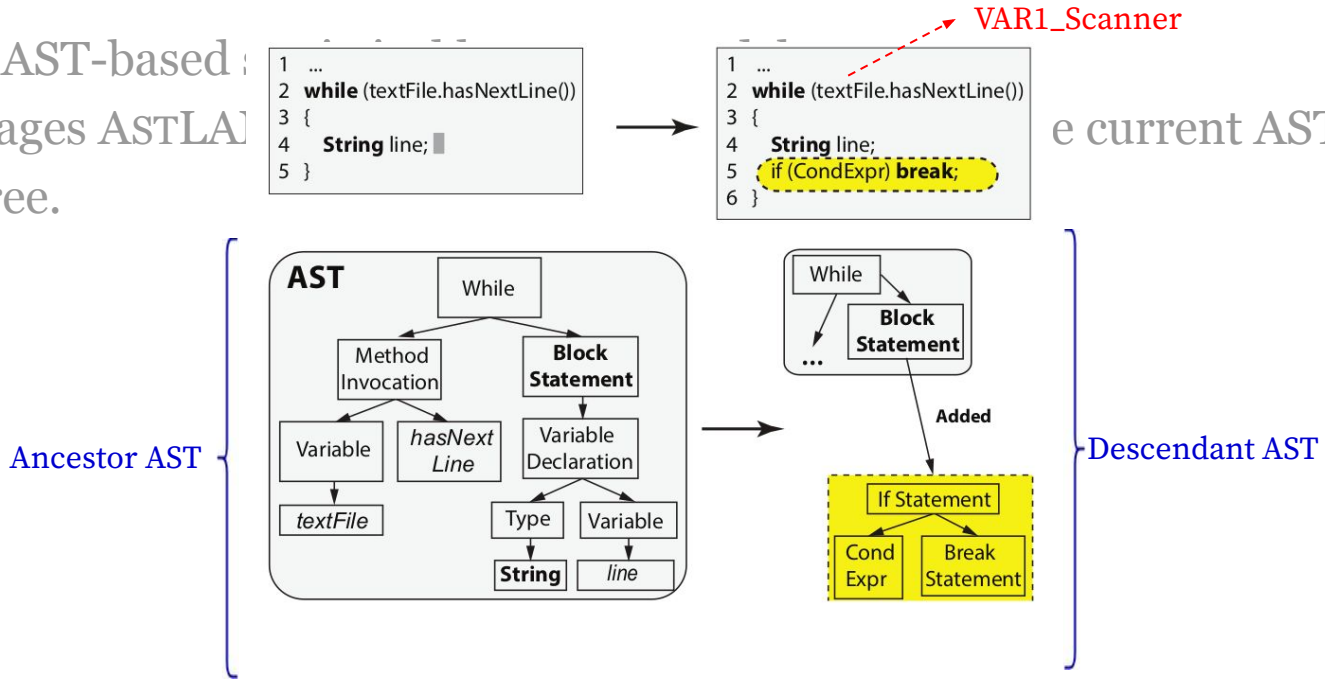

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Step 1. Training for ASTLAN.

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Step 1. Training for *A*

Syntax	Valid Expansion
If ::= **if** E S1 S2	If → E, S1 If → E, S1, S2
While ::= **while** E Stmt	While → E While → E, Stmt
For ::= **for** Init E Update Stmt	For → Init, E, Update For → Init, E, Update, Stmt
Switch ::= **switch** E Case* Def	Switch → E Switch → E, F with F ∈ all Case combinations Switch → E, Def Switch → E, F, Def with F ∈ all Case combs
Case ::= **case** E: Stmt	Case → E Case → E, Stmt
InfixOp ::= E1 Op E2	InfixOp → E1, E2
EnhancedFor ::= VarDec, Ref, Stmt	ForEach → VarDec, Ref ForEach → VarDec, Ref, Stmt
Do ::= Stmt, Cond	Do → Stmt, Cond
Try ::= **try** Block {Catches | Finally}	Try → Block, all combinations of Catches Try → Block, Finally Try → Block , all comb. of Catches, Finally
Conditional ::= E1 ? E2 : E3	Conditional → E1, E2, E3
Synchronized ::= Exp, Stmt	Synchronized → Exp, Stmt
Labeled ::= Lit, Stmt	Labeled → Lit, Stmt
Variable Dec. ::= TypeRef, VarSpec	VarDec → TypeRef, VarSpec
Variable Spec. ::= Name, Init	VarSpec → Name VarSpec → Name, Init
Type Reference ::= TypeName, TypeArg	TypeRef → TypeName TypeRef → TypeName, TypeArg
Other	All combinations

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$$Pr(C(t)|Ctxt) = Pr((t, N^+, E^+)|t_1, .., t_n)$$
$$= \frac{\#methods(t_1, C(t))+\alpha}{\#method(C(t))+\alpha.\#methods} \cdots \frac{\#methods(t_{(i-1)}, C(t))+\alpha}{\#method(C(t))+\alpha.\#methods} \cdot \frac{\#methods(t, C(t))}{\#methods(t)} \cdot \frac{\#methods(t)}{\#methods} \cdots \frac{\#methods(t_n, C(t))+\alpha}{\#method(C(t))+\alpha.\#methods}$$

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Step 1. Training for ASTLAN.

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Step 3. Variable names' concretization in the syntactic template.

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Algorithm 1 Concretizing Syntactic Template

```
1:  function Main(templ, V)
2:      candList = concretizeNext(templ, V, ∅, 1)
3:      return candList

4:  function Concretize(templ,V,curCandList,loc)
5:      if loc > size(templ) then return curCandList
6:      codeCands = ∅
7:      codeTokens = α(templ[loc], V)
8:      if curCandList = ∅ then
9:          for all t ∈ codeTokens do
10:             newCand = connect(EMPTY_TREE, t)
11:             codeCands.adds(newCand)
12:     else
13:         for all t ∈ codeTokens do
14:             for all cand ∈ curCandList do
15:                 newCand = connect(cand, t)
16:                 codeCands.adds(newCand)
17:     return Concretize(templ, V, codeCands, DFS.next(loc))
```

Preliminary Empirical Evaluation

We evaluate accuracy of ASTCC in:

1. suggesting next *syntactic-unit*
2. suggesting next *statement*

1. *Next Syntactic-Unit Code Completion*

- Data Collection
  -

Total projects	1,000
Total classes	104,645
Total methods	638,293
Total SLOCs	7,144,198
Total valid AST's fragments	1,047,614,720
Total distinctive fragments	36,608,102
Total distinctive AST nodes	302,367

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- Evaluation Metrics
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- Experimental Results
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Top-1	Top-2	Top-3	Top-4	Top-5
33.2	**42.6**	**43.7**	**50.6**	**62.1**

2. *Next Statement Code Completion*

- Experimental Results
  -

	Top 1	Top 3	Top 6	Top 10
AutoSC [15]	20.3	28.5	32.0	42.2
PCC [19]	28.9	51.1	54.8	59.3
AstCC	35.1	59.0	67.8	80.7

Future Applications and Plan

1. Real-world Code Completion Benchmark and Human Studies.
2. Syntactic Patterns Mining
3. Automated Program Repair
4. Using ASTCC in Automated Unit Test Generation

Summary

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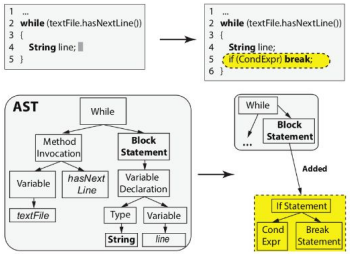

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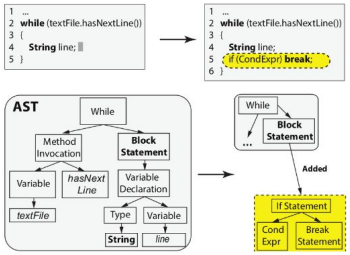

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- AstCC can correctly suggest the next *syntactic unit* in 33% of the cases, and in 62% of the cases, it correctly suggests within five candidates
- AstCC can correctly suggest the next *statement* in 35% of the cases, and in 80% of the cases, it correctly suggests within ten candidates

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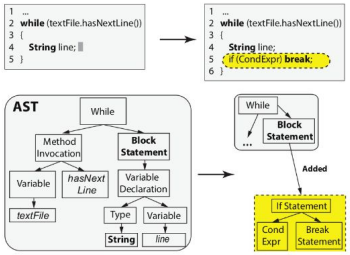

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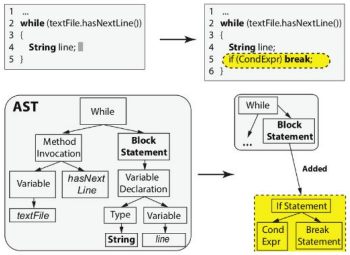

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...feel free to reach out to us if you've any questions :)

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