Tutorial 5

Q1.

(1) According to the notes — «Syntax Analysis» P_{25}, we should do the left-factoring for the production: $S \to (L) | aS | a$.

That means: $A \to \alpha\beta_1 | \cdots | \alpha\beta_k | \gamma_1 | \cdots | \gamma_n$

$$\xrightarrow[\text{changed as}]{\text{should be}} \begin{cases} A \to \alpha A' | \gamma_1 | \cdots | \gamma_n \\ A' \to \beta_1 | \cdots | \beta_k \end{cases}$$

So. $S \to \underbrace{(L)}_{\gamma_1} | a\underbrace{S}_{\beta_1} | a\underbrace{\varepsilon}_{\beta_2}$

$$\Rightarrow \begin{array}{l} S \to (L) | aS' \\ S' \to S | \varepsilon \end{array}$$

(2) Similarly, according to the notes. P_{27}, we should eleminate the left recursion for the production: $L \to L,S | S$.

That means: $A \to A\alpha_1 | \cdots | A\alpha_k | \beta_1 | \cdots | \beta_n$

$$\xrightarrow[\text{changed as}]{\text{should be}} \begin{cases} A \to \beta_1 A' | \cdots | \beta_n A' \\ A' \to \alpha_1 A' | \cdots | \alpha_k A' | \varepsilon \end{cases}$$

So, $L \to L\underbrace{,S}_{\alpha} | \underbrace{S}_{\beta}$

$$\Rightarrow \begin{array}{l} L \to SL' \\ L' \to ,SL' | \varepsilon \end{array}$$

So, we can get the estimate form after doing the Left-factoring and left-recursion:

$$\begin{array}{l} S \to (L) | aS' \\ S' \to S | \varepsilon \\ L \to SL' \\ L' \to ,SL' | \varepsilon \end{array}$$

Q2

$$\begin{array}{l} S \to E+S | E \\ E \to num | (S) \end{array}$$

(1) After doing the Left-factoring, the grammar will become as:

$$\begin{array}{l} S \to ES' \\ S' \to \varepsilon | +S \\ E \to num | (S) \end{array}$$

(2) P44-45. According to the note, nonterminals are S, S', E; terminals are ε, +, num, (,).

Determining FIRST(X)

1. if X is a terminal, then add X to FIRST(X).
2. if $X \to \varepsilon$ then add ε to FIRST(X).
3. if X is a nonterminal and $X \to Y_1Y_2 \cdots Y_k$, then a is in FIRST(X) if a is in FIRST(Y_i) and ε is in FIRST(Y_j) for $j = 1, 2, \cdots, i-1$ (i.e. its possible to have an empty prefix $Y_1 Y_2 \cdots Y_{k-1}$.
4. if ε is in FIRST($Y_1 Y_2 \cdots Y_k$) then ε is in FIRST(X).

① According to $S' \to \varepsilon | +S$, we should add ε, + into FIRST(S'), then we have FIRST(S') = {ε, + ;
According to $E \to num | (S)$, we should add num, (into FIRST(E), then we have FIRST(E) = {num, (,

② According to $S \to ES'$, here ε is not in FIRST(E). So, FIRST(E) − ε should be added into FIRST(S). So, FIRST(S) = {num, (.

There is no other spare prodution which can be used to analyze. So we can get the FIRST set as follows:

FIRST(S) = {num, (}

FIRST(S') = {ε, +}

FIRST(E) = {num, (}

(3) Determing the FOLLOW set

P45

Determining FOLLOW(X)

1. if S is the start symbol then \$ is in Follow(S).
2. if $A \to \alpha B \beta$ then add all FIRST(β) != ε to FOLLOW(B).
3. if $A \to \alpha B$ or $\alpha B \beta$ and ε is in FIRST(β) then add FOLLOW(A) to FOLLOW(B)

According to the rules, we should determine the containment relationship of the nonterminals.

① 1° $S \to ES'$, then $FOLLOW(S) \subseteq Follow(S')$

2° As $S' \to \varepsilon$, combine with $S \to ES'$, then $S \xrightarrow{*} E$, that is to say $S \to \underset{\alpha}{\varepsilon}\underset{B}{E}$

then $Follow(S) \subseteq Follow(E)$

3° $S' \to +S$, then $FOLLOW(S') \subseteq FOLLOW(S)$

In one word. $\begin{cases} Follow(S) = FOLLOW(S') \\ Follow(S) \subseteq Follow(E) \end{cases}$

② According to rule 1, Follow(S) = {\$,

③ According to rule 2.

1° $S \to ES'$ can be seen as $S \to \underset{\alpha}{\varepsilon}\underset{B}{E}\underset{\beta}{S'}$

So FIRST(S') − ε should be add into Follow(E)

So FOLLOW(E) = {+

2° $E \to (S)$ then) should be added into Follow(S) So FOLLOW(S) = {\$,)

Combine with ① ② ③, we can get:

Follow(S) = {\$,)}

Follow(S') = {\$,)}

Follow(E) = {+, \$,)}

(4) Determine the parsing table.

FIRST OF ALL, we can use the Select table to get the parsing Table.

Determine the Select set.

对于产生式A→α,集合select(A→α)定义如下:

①若α不能推出ε,则select(A→α)=FIRST(α).

②若α能推出ε,则select(A→α) = FIRST(α) ∪ FOLLOW(A)

③如果Select(A→α)={a,b,c},那么需要将A→α填进A行a列,A行b列,A行c列.

1° Here, Select($S \to ES'$) = FIRST(ES) = FIRST(E) = {num, (}

2° Select($S' \to \varepsilon$) = FIRST(ε) ∪ Follow(S')
= {ε} ∪ {\$,)}
= {\$,), ε}

3° Select($S' \to +S$) = FIRST(+S) = {+}

4° select($E \to num$) = FIRST(num) = {num}

5° select($E \to (S)$) = FIRST((S)) = {(}

So we can construct the parsing table.

the column is about the nonterminals.

the row is about the terminals (except for ε).

	+	num	(	)	\$
S		$S \to ES'$	$S \to ES'$		
S'	$S' \to +S$			$S' \to \varepsilon$	$S' \to \varepsilon$
E		$E \to num$	$E \to (S)$		

There is no conflict in this table.

So this grammar is LL(1) grammar

(5) string: $(1+2+(3+4))+5$

Grammar: $S \rightarrow ES'$

$S' \rightarrow \varepsilon \mid +S$

$E \rightarrow num \mid (S)$

Using Leftmost derivation

$$S \xrightarrow{S\to ES'} ES' \xrightarrow{E\to(S)} (S)S' \xrightarrow{S\to ES'} (ES')S'$$

$$\xrightarrow{E\to num} (1S')S' \xrightarrow{S'\to +S} (1+S)S'$$

$$\xrightarrow{S\to ES'} (1+ES')S' \xrightarrow{E\to num} (1+2S')S'$$

$$\xrightarrow{S'\to +S} (1+2+S)S' \xrightarrow{S\to ES'} (1+2+ES')S'$$

$$\xrightarrow{E\to (S)} (1+2+(S)S')S' \xrightarrow{S\to ES'} (1+2+(ES')S')S'$$

$$\xrightarrow{E\to num} (1+2+(3S')S')S' \xrightarrow{S'\to +S} (1+2+(3+S)S')S'$$

$$\xrightarrow{S\to ES'} (1+2+(3+ES')S')S' \xrightarrow{E\to num} (1+2+(3+4S')S')S'$$

$$\xrightarrow{S'\to \varepsilon} (1+2+(3+4)S')S' \xrightarrow{S'\to\varepsilon} (1+2+(3+4))S'$$

$$\xrightarrow{S'\to +S} (1+2+(3+4))+S \xrightarrow{S\to ES'} (1+2+(3+4))+ES'$$

$$\xrightarrow{E\to num} (1+2+(3+4))+5S' \xrightarrow{S'\to\varepsilon} (1+2+(3+4))+5$$

Stack	Input	Output
$\$S$	$(1+2+(3+4))+5\$$	
$\$S'E$	$(1+2+(3+4))+5\$$	$S\rightarrow ES'$
$\$S')S($	$(1+2+(3+4))+5\$$	$E\rightarrow(S)$
$\$S')S$	$1+2+(3+4))+5\$$	
$\$S')S'E$	$1+2+(3+4))+5\$$	$S\rightarrow ES'$
$\$S')S'1$	$1+2+(3+4))+5\$$	$E\rightarrow num$
$\$S')S'$	$+2+(3+4))+5\$$	
$\$S')S+$	$+2+(3+4))+5\$$	$S'\rightarrow +S$
$\$S')S$	$2+(3+4))+5\$$	
$\$S')S'E$	$2+(3+4))+5\$$	$S\rightarrow ES'$
$\$S')S'2$	$2+(3+4))+5\$$	$E\rightarrow num$
$\$S')S'$	$+(3+4))+5\$$	
$\$S')S+$	$+(3+4))+5\$$	$S'\rightarrow +S$
$\$S')S$	$(3+4))+5\$$	
$\$S')S'E$	$(3+4))+5\$$	$S\rightarrow ES'$
$\$S')S')S($	$(3+4))+5\$$	$E\rightarrow(S)$
$\$S')S')S$	$3+4))+5\$$	
$\$S')S')S'E$	$3+4))+5\$$	$S\rightarrow ES'$
$\$S')S')S'3$	$3+4))+5\$$	$E\rightarrow num$
$\$S')S')S'$	$+4))+5\$$	

Stack	Input	Output
$\$S')S')S+$	$+4))+5\$$	$S'\rightarrow +S$
$\$S')S')S$	$4))+5\$$	
$\$S')S')S'E$	$4))+5\$$	$S\rightarrow ES'$
$\$S')S')S'4$	$4))+5\$$	$E\rightarrow num$
$\$S')S')S'$	$))+5\$$	
$\$S')S')$	$))+5\$$	$S'\rightarrow\varepsilon$
$\$S')S'$	$)+5\$$	
$\$S')$	$)+5\$$	$S'\rightarrow\varepsilon$
$\$S'$	$+5\$$	
$\$S+$	$+5\$$	$S'\rightarrow +S$
$\$S$	$5\$$	
$\$S'E$	$5\$$	$S\rightarrow ES'$
$\$S'5$	$5\$$	$E\rightarrow num$
$\$S'$	$\$$	
$\$$	$\$$	$S'\rightarrow\varepsilon$