# 编译技术第五章

**5.1 算符优先分析**

1、已知文法**G[S]**为：

**S→a|**∧**|(T)**

**T→T,S|S**

**(1)** 计算**G[S]**的**FIRSTVT** 和**LASTVT**。

答：FIRSTVT(S)={a∧(}

FIRSTVT(T)={a∧(,}

LASTVT(S)={a∧)}

LASTVT(T)={a∧),}

**(2)** 构造**G[S]**的算符优先关系表并说明**G[S]**是否为算符优先文法。

答：算符优先关系表如下：

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | a | ∧ | ( | ) | , | # |
| a |  |  |  | > | > | > |
| ∧ |  |  |  | > | > | > |
| ( | < | < | < | = | < |  |
| ) |  |  |  | > | > | > |
| , | < | < | < | > | > |  |
| # | < | < | < |  |  | = |

表中无多重关系，所以是算符优先文法

**(3)** 计算**G[S]**的优先函数。

答：优先函数如下：

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | a | ∧ | ( | ) | , | # |
| f | 6 | 6 | 2 | 6 | 4 | 2 |
| g | 7 | 7 | 7 | 2 | 3 | 2 |

**(4)** 给出输入串**(a,a)#**和**(a,(a,a))#**的算符优先分析过程。

答：

输入串**(a,a)#**分析过程如下:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 步骤 | 栈 | 当前输入符 | 剩余符号串 | 动作 |
| 1 | # | ( | a,a)# | 移进 |
| 2 | #( | a | ,a)# | 移进 |
| 3 | #(a | , | a)# | 规约S->a |
| 4 | #(N | , | a)# | 移进 |
| 5 | #(N, | a | )# | 移进 |
| 6 | #(N,a | ) | # | 规约S->a |
| 7 | #(N,N | ) | # | 规约T->T,S |
| 8 | #(TV | ) | # | 移进 |
| 9 | #(N) | # | # | 规约S->(T) |
| 10 | #N | # |  | 接受 |

输入串**(a,(a,a))#**的分析过程如下：

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 步骤 | 栈 | 当前输入符 | 剩余符号串 | 动作 |
| 1 | # | ( | a,(a,a))# | 移进 |
| 2 | #( | a | ,(a,a))# | 移进 |
| 3 | #(a | , | (a,a))# | 规约S->a |
| 4 | #(S | , | (a,a))# | 移进 |
| 5 | #(S, | ( | a,a))# | 移进 |
| 6 | #(S,( | a | ,a))# | 移进 |
| 7 | #(S,(a | , | a))# | 规约S->a |
| 8 | #(S,(S | , | a))# | 移进 |
| 9 | #(S,(S, | a | ))# | 移进 |
| 10 | #(S,(S,a | ) | )# | 规约S->a |
| 11 | #(S,(S,S | ) | )# | 规约T->T,S |
| 12 | #(S,S | ) | )# | 规约T->T,S |
| 13 | #(S | ) | # | 移进 |
| 14 | #(S) |  |  | 规约S->(T) |
| 15 | # |  |  | 接受 |

2、已知文法**G[S]**为：

**S→a|**∧**|(T)**

**T→T,S|S**

**(1)** 给出**(a,(a,a))**和**(a,a)**的最右推导，和规范归约过程。

答：

(a,a)最右推导：

S=>(T)=>(T,S)=>(T,a)=>(S,a)=>(a,a)

规范规约过程：

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 步骤 | 栈 | 当前输入符 | 剩余串 | 动作 |
| 1 | # | ( | a,a)# | 移进 |
| 2 | #( | a | ,a)# | 移进 |
| 3 | #(a | , | a)# | 规约S->a |
| 4 | #(S | , | a)# | 规约T->S |
| 5 | #(T | , | a)# | 移进 |
| 6 | #(T) | a | )# | 移进 |
| 7 | #(T,a | ) | # | 规约S->a |
| 8 | #(T,S | ) | # | 规约T->T,S |
| 9 | #(T | ) | # | 移进 |
| 10 | #(T) | # |  | 规约S->(T) |
| 11 | #S |  |  | 接受 |

(a,(a,a)最右推导：

S=>(T)=>(T,S)=>(T,(T))=>(T,(T,S))=>(T,(T,a))=>(T,(S,a)=>(T,(a,a)=>(S,(a,a))=>(a,(a,a))

规范规约过程：

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 步骤 | 符号栈 | 当前输入符 | 剩余符号串 | 动作 |
| 1 | # | ( | a,(a,a))# | 移进 |
| 2 | #( | a | ,(a,a))# | 移进 |
| 3 | #(a | , | (a,a))# | 规约S->a |
| 4 | #(S | , | (a,a))# | 规约T->S |
| 5 | #(T | , | (a,a))# | 移进 |
| 6 | #(T, | ( | a,a))# | 移进 |
| 7 | #(T,( | a | ,a))# | 移进 |
| 8 | #(T,(a | , | a))# | 规约S->a |
| 9 | #(T,(S | , | a))# | 规约T->S |
| 10 | #(T,(T | , | a))# | 移进 |
| 11 | #(T,(T, | a | ))# | 移进 |
| 12 | #(T,(T,a | ) | )# | 规约S->a |
| 13 | #(T,(T,S | ) | )# | 规约T->T,S |
| 14 | #(T,(T | ) | )# | 移进 |
| 15 | #(T,(T) | ) | # | 规约S->(T) |
| 16 | #(T,S | ) | # | 规约T->T,S |
| 17 | #(T | ) | # | 移进 |
| 18 | #(T) | # |  | 规约S->(T) |
| 19 | #S |  |  | 接受 |

**(2)** 将**(1)**和题**1** 中的**(4)**进行比较给出算符优先归约和规范归约的区别。

答：算符优先文法在归约过程中只考虑终结符之间的优先关系从而确定可归约串,而与非终结符无关,只需知道把当前可归约串归约为某一个非终结符,不必知道该非终结符的名字是什么,因此去掉了单非终结符的归约。

规范归约的可归约串是句柄,并且必须准确写出可归约串归约为哪个非终结符。

3、有文法**G[S]**：

**S→V**

**V→T|ViT**

**T→F|T+F**

**F→)V\*|(**

**(1)** 给出**(+(i(**的规范推导。

答：S=>V=>ViT=>TiT=>T+FiT=>F+FiT=>(+FiT=>(+(iT=>(+(i(

**(2)** 指出句型 **F+Fi(**的短语，句柄，素短语。

答：

短语：F+Fi(、F+F、F、(

句柄：F

素短语：F+F、(

**(3) G[S]**是否为**OPG**？若是，给出**(1)**中句子的分析过程。

FIRSTVT和LASTVT如下：

|  |  |  |
| --- | --- | --- |
|  | FIRSTVT | LASTVT |
| S | i,+,),( | i,+,\*,( |
| V | i,+,),( | i,+,\*,( |
| T | +,),( | +,(,\* |
| F | ),( | \*,( |

算符优先分析表如下：

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | i | + | ) | \* | ( | # |
| i | > | < | < | > | < | > |
| + | > | > | < | > | < | > |
| ) | < | < | < | = | < |  |
| \* | > | > |  | > |  | > |
| ( | > | > |  | > |  | > |
| # | < | < | < |  | < | = |

表中无多重关系，所以是OPG

**(+(i(**的算符优先分析表如下：

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 步骤 | 符号栈 | 优先关系 | 当前符号 | 剩余输入串 | 动作 |
| 1 | # | < | ( | +(i(# | 移进 |
| 2 | #( | > | + | (i(# | 规约F->( |
| 3 | #N | < | + | (i(# | 移进 |
| 4 | #N | < | ( | i(# | 移进 |
| 5 | #N+( | > | i | (# | 规约F->( |
| 6 | #N+N | < | i | (# | 移进 |
| 7 | #N | < | ( | # | 移进 |
| 8 | #N+Ni( | > | # |  | 规约F->( |
| 9 | #N+NiN | > | # |  | 规约T->T+F |
| 10 | #NiN | > | # |  | 规约V->TiN |
| 11 | #N | = | # |  | 接受 |

**5.2 LR分析**

1、已知文法

A→aAd|aAb|ε

判断该文法是否是SLR(1)文法，若是构造相应分析表，并对输入串ab#给出分析过程。

答：增加一条产生式S’->A改造为拓广文法:

1. S’->A
2. A->aAd
3. A->aAb
4. A->ε

FIRST(A)={ε,a}

FOLLOW(S’)={#}

FIRST(S’)={ε,a}

FOLLOW(A)={d,b,#}

项目集规范族如下：

I1:

S’->A.

I0:

S’->.A

A->.aAd

A->.aAb

A->.

I2:

A->a.Ad

A->a.Ab

A->.aAd

A->.aAb

A->.

I4:

A->aAd.

I5:

A->aA.d

A->aA.b

A->aAb.

在I0中：A->.aAd和A->.aAb为移进项目，A->.为规约项目，存在移进-规约冲突，因此不是LR(0)文法。

在I0，I2中的移进-规约冲突，可以由FOLLOW集解决，所以G是SLR(0)文法。

构造的SLR(1)分析表如下：

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 状态 | Action | | | | Goto |
| a | d | b | # | A |
| 0 | S2 | R3 | R3 | R3 | 1 |
| 1 |  |  |  | Acc |  |
| 2 | S2 | R3 | R3 | R3 | 3 |
| 3 |  | S4 | S5 |  |  |
| 4 |  | R1 | R1 | R1 |  |
| 5 |  | R2 | R2 | R2 |  |

输入串#ab#的分析过程：

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 步骤 | 状态栈 | 符号栈 | 输入串 | Action | Goto |
| 1 | 0 | # | ab# | S2 |  |
| 2 | 02 | #a | b# | R3 | 3 |
| 3 | 023 | #aA | b# | S5 |  |
| 4 | 0235 | #aAb | # | R2 | 1 |
| 5 | 01 | #A | # | acc |  |

2、若有定义二进制数的文法如下：

S→L·L|L

L→LB|B

B→0|1

(1) 试为该文法构造LR 分析表，并说明属哪类LR 分析表。

答：

增加一条产生式S’->S改造为拓广文法

1. S’->S
2. S->L.L
3. S->L
4. L->LB
5. L->B
6. B->0
7. B->1

FOLLOW(S’)={#}

FOLLOW(S)={#}

FOLLOW(L)={.,0,1,#}

FOLLOW(B)={.,0,1,#}

项目集规范族：

I0:

S’->.S

S->.L.L

S->.L

L->.LB

L->.B

B->.0

B->.1

I1:

S’->S.

I2:

1. >L..L

S->L.

L->L.B

B->.0

B->.1

I4：

B->0.

I5:

L->B.

I6:

S->L..L

L->.LB

L->.B

B->.0

B->.1

B->1.

I7:

1. >LB.

I8:

S->L.L.

L->L.B

B->.0

B->.1

在I2中，B->.0和B->.1为移进项目，S->L.为规约项目，存在移进-规约冲突，因此该文法不是LR(0)文法。

在I2、I8中的移进-规约冲突可以由FOLLOW集解决，所以G是SLR(1)文法。

构造的SLR(1)分析表如下：

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| State | Action | | | | Goto | | |
| . | 0 | 1 | # | S | L | B |
| 0 |  | S4 | S5 |  | 1 | 2 | 3 |
| 1 |  |  |  | Acc |  |  |  |
| 2 | S6 | S4 | S5 | R3 |  |  | 7 |
| 3 | R5 | R5 | R5 | R5 |  |  |  |
| 4 | R6 | R6 | R6 | R6 |  |  |  |
| 5 | R7 | R7 | R7 | R7 |  |  |  |
| 6 |  | S4 | S5 |  |  | 8 | 3 |
| 7 | R4 | R4 | R4 | R4 |  |  |  |
| 8 |  | S4 | S5 | R2 |  |  | 7 |

1. 给出输入串101.110 的分析过程。

答：

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 步骤 | 状态栈 | 符号栈 | 输入串 | Action | Goto |
| 1 | 0 | # | 101.110# | S5 |  |
| 2 | 05 | #1 | 01.110# | R7 | 3 |
| 3 | 03 | #B | 01.110# | R5 | 2 |
| 4 | 02 | #L | 01.110# | S4 |  |
| 5 | 024 | #L0 | 1.110# | R6 | 7 |
| 6 | 027 | #LB | 1.110# | R4 | 2 |
| 7 | 02 | #L | 1.110# | S5 |  |
| 8 | 025 | #L1 | .110# | R7 | 7 |
| 9 | 027 | #LB | .110# | R4 | 2 |
| 10 | 02 | #L | .110# | S6 |  |
| 11 | 026 | #L. | 110# | S5 |  |
| 12 | 0265 | #L.1 | 10# | R7 | 3 |
| 13 | 0263 | #L.B | 10# | R5 | 8 |
| 14 | 0268 | #L.L | 10# | S5 |  |
| 15 | 02685 | #L.L1 | 0# | R7 | 7 |
| 16 | 02687 | #L.LB | 0# | R4 | 8 |
| 17 | 0268 | #L.L | 0# | S4 |  |
| 18 | 02684 | #L.L0 | # | R6 | 7 |
| 19 | 02687 | #L.LB | # | R4 | 8 |
| 20 | 0268 | #L.L | # | R2 | 1 |
| 21 | 01 | #S | # | Acc |  |

3、文法G=({U,T,S},{a,b,c,d,e},P,S)

其中P 为：

S→UTa|Tb

T→S|Sc|d

U→US|e

1. 判断G 是LR(0)，SLR(1)，LALR(1)还是LR(1)，说明理由。

答：

拓广文法：

1. S’->S
2. S->UTa
3. S->Tb
4. T->S
5. T->Sc
6. T->d
7. V->VS
8. V->e

构造相应的LR(0)项目集得：

I0:

S’->.S

S->.VTa

S->.Tb

T->.S

T->.Sc

T->.d

V->.VS

V->.e

I1:

S’->S.

T->S.

T->S.c

I2:

S->V.Ta

V->V.S

T->.S

T->.Sc

T->.d

S->.VTa

S->.Tb

V->.VS

V->.e

I3:

S->T.b

I4:

T->d.

I5:

V->e.

I6:

T->Sc.

I7:

S->VT.a

S->T.b

I8:

V->VS.

T->S.

T->S.c

I9:

S->Tb.

I10:

S->VTa.

在I1、I8中存在移进-规约冲突，所以不是LR(0)文法

FOLLOW(T)={a,b}∩{c}=Ø

FOLLOW(S’)={#}∩FOLLOW(T)=Ø

FOLLOW(V)=(d,e)∩FOLLOW(T)∩{c}=Ø

故该文法为SLR(1)文法,也是LALR(1)文法,LR(1)文法。

(2) 构造相应的分析表。

答：

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| State | Action | | | | | | Goto | | |
| a | b | c | d | e | # | S | V | T |
| 0 |  |  |  | S4 | S5 |  | 1 | 2 | 3 |
| 1 | R3 | R3 | S6 |  |  | Acc | 8 | 2 | 7 |
| 2 |  |  |  | S4 | S5 |  |  |  |  |
| 3 |  | S4 |  |  |  |  |  |  |  |
| 4 | R5 | R5 |  |  |  |  |  |  |  |
| 5 |  |  |  | R7 | R7 |  |  |  |  |
| 6 | R4 | R4 |  |  |  |  |  |  |  |
| 7 | S10 | S10 |  |  |  |  |  |  |  |
| 8 | R3 | R3 | S6 | R6 | R6 |  |  |  |  |
| 9 | R2 | R2 | R2 | R2 | R2 |  |  |  |  |
| 10 | R1 | R1 | R1 | R1 | R1 |  |  |  |  |