

10. ①消  $\varepsilon$  生成式

$$G = (\{S_1, S, A_1, A_2, A_3, A_4, A_5\}$$

$$P : S_1 \rightarrow S / \varepsilon$$

$$S \rightarrow A_1 / A_2$$

$$A_1 \rightarrow A_3 / A_4$$

$$A_2 \rightarrow A_4 / A_5$$

$$A_3 \rightarrow S / b$$

$$A_4 \rightarrow S / a$$

$$A_5 \rightarrow S / d$$

②消单生成式

$$G = (\{S_1, S, A_1, A_2, A_3, A_4, A_5\}$$

$$P : S_1 \rightarrow \varepsilon / a / b / d$$

$$S \rightarrow a / b / d$$

$$A_i \rightarrow a / b / d \quad (i=1,2,3)$$

③删除无用符号

$$G = (\{S_1\}, \{a, b, d\}, P, S)$$

$$P : S_1 \rightarrow \varepsilon / a / b / d$$

## 11 题参考答案:

(1) 由算法 3, 变换为无  $\varepsilon$  生成式:  $N' = S$  由  $S \rightarrow ASB$  得出  $S \rightarrow ASB|AB$ ,  
 由  $A \rightarrow aAS$  得出  $A \rightarrow aAS|aA$ ,  
 由  $B \rightarrow SBS$  得出  $B \rightarrow SBS|SB|BS|B$ ,  
 由  $S N'$  得出  $S1 \rightarrow |S$ ,  
 因此无  $\varepsilon$  的等效文法  $G1 = (S1, S, A, B, a, b, d, P1, S1)$ , 其中生成式  $P1$  如下:

$$S1 \rightarrow |S$$

$$S \rightarrow ASB|AB$$

$$A \rightarrow aAS|aA|a$$

$$B \rightarrow SBS|SB|BS|B|A|bb$$

(2) 由算法 4, 消单生成式:

$NS1 = S1, S$ ,  $NS = S$ ,  $NA = A$ ,  $NB = A, B$  由于  $S \rightarrow ASB|AB$  且不是单生成式, 故  $P1$  中有  $S1 \rightarrow |ASB|AB$ ,

同理有  $S \rightarrow ASB|AB, A \rightarrow aAS|aA|a, B \rightarrow SBS|SB|BS|aAS|aA|a|bb$ ,

因此生成的无单生成式等效文法为:

$G1 = (S1, S, A, B, a, b, P1, S1)$ , 其中生成式  $P1$  如下:

$$S1 \rightarrow |ASB|AB$$

$$S \rightarrow ASB|AB$$

$$A \rightarrow aAS|aA|a$$

$$B \rightarrow SBS|SB|BS|aAS|aA|a|bb$$

(3) 由算法 1 和算法 2, 消除无用符号 (此题没有无用符号);

(4) 转化为等价的 Chomsky 范式的文法: 将  $S1 \rightarrow ASB$  变换为  $S \rightarrow AC, C \rightarrow SB$ , 将  $S \rightarrow ASB$  变换为

$S \rightarrow AC$ , 将  $A \rightarrow aAS|aA$  变换为  $A \rightarrow ED|EA, D \rightarrow AS, E \rightarrow a$ , 将  $B \rightarrow SBS|aAS|aA|a|bb$ , 变换为  $B \rightarrow CS|ED|EA|FF, F \rightarrow$

(5) 由此得出符合题目要求的等价文法:  $G1 = (S1, S, A, B, C, D, a, b, P1, S1)$ , 其中生成式  $P1$  如下:

$$S1 \rightarrow |AC|AB$$

$$S \rightarrow AC|AB$$

$$A \rightarrow ED|EA|a$$

$$B \rightarrow CS|SB|BS|ED|EA|a|FF$$

$$C \rightarrow SB$$

$$D \rightarrow AS$$

$$E \rightarrow a$$

$$F \rightarrow b$$

## 15 题参考答案:

(1):

转化为等价的 Chomsky 范式的文法:

$$\begin{aligned}
 A_1 &\rightarrow A_3 A_4 | A_2 A_5 \\
 A_2 &\rightarrow A_1 A_4 | A_2 A_6 | b \\
 A_3 &\rightarrow A_1 A_5 | A_3 A_7 | a \\
 A_4 &\rightarrow b \\
 A_5 &\rightarrow a \\
 A_6 &\rightarrow A_2 A_5 \\
 A_7 &\rightarrow A_3 A_4
 \end{aligned}$$

(2):

转化为等价的 Greibach 范式的文法: 将非终结符排序为  $A_1, A_2, A_3, A_4, A_5, A_6, A_7$ ,  $A_1$  为低位

$A_7$  为高位, (1) 对于  $A_2 \rightarrow A_1 A_4$ , 用  $A_1 \rightarrow A_3 A_4 | A_2 A_5$  代入得  $A_2 \rightarrow A_3 A_4 A_4 | A_2 A_5 A_4 | A_2 A_6 | b$

用引理 4.2.4, 变化为:

$$A_2 \rightarrow A_3 A_4 A_4 | b | A_3 A_4 A_4 A_2' | b A_2' \quad A_2' \rightarrow A_5 A_4 A_2' | A_6 A_2' | A_5 A_4 | A_6$$

(2) 对于  $A_3 \rightarrow A_1 A_5$ , 用  $A_1 \rightarrow A_3 A_4 | A_2 A_5$  代入得  $A_3 \rightarrow A_3 A_4 A_5 | A_2 A_5 A_5 | A_3 A_7 | a$ ,

$A_3$  生成式右边第一个字符仍是较低位的非终结符, 将  $A_2$  生成式代入  $A_3$  生成式得:

$$A_3 \rightarrow A_3 A_4 A_5 | A_3 A_4 A_4 A_5 A_5 | b A_5 A_5 | A_3 A_4 A_4 A_2' A_5 A_5 | b A_2' A_5 A_5 | A_3 A_7 | a$$

用引理 4.2.4, 变化为:

$$A_3 \rightarrow b A_5 A_5 | b A_2' A_5 A_5 | a | b A_5 A_5 A_3' | b A_2' A_5 A_5 A_3' | a A_3'$$

$$A_3' \rightarrow A_4 A_5 | A_4 A_4 A_5 A_5 | A_4 A_4 A_2' A_5 A_5 | A_7 | A_4 A_5 A_3' | A_4 A_4 A_5 A_5 A_3' | A_4 A_4 A_2' A_5 A_5 A_3' | A_7 A_3'$$

(3) 对于  $A_6 \rightarrow A_2 A_5$ , 将  $A_2$  生成式代入  $A_6$  生成式得:

$$A_6 \rightarrow A_3 A_4 A_4 A_5 | b A_5 | A_3 A_4 A_4 A_2' A_5 | b A_2' A_5$$

$A_6$  生成式右边第一个字符仍是较低位的非终结符, 将  $A_3$  生成式代入  $A_6$  生成式得

$$\begin{aligned}
 A_6 &\rightarrow b A_5 A_5 A_4 A_4 A_5 | b A_2' A_5 A_5 A_4 A_4 A_5 | a A_4 A_4 A_5 | b A_5 A_5 A_3' A_4 A_4 A_5 | b A_2' A_5 A_5 A_3' A_4 A_4 A_5 \\
 &\quad | a A_3' A_4 A_4 A_5 | b A_5 A_5 A_4 A_4 A_2' A_5 | b A_2' A_5 A_5 A_4 A_4 A_2' A_5 | a A_4 A_4 A_2' A_5 | b A_5 A_5 A_3' A_4 A_4 A_2' A_5 \\
 &\quad | b A_2' A_5 A_5 A_3' A_4 A_4 A_2' A_5 | a A_3' A_4 A_4 A_2' A_5 | b A_2' A_5 | b A_5
 \end{aligned}$$

(4) 对于  $A_7 \rightarrow A_3 A_4$ , 将  $A_3$  生成式代入  $A_7$  生成式得:

$$A_7 \rightarrow b A_5 A_5 A_4 | b A_2' A_5 A_5 A_4 | a A_4 | b A_5 A_5 A_3' A_4 | b A_2' A_5 A_5 A_3' A_4 | a A_3' A_4$$

(5) 将  $A_5, A_6$  生成式代入  $A_2'$  生成式得:

$$\begin{aligned}
 A_2' &\rightarrow a A_4 A_2' | b A_5 A_5 A_4 A_4 A_5 A_2' | b A_2' A_5 A_5 A_4 A_4 A_5 A_2' | a A_4 A_4 A_5 A_2' | b A_5 A_5 A_3' A_4 A_4 A_5 A_2' \\
 &\quad | b A_2' A_5 A_5 A_3' A_4 A_4 A_5 A_2' | a A_3' A_4 A_4 A_5 A_2' | b A_5 A_5 A_4 A_4 A_2' A_5 A_2' | b A_2' A_5 A_5 A_4 A_4 A_2' A_5 A_2' \\
 &\quad | a A_4 A_4 A_2' A_5 A_2' | b A_5 A_5 A_3' A_4 A_4 A_2' A_5 A_2' | b A_2' A_5 A_5 A_3' A_4 A_4 A_2' A_5 A_2' | a A_3' A_4 A_4 A_2' A_5 A_2' \\
 &\quad | b A_2' A_5 A_2' | b A_5 A_2' | a A_4 | b A_5 A_5 A_4 A_4 A_5 | b A_2' A_5 A_5 A_4 A_4 A_5 | a A_4 A_4 A_5 | b A_5 A_5 A_3' A_4 A_4 A_5 \\
 &\quad | b A_2' A_5 A_5 A_3' A_4 A_4 A_5 | a A_3' A_4 A_4 A_5 | b A_5 A_5 A_4 A_4 A_2' A_5 | b A_2' A_5 A_5 A_4 A_4 A_2' A_5 | a A_4 A_4 A_2' A_5 \\
 &\quad | b A_5 A_5 A_3' A_4 A_4 A_2' A_5 | b A_2' A_5 A_5 A_3' A_4 A_4 A_2' A_5 | a A_3' A_4 A_4 A_2' A_5 | b A_2' A_5 | b A_5
 \end{aligned}$$

将  $A_4, A_7$  生成式代入  $A_3'$  生成式得

$$\begin{aligned} A_3' \rightarrow & aA_5|aA_4A_5A_5|aA_4A_2'A_5A_5|aA_5A_3'|aA_4A_5A_5A_3'|aA_4A_2'A_5A_5A_3'|bA_5A_5A_4 \\ & |bA_2'A_5A_5A_4|aA_4|bA_5A_5A_3'A_4|bA_2'A_5A_5A_3'A_4|aA_3'A_4|bA_5A_5A_4A_3'|bA_2'A_5A_5A_4A_3' \\ & |aA_4A_3'|bA_5A_5A_3'A_4A_3'|bA_2'A_5A_5A_3'A_4A_3'|aA_3'A_4A_3' \end{aligned}$$

(6) 由此得出等价的 Greibach 范式文法:  $G1 = (S, D, D', a, b, P1, S)$ , 其中生成式  $P1$  如下:

$$A_1 \rightarrow A_3A_4|A_2A_5$$

$$A_2 \rightarrow A_3A_4A_4|b|A_3A_4A_4A_2'|bA_2'$$

$$A_3 \rightarrow bA_5A_5|bA_2'A_5A_5|a|bA_5A_5A_3'|bA_2'A_5A_5A_3'|aA_3'$$

$$A_4 \rightarrow b$$

$$A_5 \rightarrow a$$

$$\begin{aligned} A_6 \rightarrow & bA_5A_5A_4A_4A_5|bA_2'A_5A_5A_4A_4A_5|aA_4A_4A_5|bA_5A_5A_3'A_4A_4A_5|bA_2'A_5A_5A_3'A_4A_4A_5 \\ & |aA_3'A_4A_4A_5|bA_5A_5A_4A_4A_2'A_5|bA_2'A_5A_5A_4A_4A_2'A_5|aA_4A_4A_2'A_5|bA_5A_5A_3'A_4A_4A_2'A_5 \\ & |bA_2'A_5A_5A_3'A_4A_4A_2'A_5|aA_3'A_4A_4A_2'A_5|bA_2'A_5|bA_5 \end{aligned}$$

$$A_7 \rightarrow bA_5A_5A_4|bA_2'A_5A_5A_4|aA_4|bA_5A_5A_3'A_4|bA_2'A_5A_5A_3'A_4|aA_3'A_4$$

$$\begin{aligned} A_2' \rightarrow & aA_4A_2'|bA_5A_5A_4A_4A_5A_2'|bA_2'A_5A_5A_4A_4A_5A_2'|aA_4A_4A_5A_2'|bA_5A_5A_3'A_4A_4A_5A_2' \\ & |bA_2'A_5A_5A_3'A_4A_4A_5A_2'|aA_3'A_4A_4A_5A_2'|bA_5A_5A_4A_4A_2'A_5A_2'|bA_2'A_5A_5A_4A_4A_2'A_5A_2' \\ & |aA_4A_4A_2'A_5A_2'|bA_5A_5A_3'A_4A_4A_2'A_5A_2'|bA_2'A_5A_5A_3'A_4A_4A_2'A_5A_2'|aA_3'A_4A_4A_2'A_5A_2' \\ & |bA_2'A_5A_2'|bA_5A_2'|aA_4|bA_5A_5A_4A_4A_5|bA_2'A_5A_5A_4A_4A_5|aA_4A_4A_5|bA_5A_5A_3'A_4A_4A_5 \\ & |bA_2'A_5A_5A_3'A_4A_4A_5|aA_3'A_4A_4A_5|bA_5A_5A_4A_4A_2'A_5|bA_2'A_5A_5A_4A_4A_2'A_5|aA_4A_4A_2'A_5 \\ & |bA_5A_5A_3'A_4A_4A_2'A_5|bA_2'A_5A_5A_3'A_4A_4A_2'A_5|aA_3'A_4A_4A_2'A_5|bA_2'A_5|bA_5 \end{aligned}$$

$$\begin{aligned} A_3' \rightarrow & aA_5|aA_4A_5A_5|aA_4A_2'A_5A_5|aA_5A_3'|aA_4A_5A_5A_3'|aA_4A_2'A_5A_5A_3'|bA_5A_5A_4 \\ & |bA_2'A_5A_5A_4|aA_4|bA_5A_5A_3'A_4|bA_2'A_5A_5A_3'A_4|aA_3'A_4|bA_5A_5A_4A_3'|bA_2'A_5A_5A_4A_3' \\ & |aA_4A_3'|bA_5A_5A_3'A_4A_3'|bA_2'A_5A_5A_3'A_4A_3'|aA_3'A_4A_3' \end{aligned}$$