Dec. 8

Exam Review Q&A

FOLLOW Set

var.

$$\text{FOLLOW}(V) = \{ w \mid w, x, y \in \Sigma^* \wedge V \overset{*}{\Rightarrow} x \wedge S \overset{*}{\Rightarrow} xwy \}$$

a member in the Follow(V)

Right-Recursive CFG:

0	*Goal*	→	*Expr*	6	*Term′*	→	x *Factor Term′*
1	*Expr*	→	*Term Expr′*	7		|	÷ *Factor Term′*
2	*Expr′*	→	+ *Term Expr′*	8		|	ϵ
3		|	- *Term Expr′*	9	*Factor*	→	(*Expr*)
4		|	ϵ	10		|	num
5	*Term*	→	*Factor Term′*	11		|	name

	Expr	Expr′	Term	Term′	Factor
FIRST	(, name, num	+, -, ϵ	(, name, num	x, ÷, ϵ	(, name, num

	Expr	Expr′	Term	Term′	Factor
FOLLOW	eof,)	eof,)	eof, +, -,)	eof, +, -,)	eof, +, -, x, ÷,)

FOLLOW Set: Algorithm

$$\textsc{Follow}(v) = \{w \mid w, x, y \in \Sigma^* \wedge v \overset{*}{\Rightarrow} x \wedge S \overset{*}{\Rightarrow} xwy\}$$

```
ALGORITHM: GetFollow
   INPUT: CFG G = (V, Σ, R, S)
   OUTPUT: FOLLOW : V ⟶ ℙ(T ∪ {eof})
PROCEDURE:
   for A ∈ V: FOLLOW(A) := ∅
   FOLLOW(S) := {eof}
   lastFollow := ∅
   while (lastFollow ≠ FOLLOW):
      lastFollow := FOLLOW
      for A → β1 β2 ... βk ∈ R:
         trailer := FOLLOW(A)
         for i: k .. 1:
            if βi ∈ V then
               FOLLOW(βi) := FOLLOW(βi) ∪ trailer
               if ε ∈ FIRST(βi)
                  then trailer := trailer ∪ (FIRST(βi) − ε)
                  else trailer := FIRST(βi)
            else
               trailer := FIRST(βi)
```

May update the Follow of $\beta_k, \beta_{k-1}, \ldots, \beta_2, \beta_1$

$A \to \beta_1 \beta_2$

trailer = F(A)

$$A \longrightarrow \beta_1 \; \beta_2 \quad \cdots \quad \beta_{k-1} \mid \beta_k$$

FOLLOW(β_k) = ?

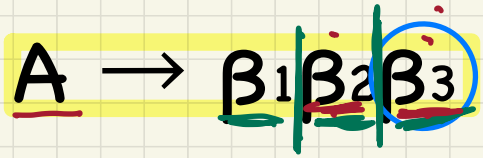
When $\varepsilon \in$ FIRST(β_k)

FOLLOW(β_{k-1}) = ?

When $\varepsilon \notin$ FIRST(β_k)

FOLLOW(β_{k-1}) = ?

Computing the FOLLOW Sets: Trailers



$\varepsilon \in FIRST(\beta_3)$
$\varepsilon \notin FIRST(\beta_3)$

Case 1: $\varepsilon \notin$ FIRST(β_3), $\varepsilon \notin$ FIRST(β_2)

+ FOLLOW(β_3) = Follow(A)
+ FOLLOW(β_2) = FIRST(β_3) ∪ Follow(A)
+ FOLLOW(β_1) = FIRST(β_2) ∪ FIRST(β_3) ∪ Follow(A)

not nullable

not nullable

∵ $\varepsilon \notin FIRST(\beta_3)$

∵ $\varepsilon \notin FIRST(\beta_2)$

∵ both β_2 and β_3 are not nullable

Case 2: $\varepsilon \in$ FIRST(β_3), $\varepsilon \in$ FIRST(β_2)

+ FOLLOW(β_3)
+ FOLLOW(β_2)
+ FOLLOW(β_1)

Right-Recursive CFG:

0	*Goal*	→	*Expr*	6	*Term′*	→	× *Factor Term′*
1	*Expr*	→	*Term Expr′*	7		|	÷ *Factor Term′*
2	*Expr′*	→	+ *Term Expr′*	8		|	ϵ
3		|	- *Term Expr′*	9	*Factor*	→	(*Expr*)
4		|	ϵ	10		|	num
5	*Term*	→	*Factor Term′*	11		|	name

FIRST(>) = {>}

Follow(Expr) not including Follow(F) not nullable

G, F, E, T, T′

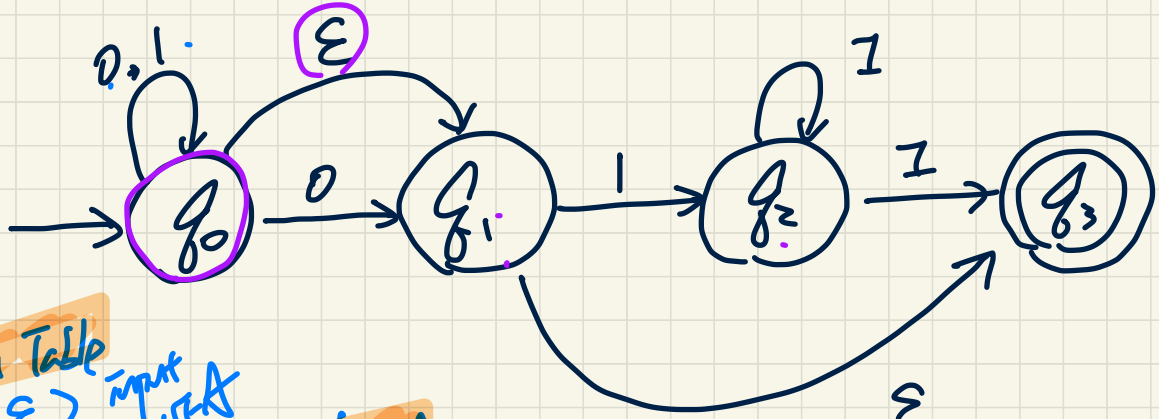
```
ALGORITHM: GetFollow
  INPUT: CFG G = (V, Σ, R, S)
  OUTPUT: FOLLOW : V ⟶ ℙ(T ∪ {eof})
PROCEDURE:
  for A ∈ V: FOLLOW(A) := ∅
  FOLLOW(S) := {eof}
  lastFollow := ∅
  while (lastFollow ≠ FOLLOW):
    lastFollow := FOLLOW
    for A → β1 β2 ... βk ∈ R:
      trailer := FOLLOW(A)
      for i: k .. 1:
        if βi ∈ V then
          FOLLOW(βi) := FOLLOW(βi) ∪ trailer
          if ϵ ∈ FIRST(βi)
            then trailer := trailer ∪ (FIRST(βi) − ϵ)
            else trailer := FIRST(βi)
        else
          trailer := FIRST(βi)
```

FOLLOW Set: Tracing

First choose rules whose LHS is processed. Then rules whose RHS ends with a terminal.

	Expr	Expr′	Term	Term′	Factor
FIRST	(, name, num	+, -, ϵ	(, name, num	×, ÷, ϵ	(, name, num

Goal	Expr	Expr′	Term	Term′	Factor
~~∅~~	∅	∅	∅	∅	∅
eof	eof				
	)				



Transition Table (ε) input ε-NFA

	ε
q_0	$\{q_1\}$
q_1	$\{q_3\}$
q_2	ϕ
q_3	ϕ

ε-closure

$E\text{-close}(q_0) = \{q_0, q_1, q_3\}$

$E\text{-close}(q_1) = \{q_1, q_3\}$

Transition Table (output DFA)

	0	1
$\{q_0, q_1, q_3\}$	$\delta(q_0,0) \cup \delta(q_1,0) \cup \delta(q_3,0)$ E-CLOSE(each state)	
E-close(q_0)		

ε

* you don't need to trace line by line

Lexical Analysis

↳ slide 40 * (NFA → DFA)

↳ slide 57 (minimize DFA)

↳ slide 62 (NextWord)

Syntactic Analysis

↳ slide 34 (TDParse)

↳ slide 38 (RemoveLR)

↳ slide 61 (BUParse)

↳ slide 73 (closure)

↳ slide 44 * (GetFirst)

↳ slide 49 * (GetFollow)

↳ slide 82 (table)

↳ slide 75 (goto)

↳ slide 77 (BuildCC)