# 语法分析程序的设计与实现

班级:2017211301 学号:2017211137 姓名: 王亚宇

2019 年 12 月 2 日

## 目录

# 1 实验内容

## 1.1 实验内容

编写语法分析程序，实现对算数表达式的语法分析。要求所分析算数表达式由如下文法产生。

$$
\begin{aligned}
E \rightarrow &\quad E + T \quad | \quad E - T \quad | T \\
T \rightarrow &\quad T * F \quad | \quad T / F \quad | F \\
F \rightarrow &\quad (E) \quad | \quad num
\end{aligned}
$$

## 1.2 实验要求

在对输入的算数表达式进行分析的过程中，一次输出所采用的产生式。利用 YACC 自动生成语法分析程序，调用 LEX 自动生成的词法分析程序。

# 2 实验环境

## 2.1 操作系统

Ubuntu 18.04 LTS

## 2.2 编译环境

g++ (Ubuntu 7.4.0-1ubuntu1 18.04.1) 7.4.0 flex 2.6.4 bison (GNU Bison) 3.0.4

# 3 实验过程

## 3.1 编写词法分析程序

### 3.1.1 lex.l

```
%{
#include <bits/stdc++.h>
#include "y.tab.hh"
extern "C"{
int yywrap(void);
```

```
int yylex(void);
}
using namespace std;
%}

digit                           [0-9]
exponent                        ([Ee][+-]?{digit}+)

%%

[-/+*()]                        { yylval.char_value = yytext[0];
↪  return yytext[0]; }
0|([1-9]{digit}*?)              { yylval.double_value = atoi(yytext);
↪  return CONSTANT; }
{digit}+{exponent}?             { yylval.double_value = atof(yytext);
↪  return CONSTANT; }
{digit}*"."{digit}+{exponent}?  { yylval.double_value = atof(yytext);
↪  return CONSTANT; }
{digit}+"."{digit}*{exponent}?? { yylval.double_value = atof(yytext);
↪  return CONSTANT; }

%%

int yywrap(void) {
  return 1;
}
```

使用 lex 识别运算符和数字

### 3.1.2 lex.y

```
%union {
  char char_value;
  double double_value;
}

%start E
```

```
7
8  %token <double_value> CONSTANT
9  %type <double_value> E T F
10
11 %left <char_value> '+' '-' '*' '/'
12 %token <char_value> '(' ')'
```

重写 yylval 类型并给予所有文法符号定义类型以进行值传递和输出。

```
1  E : E '+' T { $$ = $1 + $3 ;}
2    | E '-' T { $$ = $1 - $3 ;}
3    | T       { $$ = $1      ;}
4    ;
5
6  T : T '*' F {$$ = $1 * $3  ;}
7    | T '/' F { $$ = $1 / $3 ;}
8    | F       { $$ = $1      ;}
9    ;
10
11 F : '(' E ')' { $$ = $2    ;}
12   | CONSTANT  { $$ = $1    ;}
13   ;
```

声明产生式，并进行数值运算。

### 3.1.3 生成词法分析程序

```
flex lex.l ; bison -vd --debug lex.y -o y.tab.cc ; g++ lex.yy.c
↪  y.tab.cc -o lex
```

### 3.1.4 LARA 项目簇与 DFA

```
Grammar

    0 $accept: E $end
```

```
    1 E: E '+' T
    2  | E '-' T
    3  | T

    4 T: T '*' F
    5  | T '/' F
    6  | F

    7 F: '(' E ')'
    8  | CONSTANT


Terminals, with rules where they appear

$end (0) 0
'(' (40) 7
')' (41) 7
'*' (42) 4
'+' (43) 1
'-' (45) 2
'/' (47) 5
error (256)
CONSTANT (258) 8


Nonterminals, with rules where they appear

$accept (10)
    on left: 0
E (11)
    on left: 1 2 3, on right: 0 1 2 7
T (12)
    on left: 4 5 6, on right: 1 2 3 4 5
F (13)
    on left: 7 8, on right: 4 5 6
```

```
State 0

    0 $accept: . E $end

    CONSTANT  shift, and go to state 1
    '('       shift, and go to state 2

    E  go to state 3
    T  go to state 4
    F  go to state 5


State 1

    8 F: CONSTANT .

    $default  reduce using rule 8 (F)


State 2

    7 F: '(' . E ')'

    CONSTANT  shift, and go to state 1
    '('       shift, and go to state 2

    E  go to state 6
    T  go to state 4
    F  go to state 5


State 3

    0 $accept: E . $end
    1 E: E . '+' T
    2  | E . '-' T
```

```
    $end  shift, and go to state 7
    '+'   shift, and go to state 8
    '-'   shift, and go to state 9


State 4

    3 E: T .
    4 T: T . '*' F
    5  | T . '/' F

    '*'  shift, and go to state 10
    '/'  shift, and go to state 11

    $default  reduce using rule 3 (E)


State 5

    6 T: F .

    $default  reduce using rule 6 (T)


State 6

    1 E: E . '+' T
    2  | E . '-' T
    7 F: '(' E . ')'

    '+'  shift, and go to state 8
    '-'  shift, and go to state 9
    ')'  shift, and go to state 12


State 7
```

```
    0 $accept: E $end .

    $default  accept


State 8

    1 E: E '+' . T

    CONSTANT  shift, and go to state 1
    '('       shift, and go to state 2

    T  go to state 13
    F  go to state 5


State 9

    2 E: E '-' . T

    CONSTANT  shift, and go to state 1
    '('       shift, and go to state 2

    T  go to state 14
    F  go to state 5


State 10

    4 T: T '*' . F

    CONSTANT  shift, and go to state 1
    '('       shift, and go to state 2

    F  go to state 15
```

```
State 11

    5 T: T '/' . F

    CONSTANT  shift, and go to state 1
    '('       shift, and go to state 2

    F  go to state 16


State 12

    7 F: '(' E ')' .

    $default  reduce using rule 7 (F)


State 13

    1 E: E '+' T .
    4 T: T . '*' F
    5  | T . '/' F

    '*'  shift, and go to state 10
    '/'  shift, and go to state 11

    $default  reduce using rule 1 (E)


State 14

    2 E: E '-' T .
    4 T: T . '*' F
    5  | T . '/' F

    '*'  shift, and go to state 10
    '/'  shift, and go to state 11
```

```
    $default  reduce using rule 2 (E)


State 15

    4 T: T '*' F .

    $default  reduce using rule 4 (T)


State 16

    5 T: T '/' F .

    $default  reduce using rule 5 (T)
```

#### 3.1.5 分析过程

##### 3.1.5.1 测试用例

```
1 (3+5/2)*(2.4/3)-(1-2)
```

##### 3.1.5.2 分析过程

```
1  Starting parse
2  Entering state 0
3  Reading a token: Next token is token '(' ('(')
4  Shifting token '(' ('(')
5  Entering state 2
6  Reading a token: Next token is token CONSTANT (3)
7  Shifting token CONSTANT (3)
8  Entering state 1
9  Reducing stack by rule 8 (line 55):
10    $1 = token CONSTANT (3)
11 -> $$ = nterm F (3)
```

```
Stack now 0 2
Entering state 5
Reducing stack by rule 6 (line 51):
   $1 = nterm F (3)
-> $$ = nterm T (3)
Stack now 0 2
Entering state 4
Reading a token: Next token is token '+' ('+')
Reducing stack by rule 3 (line 46):
   $1 = nterm T (3)
-> $$ = nterm E (3)
Stack now 0 2
Entering state 6
Next token is token '+' ('+')
Shifting token '+' ('+')
Entering state 8
Reading a token: Next token is token CONSTANT (5)
Shifting token CONSTANT (5)
Entering state 1
Reducing stack by rule 8 (line 55):
   $1 = token CONSTANT (5)
-> $$ = nterm F (5)
Stack now 0 2 6 8
Entering state 5
Reducing stack by rule 6 (line 51):
   $1 = nterm F (5)
-> $$ = nterm T (5)
Stack now 0 2 6 8
Entering state 13
Reading a token: Next token is token '/' ('/')
Shifting token '/' ('/')
Entering state 11
Reading a token: Next token is token CONSTANT (2)
Shifting token CONSTANT (2)
Entering state 1
Reducing stack by rule 8 (line 55):
```

```
48    $1 = token CONSTANT (2)
49 -> $$ = nterm F (2)
50 Stack now 0 2 6 8 13 11
51 Entering state 16
52 Reducing stack by rule 5 (line 50):
53    $1 = nterm T (5)
54    $2 = token '/' ('/')
55    $3 = nterm F (2)
56 -> $$ = nterm T (2.500000)
57 Stack now 0 2 6 8
58 Entering state 13
59 Reading a token: Next token is token ')' (')')
60 Reducing stack by rule 1 (line 44):
61    $1 = nterm E (3)
62    $2 = token '+' ('+')
63    $3 = nterm T (2.500000)
64 -> $$ = nterm E (5.500000)
65 Stack now 0 2
66 Entering state 6
67 Next token is token ')' (')')
68 Shifting token ')' (')')
69 Entering state 12
70 Reducing stack by rule 7 (line 54):
71    $1 = token '(' ('(')
72    $2 = nterm E (5.500000)
73    $3 = token ')' (')')
74 -> $$ = nterm F (5.500000)
75 Stack now 0
76 Entering state 5
77 Reducing stack by rule 6 (line 51):
78    $1 = nterm F (5.500000)
79 -> $$ = nterm T (5.500000)
80 Stack now 0
81 Entering state 4
82 Reading a token: Next token is token '*' ('*')
83 Shifting token '*' ('*')
```

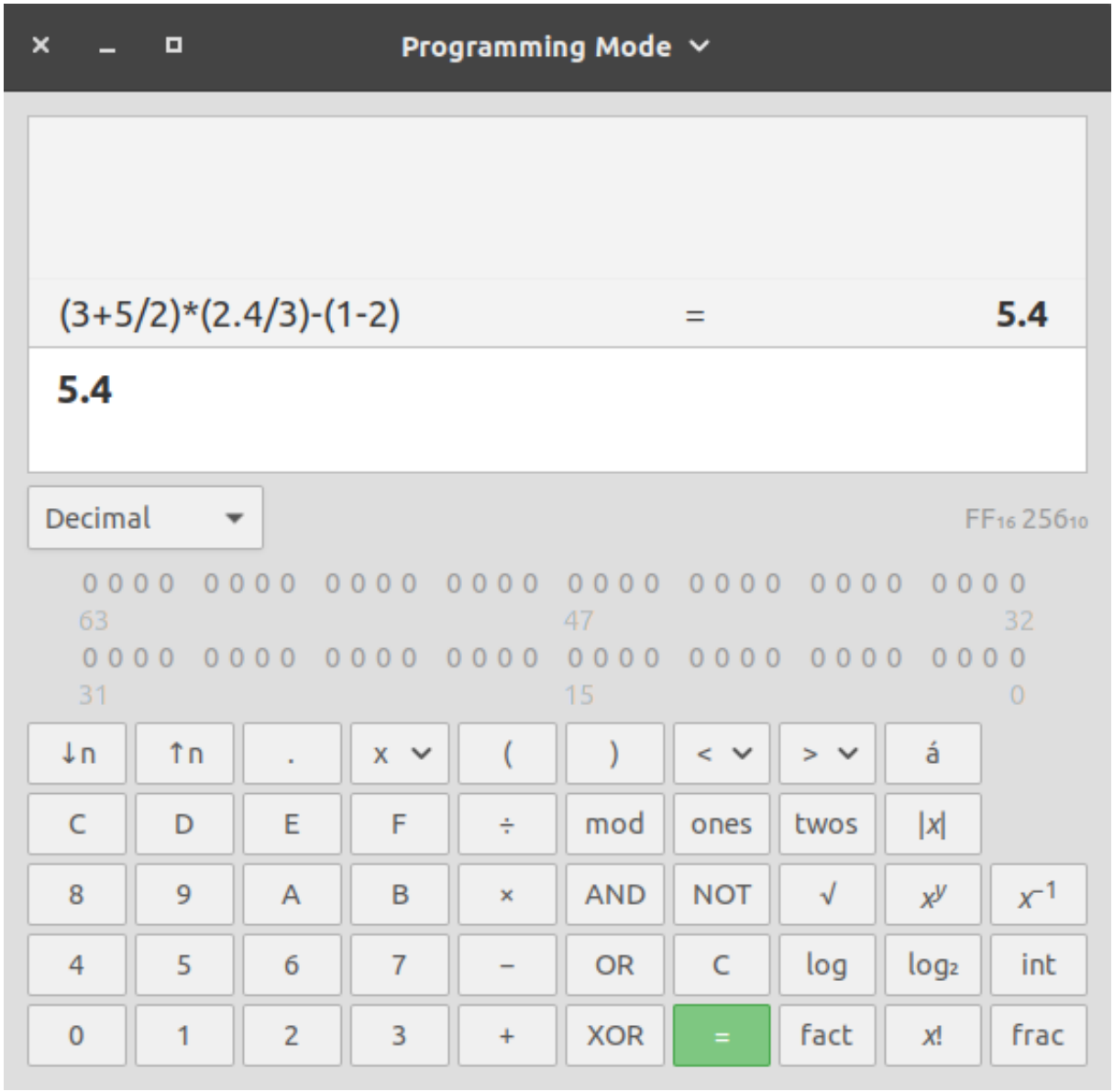
```
Entering state 10
Reading a token: Next token is token '(' ('(')
Shifting token '(' ('(')
Entering state 2
Reading a token: Next token is token CONSTANT (2.400000)
Shifting token CONSTANT (2.400000)
Entering state 1
Reducing stack by rule 8 (line 55):
   $1 = token CONSTANT (2.400000)
-> $$ = nterm F (2.400000)
Stack now 0 4 10 2
Entering state 5
Reducing stack by rule 6 (line 51):
   $1 = nterm F (2.400000)
-> $$ = nterm T (2.400000)
Stack now 0 4 10 2
Entering state 4
Reading a token: Next token is token '/' ('/')
Shifting token '/' ('/')
Entering state 11
Reading a token: Next token is token CONSTANT (3)
Shifting token CONSTANT (3)
Entering state 1
Reducing stack by rule 8 (line 55):
   $1 = token CONSTANT (3)
-> $$ = nterm F (3)
Stack now 0 4 10 2 4 11
Entering state 16
Reducing stack by rule 5 (line 50):
   $1 = nterm T (2.400000)
   $2 = token '/' ('/')
   $3 = nterm F (3)
-> $$ = nterm T (0.800000)
Stack now 0 4 10 2
Entering state 4
Reading a token: Next token is token ')' (')')
```

```
Reducing stack by rule 3 (line 46):
   $1 = nterm T (0.800000)
-> $$ = nterm E (0.800000)
Stack now 0 4 10 2
Entering state 6
Next token is token ')' (')')
Shifting token ')' (')')
Entering state 12
Reducing stack by rule 7 (line 54):
   $1 = token '(' ('(')
   $2 = nterm E (0.800000)
   $3 = token ')' (')')
-> $$ = nterm F (0.800000)
Stack now 0 4 10
Entering state 15
Reducing stack by rule 4 (line 49):
   $1 = nterm T (5.500000)
   $2 = token '*' ('*')
   $3 = nterm F (0.800000)
-> $$ = nterm T (4.400000)
Stack now 0
Entering state 4
Reading a token: Next token is token '-' ('-')
Reducing stack by rule 3 (line 46):
   $1 = nterm T (4.400000)
-> $$ = nterm E (4.400000)
Stack now 0
Entering state 3
Next token is token '-' ('-')
Shifting token '-' ('-')
Entering state 9
Reading a token: Next token is token '(' ('(')
Shifting token '(' ('(')
Entering state 2
Reading a token: Next token is token CONSTANT (1)
Shifting token CONSTANT (1)
```

```
Entering state 1
Reducing stack by rule 8 (line 55):
   $1 = token CONSTANT (1)
-> $$ = nterm F (1)
Stack now 0 3 9 2
Entering state 5
Reducing stack by rule 6 (line 51):
   $1 = nterm F (1)
-> $$ = nterm T (1)
Stack now 0 3 9 2
Entering state 4
Reading a token: Next token is token '-' ('-')
Reducing stack by rule 3 (line 46):
   $1 = nterm T (1)
-> $$ = nterm E (1)
Stack now 0 3 9 2
Entering state 6
Next token is token '-' ('-')
Shifting token '-' ('-')
Entering state 9
Reading a token: Next token is token CONSTANT (2)
Shifting token CONSTANT (2)
Entering state 1
Reducing stack by rule 8 (line 55):
   $1 = token CONSTANT (2)
-> $$ = nterm F (2)
Stack now 0 3 9 2 6 9
Entering state 5
Reducing stack by rule 6 (line 51):
   $1 = nterm F (2)
-> $$ = nterm T (2)
Stack now 0 3 9 2 6 9
Entering state 14
Reading a token: Next token is token ')' (')')
Reducing stack by rule 2 (line 45):
   $1 = nterm E (1)
```

```
   $2 = token '-' ('-')
   $3 = nterm T (2)
-> $$ = nterm E (-1)
Stack now 0 3 9 2
Entering state 6
Next token is token ')' (')')
Shifting token ')' (')')
Entering state 12
Reducing stack by rule 7 (line 54):
   $1 = token '(' ('(')
   $2 = nterm E (-1)
   $3 = token ')' (')')
-> $$ = nterm F (-1)
Stack now 0 3 9
Entering state 5
Reducing stack by rule 6 (line 51):
   $1 = nterm F (-1)
-> $$ = nterm T (-1)
Stack now 0 3 9
Entering state 14
Reading a token:
Now at end of input.
Reducing stack by rule 2 (line 45):
   $1 = nterm E (4.400000)
   $2 = token '-' ('-')
   $3 = nterm T (-1)
-> $$ = nterm E (5.400000)
Stack now 0
Entering state 3
Now at end of input.
Shifting token $end ()
Entering state 7
Stack now 0 3 7
Cleanup: popping token $end ()
Cleanup: popping nterm E (5.400000)
```

最后计算得表达式值为 5.4 与实际吻合极好


Programming Mode
(3+5/2)*(2.4/3)-(1-2) = 5.4
5.4
Decimal
FF16 25610
0000 0000 0000 0000 0000 0000 0000 0000
63 47 32
0000 0000 0000 0000 0000 0000 0000 0000
31 15 0
↓n ↑n . x ( ) < > á
C D E F ÷ mod ones twos |x|
8 9 A B × AND NOT √ x^y x^-1
4 5 6 7 − OR C log log2 int
0 1 2 3 + XOR = fact x! frac

# 4 Appendices

## 4.1 lex.l

```
%{
#include <bits/stdc++.h>
#include "y.tab.hh"
extern "C"{
int yywrap(void);
int yylex(void);
}
using namespace std;
%}

digit                           [0-9]
exponent                        ([Ee][+-]?{digit}+)

%%

[-/+*()]                        { yylval.char_value = yytext[0];
↪  return yytext[0]; }
0|([1-9]{digit}*?)              { yylval.double_value = atoi(yytext);
↪  return CONSTANT; }
{digit}+{exponent}?             { yylval.double_value = atof(yytext);
↪  return CONSTANT; }
{digit}*"."{digit}+{exponent}?  { yylval.double_value = atof(yytext);
↪  return CONSTANT; }
{digit}+"."{digit}*{exponent}?? { yylval.double_value = atof(yytext);
↪  return CONSTANT; }

%%

int yywrap(void) {
  return 1;
}
```

## 4.2 lex.y

```
%{
  #include <bits/stdc++.h>
  #define YYDEBUG 1
  #define eps 1e-5
  extern "C" {
    void yyerror(const char *){};
    extern int yylex(void);
    extern char *yytext;
    extern int yydebug;
  }

  using namespace std;
%}

%union {
  char char_value;
  double double_value;
}

%start E

%token <double_value> CONSTANT
%type <double_value> E T F

%left <char_value> '+' '-' '*' '/'
%token <char_value> '(' ')'

%printer {
  int r = round($$);
  if( abs(r-$$)<=eps ){
    fprintf (yyo, "%d", r);
  }
  else{
    fprintf (yyo, "%lf", $$);
```

```
  }
 } <double_value>

%printer {
   fprintf (yyo, "'%c'", $$);
} <char_value>

%%

E : E '+' T { $$ = $1 + $3 ;}
  | E '-' T { $$ = $1 - $3 ;}
  | T       { $$ = $1      ;}
  ;

T : T '*' F {$$ = $1 * $3  ;}
  | T '/' F { $$ = $1 / $3 ;}
  | F       { $$ = $1      ;}
  ;

F : '(' E ')' { $$ = $2    ;}
  | CONSTANT  { $$ = $1    ;}
  ;

%%

int main() {
  yydebug = 1;
  return yyparse();
}
```