

# 编译原理—习题五参考答案

2019(1)

5.1 设一NDPDA识别由下述CFG定义的语言，试给出这个NDPDA的完整形式描述。

$$S \rightarrow SASC \mid \varepsilon$$

$$A \rightarrow Aa \mid b$$

$$C \rightarrow DcD$$

$$D \rightarrow d$$

解：根据算法5.1 从CFG到NDPDA,  $\delta$ 规则为：

$$(1) \delta(q, a, a) = (q, \varepsilon)$$

$$(2) \delta(q, b, b) = (q, \varepsilon)$$

$$(3) \delta(q, c, c) = (q, \varepsilon)$$

$$(4) \delta(q, d, d) = (q, \varepsilon)$$

$$(5) \delta(q, S, \varepsilon) = \{ (q, SASC), (q, \varepsilon) \}$$

$$(6) \delta(q, A, \varepsilon) = \{ (q, Aa), (q, b) \}$$

$$(7) \delta(q, C, \varepsilon) = (q, DcD)$$

$$(8) \delta(q, D, \varepsilon) = (q, d)$$

算法5.1 给定 CFG  $G = (N, \Sigma, P, S)$  可以构造一个相应的非确定的PDA  $M$ :

$$M = (Q, \Sigma', H, \delta, q_0, Z_0, F)$$

它只有一个状态 $q$ 和下面的转换规则:

- ① 对 $P$ 中每一个形如 $A \rightarrow w$ 的产生式,  $\delta(q, \varepsilon, A)$ 包含 $(q, w)$ ;
- ② 对每个 $a \in \Sigma$ ,  $\delta(p, a, a)$ 包含 $(q, \varepsilon)$  且

$$Q = \{q\}$$

$$\Sigma' = \Sigma$$

$$H = N \cup \Sigma$$

$$q_0 = q$$

$$Z_0 = S$$

$F$ 为终态集(可空)。

这个PDA停止于空栈。

## 5.2 消除下列文法的左递归

①  $G[A]$ :

$$A \rightarrow Bx \mid Cz \mid w \quad (1)$$

$$B \rightarrow Ab \mid Bc \quad (2)$$

$$C \rightarrow Ax \mid By \mid Cp \quad (3)$$

解： 将 (1) 代入 (2) 得

$$B \rightarrow Bxb \mid Czb \mid wb \mid Bc$$

消除左递归

$$B \rightarrow CzbB' \mid wbB' \quad (4)$$

$$B' \rightarrow xbB' \mid cB' \mid \varepsilon \quad (5)$$

将 (1) 代入 (3) 得

$$C \rightarrow Bxx \mid Czx \mid wx \mid By \mid Cp \quad (6)$$

将 (4) 代入 (6) 得

$$\begin{aligned} C \rightarrow & CzbB'xx \mid wbB'xx \mid Czx \mid wx \\ & \mid CzbB'y \mid wbB'y \mid Cp \end{aligned}$$

消除左递归

$$C \rightarrow wbB'xxC' \mid wxC' \mid wbB'yC'$$

$$C' \rightarrow CzbB'xxC' \mid zxC' \mid zbB'yC' \mid pC' \mid \varepsilon$$

最后得

$$A \rightarrow Bx \mid Cz \mid w$$

$$B \rightarrow CzbB' \mid wbB'$$

$$B' \rightarrow xbB' \mid cB' \mid \varepsilon$$

$$C \rightarrow wbB'xxC' \mid wxC' \mid wbB'yC'$$

$$C' \rightarrow CzbB'xxC' \mid zxC' \mid zbB'yC' \mid pC' \mid \varepsilon$$

## 5.2消除下列文法的左递归

②  $G[E]$ :

$$E \rightarrow ET+ \mid ET- \mid T$$

$$T \rightarrow TF^* \mid TF/ \mid F$$

$$F \rightarrow (E) \mid i$$

解:  $E \rightarrow TE'$

$$E' \rightarrow T+E' \mid T-E \mid \varepsilon$$

$$T \rightarrow FT'$$

$$T' \rightarrow F^*T' \mid F/T' \mid \varepsilon$$

$$F \rightarrow (E) \mid i$$

## 5.2消除下列文法的左递归

③  $G[X]$ :

$$X \rightarrow Ya \mid Zb \mid c \quad (1)$$

$$Y \rightarrow Zd \mid Xe \mid f \quad (2)$$

$$Z \rightarrow Xc \mid Yf \mid a \quad (3)$$

解：将(1)代入(2)得

$$Y \rightarrow Zd \mid Yae \mid Zbe \mid ce \mid f$$

消除左递归

$$Y \rightarrow ZdY' \mid ZbeY' \mid ceY' \mid fY' \quad (4)$$

$$Y' \rightarrow aeY' \mid \varepsilon \quad (5)$$

将(1)代入(3)得

$$Z \rightarrow Yac \mid Zbc \mid cc \mid Yf \mid a \quad (6)$$

将(4)代入(6)得

$$\begin{aligned} Z \rightarrow & ZdY'ac \mid ZbeY'ac \mid ceY'ac \\ & \mid fY'ac \mid Zbc \mid cc \mid ZdY'f \\ & \mid ZbeY'f \mid ceY'f \mid fY'f \mid a \end{aligned}$$

消除左递归

$$\begin{aligned} Z \rightarrow & ceY'acZ' \mid fY'acZ' \mid ccZ' \\ & \mid ceY'fZ' \mid fY'fZ' \mid aZ' \\ Z' \rightarrow & dY'acZ' \mid beY'acZ' \mid bcZ' \\ & \mid dY'fZ' \mid beY'fZ' \mid \varepsilon \end{aligned}$$

最后得

$$\begin{aligned} X \rightarrow & Ya \mid Zb \mid c \\ Y \rightarrow & ZdY' \mid ZbeY' \mid ceY' \mid fY' \\ Y' \rightarrow & aeY' \mid \varepsilon \\ Z \rightarrow & ceY'acZ' \mid fY'acZ' \mid ccZ' \mid c \\ & eY'fZ' \mid fY'fZ' \mid aZ' \\ Z' \rightarrow & dY'acZ' \mid beY'acZ' \mid bcZ' \\ & dY'fZ' \mid beY'fZ' \mid \varepsilon \end{aligned}$$

5.3 设文法  $G[E]$ :  $E \rightarrow TE'$      $E' \rightarrow +E' | \varepsilon$      $T \rightarrow FT'$      $T' \rightarrow T | \varepsilon$   
 $F \rightarrow PF'$      $F' \rightarrow *F | \varepsilon$      $P \rightarrow (E) | a | ^$

① 构造该文法的递归下降分析程序;

解: 无左递归

```
int PE() { if PT() return PE'(); else return Error; }
int PE'() { j++; if (ch[j]=='+') return PE'(); else {j--;return OK; }}
int PT() { if PF() return PT'(); else return Error; }
int PT'() { if PT() return OK ;else return OK; }
int PF() { if PP() return PF'(); else return Error; }
int PF'() { j++;if (ch[j]=='*') return PF(); else{j--; return OK; }}
int PP()
{ j++;
  if (ch[j]=='('){ if PE(){j++ ;if (ch[j]==')' return OK};
                  else return Error;} else return Error;}
  else if (ch[j]=='a') return OK;
  else if (ch[j]=='^') return OK;
  else return Error;
}
```

### 5.3 设文法G[E]:

$$E \rightarrow TE' \quad E' \rightarrow +E' | \varepsilon \quad T \rightarrow FT' \quad T' \rightarrow T | \varepsilon$$

$$F \rightarrow PF' \quad F' \rightarrow *F | \varepsilon \quad P \rightarrow (E) | a | ^$$

② 求该文法的每一个非终结符的FIRST和FOLLOW集合;

非终结符	FIRST	FOLLOW
E	(, a, ^	), #
E'	+, $\varepsilon$	), #
T	(, a, ^	+, ), #
T'	(, a, ^, $\varepsilon$	+, ), #
F	(, a, ^	(, a, ^, +, ), #
F'	*, $\varepsilon$	(, a, ^, +, ), #
P	(, a, ^	(, a, ^, +, *, ), #



5.3 设文法G[E]:

$E \rightarrow TE'$

$E' \rightarrow +E' \mid \varepsilon$

$T \rightarrow FT'$

$T' \rightarrow T \mid \varepsilon$

$F \rightarrow PF'$

$F' \rightarrow *F \mid \varepsilon$

$P \rightarrow (E) \mid a \mid ^$

③ 构造该文法的LL(1)分析表，并判断此文法是否LL(1)文法。

解：是LL(1)文法，因为下表无冲突

	a	^	+	*	(	)	#
E	$E \rightarrow TE'$	$E \rightarrow TE'$			$E \rightarrow TE'$		
E'			$E' \rightarrow +E'$			$E' \rightarrow \varepsilon$	$E' \rightarrow \varepsilon$
T	$T \rightarrow FT'$	$T \rightarrow FT'$			$T \rightarrow FT'$		
T'	$T' \rightarrow T$	$T' \rightarrow T$	$T' \rightarrow \varepsilon$		$T' \rightarrow T$	$T' \rightarrow \varepsilon$	$T' \rightarrow \varepsilon$
F	$F \rightarrow PF'$	$F \rightarrow PF'$			$F \rightarrow PF'$		
F'	$F' \rightarrow \varepsilon$	$F' \rightarrow \varepsilon$	$F' \rightarrow \varepsilon$	$F' \rightarrow *F$	$F' \rightarrow \varepsilon$	$F' \rightarrow \varepsilon$	$F' \rightarrow \varepsilon$
P	$P \rightarrow a$	$P \rightarrow ^$			$P \rightarrow (E)$		

5.5 设文法G[S]:

$S \rightarrow SbA \mid aa$

$B \rightarrow Sb$

$A \rightarrow Bc$

- ① 将此文法改写为LL(1)文法;
- ② 求文法的每一个非终结符的FIRST集合和FOLLOW集合。
- ③ 构造相应的LL(1)分析表。

解: ① 消除左递归

$S \rightarrow aaS'$

$S' \rightarrow bAS' \mid \epsilon$

$B \rightarrow Sb$

$A \rightarrow Bc$

②

	FIRST	FOLLOW
S	a	b, #
S'	b, $\epsilon$	b, #
B	a	c
A	a	b, #

③

	a	b	c	#
S	$S \rightarrow aaS'$			
S'		$S' \rightarrow bAS'$ / $S' \rightarrow \epsilon$		$S' \rightarrow \epsilon$
B	$B \rightarrow Sb$			
A	$A \rightarrow Bc$			

## 5.6 设文法G[S]:

$S \rightarrow aABbcd \mid \varepsilon$

$A \rightarrow ASd \mid \varepsilon$

$B \rightarrow SAh \mid eC \mid \varepsilon$

$C \rightarrow Sf \mid Cg \mid \varepsilon$

$D \rightarrow aBD \mid \varepsilon$

① 求每一个非终结符的**FOLLOW**集合；

② 对每一个非终结符的产生式选择，构造**FIRST**集合；

③ 该文法是否**LL(1)**文法？

解： ③ 该文法不是**LL(1)**文法(略)。

	FIRST	FOLLOW
S	a, $\varepsilon$	a, d, f, h, #
A	a, d, $\varepsilon$	a, b, d, h, e
B	a, d, h, e, $\varepsilon$	a, b
C	a, f, g, $\varepsilon$	g, a, b
D	a, $\varepsilon$	

	FIRST
$S \rightarrow aABbcd$	a
$A \rightarrow ASd$	a, d
$B \rightarrow SAh$	a, d, h
$C \rightarrow Sf$	a, f
$C \rightarrow Cg$	a, f, g
$D \rightarrow aBD$	a