编译专题实验报告

词法分析器

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完成模式：独立完成

实验平台

1. 操作系统：WSL2 Ubuntu 20.04
2. 编程语言：C++
3. g++版本：13.1.0

实验目的

1. 目的：构建词法分析程序能将源语言程序作为输入，并输出词法记号串到文件中。
2. 功能：
    1. 单词设计包含主文法中所有词法单位；
    2. 一遍扫描或含预处理遍，能删除注解，并允许空白字符串作为分隔；
    3. 分析框架scanner()允许连续调用直到输入串被扫描完毕，每调用一次返回一个记号；
    4. 有联合DFA设计结果以及超前搜索功能；
    5. (可选)词法错误处理。

实验内容

1. include和全局变量声明

```cpp
#include <algorithm> // 包含 std::transform
#include <cctype> // 包含 std::tolower
#include <fstream>
#include <iostream>
#include <map>
#include <stdio.h>
#include <string>
#include <unistd.h>
#include <vector>

using namespace std;
int state;    //当前状态指示
char C;     //当前读入字符
string nowstr;   //当前读入的字符串
char *buffer;   //文件缓冲区
int forwar = -1;     //向前指针
int rows = 1;    //文件行数
int sum_char = 0;   //文件总字符数

vector<string> keyword = {"auto", "break", "case", "char", "const",
"continue", "default",
```

```
                        "do", "double", "else", "enum", "extern",
"float", "for", "goto",
                        "if", "int", "long", "register", "return",
"short", "signed",
                        "sizeof", "static", "struct", "switch",
"typedef", "union",
                        "unsigned", "void", "volatile", "while",
"define","include"}; //关键字表

std::multimap<string,string> item;  //符号表(type,value)
```

1. state：当前状态指示，用于指示当前状态
2. C：当前读入字符
3. nowstr：当前读入的字符串
4. buffer：文件缓冲区
5. forwar：向前指针
6. rows：文件行数
7. sum_char：文件总字符数
8. keyword：关键字表
9. item：符号表(type,value)，用于存储识别出的符号

2. 功能函数：

```
void get_char() {
    forwar=forwar+1;
    C = buffer[forwar];
}
//从buf中读一个字符到C中，向前指针移动。

void cat() {
    nowstr.push_back(C);
}
//将字符C连接到nowstr字符串后面

std::string toLower(const std::string& str) {
    // 创建一个副本以避免修改原始字符串
    std::string lowerStr = str;

    // 使用 std::transform 和 std::tolower 将字符串转换为全小写
    std::transform(lowerStr.begin(), lowerStr.end(), lowerStr.begin(),
::tolower);

    return lowerStr; // 返回转换后的字符串
}

std::string toUper(const std::string& str) {
    // 创建一个副本以避免修改原始字符串
    std::string upperStr = str;

    // 使用 std::transform 和 std::tolower 将字符串转换为全小写
    std::transform(upperStr.begin(), upperStr.end(), upperStr.begin(),
::toupper);
```

```
28
29      return upperStr; // 返回转换后的字符串
30  }
31
32  bool is_letter(char ch) {
33      if (isalpha(ch) || ch=='_')
34          return true;
35      else
36          return false;
37  }
38  //判断ch是否为字母或下划线
39
40  int iskeyword() {
41      for (int i = 0; i < keyword.size(); i++){
42          if (nowstr == keyword[i]) {
43              return 1;
44          }
45          if (toLower(nowstr) == keyword[i]) {
46              return 2;
47          }
48      }
49      return 0;
50  }
51  //判断nowstr中是否为关键字，1表示匹配正确，2表示匹配正确但大小写不同，0表示不匹配
52
53  bool iseven() {
54      int num = 0;
55      int i = nowstr.size() - 2;
56      while (nowstr[i] == '\\') {
57          num++;
58          i--;
59      }
60      if (num % 2 == 0)
61          return true;
62      return false;
63  }
64  //判断nowstr中是否为偶数个\结尾
```

1. get_char()：从buf中读一个字符到C中，向前指针移动。
2. cat()：将字符C连接到nowstr字符串后面
3. toLower()：将字符串转换为全小写
4. toUper()：将字符串转换为全大写
5. is_letter()：判断ch是否为字母或下划线
6. iskeyword()：判断nowstr中是否为关键字，1表示匹配正确，2表示匹配正确但大小写不同，0表示不匹配
7. iseven()：判断nowstr中是否为偶数个\结尾
8. toLower()用于将字符串转换为全小写，用于判断是否是大小写错误的关键字
9. iseven()用于判断是否为偶数个\结尾，作用的情况是在遇到"时，如果是偶数个\结尾，则说明是字符串结束，否则说明是转义字符，需要继续读取
10. iskeyword()用于判断是否为关键字，如果是关键字，则返回1，如果是大小写错误的关键字，则返回2，否则返回0

3. scanner函数:

```
void scanner(){
    bool isEnd = false;
    while(!isEnd){
        get_char();
        if (C == '\n'){
            rows++;
        }
        if (C == EOF){
            isEnd = true;
        }
        switch (state) {
            case 0: //初始状态
                if (is_letter(C)){
                    state =1;   //id or keyword
                    cat();
                }
                else if (isdigit(C)){
                    state = 2; //num or wrong id
                    cat();
                }
                else if (C=='0'){
                    state=28;
                    cat();
                }
                else{
                    switch (C) {
                        case '<': state = 8; break;
                        case '>': state = 9; break;
                        case'?':
                            insert_item("OPERATOR", "?");
                            break;
                        case ':':
                            insert_item("OPERATOR", ":");
                            break;
                        case '/': state = 11; break;
                        case '=': state = 12; break;
                        case '+': state = 13; break;
                        case '-': state = 14; break;
                        case '*': state = 15; break;
                        case '%': state = 16; break;
                        case '(':
                            insert_item("DELIMITER", "(");
                            break;
                        case ')':
                            insert_item("DELIMITER", ")");
                            break;
                        case ',':
                            insert_item("DELIMITER", ",");
                            break;
                        case ';':
                            insert_item("DELIMITER", ";");
                            break;
```

```
                        case '{':
                            insert_item("DELIMITER", "{");
                            break;
                        case '}':
                            insert_item("DELIMITER", "}");
                            break;
                        case '[':
                            insert_item("DELIMITER", "[");
                            break;
                        case ']':
                            insert_item("DELIMITER", "]");
                            break;
                        case '^': state = 17; break;
                        case '|': state = 18; break;
                        case '~': state = 19; break;
                        case '!': state = 20; break;
                        case '&': state = 21; break;
                        case '"': state = 22; cat(); break;
                        case '\'':state = 23; cat(); break;
                        case '.': state = 24; break;
                        case '#': insert_item("OPERATOR", "#"); break;
                        case ' ':
                        case '\n':
                        case' ':
                        case EOF : break; //跳过空白符
                        default: cout << "error:第" << rows << "行出现非法字符" << C << endl;
                            break;
                    }
                }
                break;
            case 1:         //id or keyword
                if (is_letter(C) || isdigit(C)) {
                    cat();
                    state = 1;
                }
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    int flag = iskeyword();
                    if (flag == 1) {
                        insert_item("keyword", nowstr);
                    } else if (flag == 2) {
                        insert_item("ERROR", nowstr+" --- Keyword should be lower case");
                    } else {
                        insert_item("id", nowstr);
                    }
                    nowstr.clear();
                }
                break;
```

```
            case 2:
                if (isdigit(C)) {
                    cat();
                    state = 2;
                }
                else if (C == '.') {
                    cat();
                    state = 3;
                }
                else if (C == 'E' || C == 'e') {
                    cat();
                    state = 5;
                }
                //wrong id
                else if (is_letter(C)) {
                    cat();
                    state = 31;
                }
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    insert_item("int", nowstr);
                    nowstr.clear();
                }
                break;
            case 3:     // .
                if (isdigit(C)) {
                    cat();
                    state = 4;
                }
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    nowstr.push_back('0');
                    insert_item("float", nowstr);
                    nowstr.clear();
                }
                break;

            case 4:     // .num
                if (isdigit(C)) {
                    cat();
                    state = 4;
                }
                else if (C == 'E' || C == 'e') {
                    cat();
                    state = 5;
                }
```

```
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    insert_item("float", nowstr);
                    nowstr.clear();
                }
                break;

            case 5:     // .numE
                if (C == '+' || C == '-') {
                    cat();
                    state = 6;
                }
                else if (isdigit(C)) {
                    cat();
                    state = 7;
                }
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    insert_item("ERROR", nowstr + " --- Missing
digit");
                    nowstr.clear();
                }
                break;

            case 6:     // .numE+ or .numE-
                if (isdigit(C)) {
                    cat();
                    state = 7;
                }
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    insert_item("ERROR", nowstr + " --- Missing
digit");
                    nowstr.clear();
                }
                break;

            case 7:     // .numE+num
                if (isdigit(C)) {
                    cat();
                    state = 7;
                }
```

```
                else {
                    forwar--;
                    state = 0;
                    if (C == '\n') {
                        rows--;
                    }
                    insert_item("float", nowstr);
                    nowstr.clear();
                }
                break;

            case 8:
                if (C == '=') {
                    insert_item("OPERATOR", "≤");
                }
                else if (C == '<') {
                    insert_item("OPERATOR", "<<");
                }
                else {
                    forwar--;
                    insert_item("OPERATOR", "<");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 9:
                if (C == '=') {
                    insert_item("OPERATOR", "≥");
                }
                else if (C == '>') {
                    insert_item("OPERATOR", ">>");
                }
                else {
                    forwar--;
                    insert_item("OPERATOR", ">");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 11:
                switch (C) {
                    case '/': //单行注释
                        state = 27;
                        break;
                    case '*':   //多行注释
                        state = 26;
                        break;
                    default:
```

```
                        forwar--;
                        insert_item("OPERATOR", "/");
                        state = 0;
                        if (C == '\n') {
                            rows--;
                        }
                        break;
                }
                break;

            case 12:    // =
                if (C == '=') {
                    insert_item("OPERATOR", "==");
                }
                else {
                    forwar--;
                    insert_item("OPERATOR", "=");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 13:    // +
                if (C == '+') {
                    insert_item("OPERATOR", "++");
                }
                else if (C == '=') {
                    insert_item("OPERATOR", "+=");
                }
                else if (isdigit(C)) {
                    cat();
                    state = 2;
                }
                else {
                    forwar--;
                    insert_item("OPERATOR", "+");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 14:    // -
                if (C == '-') {
                    insert_item("OPERATOR", "--");
                }
                else if (C == '=') {
                    insert_item("OPERATOR", "-=");
                }
                else if (C == '>') {
                    insert_item("OPERATOR", "→");
```

```
319                 }
320                 else if (isdigit(C)) {
321                     cat();
322                     state = 2;
323                 }
324                 else {
325                     forwar--;
326                     insert_item("OPERATOR", "-");
327                     if (C == '\n') {
328                         rows--;
329                     }
330                 }
331                 state = 0;
332                 break;
333 
334             case 15:    // *
335                 if (C == '=') {
336                     insert_item("OPERATOR", "*=");
337                 }
338                 else {
339                     forwar--;
340                     insert_item("OPERATOR", "*");
341                     if (C == '\n') {
342                         rows--;
343                     }
344                 }
345                 state = 0;
346                 break;
347 
348             case 16:    // %
349                 if (C == '=') {
350                     insert_item("OPERATOR", "%=");
351                 }
352                 else {
353                     forwar--;
354                     insert_item("OPERATOR", "%");
355                     if (C == '\n') {
356                         rows--;
357                     }
358                 }
359                 state = 0;
360                 break;
361 
362             case 17:    // ^
363                 if (C == '=') {
364                     insert_item("OPERATOR", "^=");
365                 }
366                 else {
367                     forwar--;
368                     insert_item("OPERATOR", "^");
369                     if (C == '\n') {
370                         rows--;
371                     }
372                 }
```

```
                state = 0;
                break;

            case 18:    // |
                if (C == '|') {
                    insert_item("OPERATOR", "||");
                }
                else if (C == '=') {
                    insert_item("OPERATOR", "⊨");
                }
                else {
                    forwar--;
                    insert_item("OPERATOR", "|");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 19:    // ~
                if (C == '=') {
                    insert_item("OPERATOR", "~=");
                }
                else {
                    forwar--;

                    insert_item("OPERATOR", "~");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 20:    // !
                if (C == '=') {
                    insert_item("OPERATOR", "≠");
                }
                else {
                    forwar--;

                    insert_item("OPERATOR", "!");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 21:    // &
                if (C == '&') {
                    insert_item("OPERATOR", "&&");
                }
```

```
                else if (C == '=') {
                    insert_item("OPERATOR", "&=");
                }
                else {
                    forwar--;

                    insert_item("OPERATOR", "&");
                    if (C == '\n') {
                        rows--;
                    }
                }
                state = 0;
                break;

            case 22:    // "
                if (C == '\"') {
                    cat();
                    if (iseven()) {
                        insert_item("STRING", nowstr);
                        nowstr.clear();
                        state = 0;
                    }
                    else {
                        state = 22;
                    }
                }
                else if (C == EOF) {
                    insert_item("ERROR", nowstr + " --- String should end with \"");
                    nowstr.clear();
                    state = 0;
                }
                else {
                    cat();
                    state = 22;
                }
                break;

            case 23:    // '
                if (C == '\'') {
                    cat();
                    //判断是否是转义字符
                    if (nowstr.size() == 4 && nowstr[1] == '\\') {
                        insert_item("CHAR", nowstr);
                    }
                    //单独处理'\''这种情况
                    else if (nowstr[0]='\'' && nowstr[1]='\\' && nowstr[2]='\'') {
                        get_char();
                        if (C == '\'') {
                            cat();
                            insert_item("CHAR", nowstr);
                        }
                        else {
```

```
                            forwar--;

                        }
                    }
                    else if (nowstr.size() == 3) {
                        insert_item("CHAR", nowstr);
                    }
                    else {
                        insert_item("ERROR", nowstr + " --- Char should be one character");
                    }
                    nowstr.clear();
                    state = 0;
                }
                else if (C == EOF) {
                    insert_item("ERROR", nowstr + " --- Char should end with \'");
                    nowstr.clear();
                    state = 0;
                }
                else {
                    cat();
                    state = 23;
                }
                break;

            case 24:    // .
                if (isdigit(C)) {
                    cat();
                    state = 4;
                }
                else {
                    forwar--;

                    insert_item("OPERATOR", ".");
                    if (C == '\n') {
                        rows--;
                    }
                    state = 0;
                }
                break;

            case 26:    // /*
                if (C == '*') {
                    state = 25;
                }
                break;

            case 25:    // /*...*
                if (C == '*') {
                    state = 25;
                }
                else if (C == '/') {
                    state = 0;
```

```
531                 }
532                 else if (C == EOF) {
533                     insert_item("ERROR", nowstr + " --- Multi-line
    comment should end with */");
534                     nowstr.clear();
535                     state = 0;
536                 }
537                 break;
538 
539             case 27:    // //
540                 if (C == '\n' || C == EOF) {
541                     state = 0;
542                 }
543                 break;
544 
545             case 28:    // 0
546                 if (C == 'x' || C == 'X') {
547                     cat();
548                     state = 29;
549                 }
550                 else if (isdigit(C)) {
551                     cat();
552                     state = 2;
553                 }
554                 else if (C == '.') {
555                     cat();
556                     state = 3;
557                 }
558                 else {
559                     forwar--;
560 
561                     insert_item("int", nowstr);
562                     nowstr.clear();
563                     state = 0;
564                 }
565                 break;
566 
567             case 29:    // 0x
568                 if (isdigit(C) || (C ⩾ 'a' && C ⩽ 'f') || (C ⩾ 'A'
    && C ⩽ 'F')) {
569                     cat();
570                     state = 30;
571                 }
572                 else {
573                     forwar--;
574 
575                     insert_item("ERROR", nowstr + " --- Hexadecimal
    number should have at least one digit");
576                     nowstr.clear();
577                     state = 0;
578                 }
579                 break;
580 
581             case 30:    // 0x...
```

```
582                 if (isdigit(C) || (C ⩾ 'a' && C ⩽ 'f') || (C ⩾ 'A'
    && C ⩽ 'F')) {
583                     cat();
584                     state = 30;
585                 }
586                 else {
587                     forwar--;
588 
589                     insert_item("int", nowstr);
590                     nowstr.clear();
591                     state = 0;
592                 }
593                 break;
594 
595             case 31:    //wrong id with num at first
596                 if (is_letter(C) || isdigit(C)) {
597                     cat();
598                     state = 31;
599                 }
600                 else {
601                     forwar--;
602 
603                     insert_item("ERROR", nowstr + " --- ID should
    start with a letter");
604                     nowstr.clear();
605                     state = 0;
606                 }
607                 break;
608             default:
609                 break;
610         }
611     }
612 }
```

1. scanner()函数用于识别输入的字符，根据状态机的状态进行识别
2. scanner识别的类型如下：
    1. id：标识符
    2. keyword：关键字
    3. int：整数
    4. float：浮点数
    5. STRING：字符串
    6. CHAR：字符
    7. OPERATOR：操作符
    8. DELIMITER：分隔符
    9. ERROR：错误
3. scanner()函数中的状态机设计如下：
    1. state=0：初始状态
    2. state=1：id or keyword
    3. state=2：num or wrong id
    4. state=3：.

```
state=4 : .num
state=5 : .numE
state=6 : .numE+ or .numE-
state=7 : .numE+num
state=8 : <
state=9 : >
state=11 : /
state=12 : =
state=13 : +
state=14 : -
state=15 : *
state=16 : %
state=17 : ^
state=18 : |
state=19 : ~
state=20 : !
state=21 : &
state=22 : "
state=23 : '
state=24 : .
state=26 : /*
state=27 : //
state=28 : 0
state=29 : 0x
state=30 : 0x...
state=31 : wrong id with num at first
```

4. insert_item和read_file函数:

```cpp
//根据传入的type和value，将其插入符号表
void insert_item(string type, string value) {
    item.insert(pair<string,string>(type,value));
    sleep(0.5);
    if (type == "ERROR") {
        cout << "\033[31m"  // 31对应红色
            << rows << ": (" << type << ", " << value << ")"
            << "\033[0m" << endl;
    }
    else {
        cout << rows << ": (" << type << ", " << value << ")" << endl;
    }
}

//根据文件名，读取文件内容到buffer中
void read_file(const char *filename) {
    FILE *fp = fopen(filename, "r");  // 用二进制模式打开
    if (fp == NULL) {
```

```
        cout << "文件打开失败" << endl;
        exit(0);
    }
    fseek(fp, 0, SEEK_END);
    sum_char = ftell(fp);
    fseek(fp, 0, SEEK_SET);
    buffer = new char[sum_char+1];
    fread(buffer, 1, sum_char, fp);
    fclose(fp);
    //Buffer末尾加上EOF
    buffer[sum_char] = EOF;
}
```

1. `insert_item()`：根据传入的type和value，将其插入符号表，并输出，如果是错误，则输出为红色
2. `read_file()`：根据文件名，读取文件内容到buffer中

5. 主函数：

```
int main(int argc, char **argv) {
    if (argc < 3) {  // 检查是否提供了足够的命令行参数
        std::cerr << "请提供输入和输出文件名作为参数。" << std::endl;
        return 1;
    }

    const char *input_filename = argv[1];  // 获取输入文件名
    const char *output_filename = argv[2];  // 获取输出文件名

    freopen(output_filename, "w", stdout);  // 将输出重定向到指定的输出文件
    read_file(input_filename);  // 读取指定输入文件
    scanner();  // 扫描内容
    delete[] buffer;  // 释放分配的内存

    return 0;
}
```

1. 主函数用于读取输入文件，将输出重定向到指定的输出文件，然后调用scanner()函数进行扫描
2. 主函数从命令行参数中获取输入文件名和输出文件名

实验结果

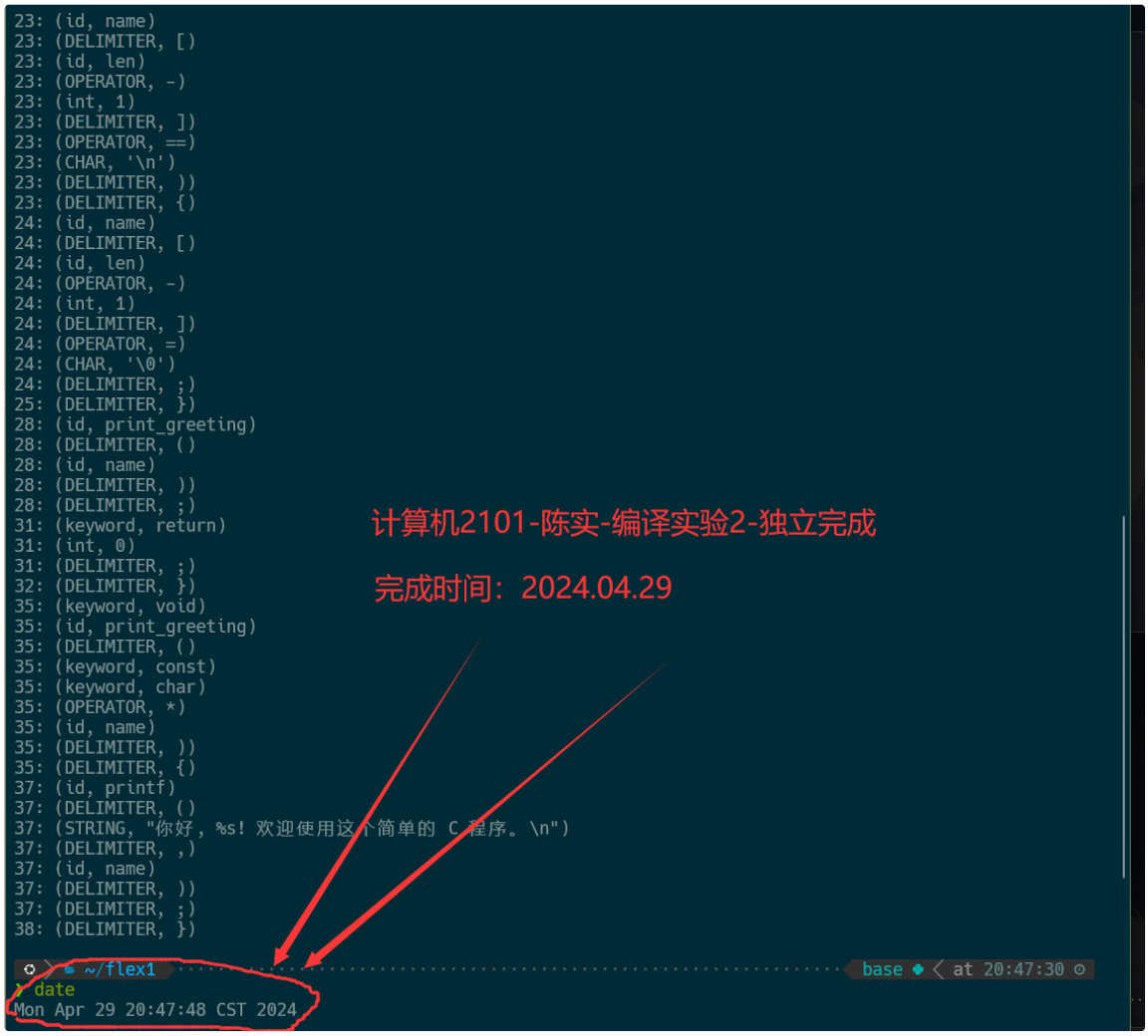
1. test1.txt

```
#include <stdio.h>  // 包含标准输入输出头文件
#include <string.h> // 包含字符串操作头文件

// 定义最大字符串长度
#define MAX_LENGTH 100

// 函数声明
void print_greeting(const char *name);

// 主函数，程序从这里开始执行
int main() {
    // 定义一个字符数组以存储输入的名字
```

```c
    char name[MAX_LENGTH];

    // 打印提示信息
    printf("请输入你的名字: ");

    // 从标准输入获取名字，最多读取 MAX_LENGTH 个字符
    fgets(name, MAX_LENGTH, stdin);

    // 删除换行符
    size_t len = strlen(name);
    if (name[len - 1] == '\n') {
        name[len - 1] = '\0';
    }

    // 打印问候语
    print_greeting(name);

    // 程序结束
    return 0;
}

// 定义一个函数，用于打印问候语
void print_greeting(const char *name) {
    // 打印问候语，使用传入的名字
    printf("你好, %s! 欢迎使用这个简单的 C 程序。\n", name);
}
```

该程序词法正确，输出如下：

```
2: (OPERATOR, >)
5: (OPERATOR, #)
5: (keyword, define)
5: (id, MAX_LENGTH)
5: (int, 100)
8: (keyword, void)
8: (id, print_greeting)
8: (DELIMITER, ()
8: (keyword, const)
8: (keyword, char)
8: (OPERATOR, *)
8: (id, name)
8: (DELIMITER, ))
8: (DELIMITER, ;)
11: (keyword, int)
11: (id, main)
11: (DELIMITER, ()
11: (DELIMITER, ))
11: (DELIMITER, {)
13: (keyword, char)
13: (id, name)
13: (DELIMITER, [)
13: (id, MAX_LENGTH)
13: (DELIMITER, ])
13: (DELIMITER, ;)
16: (id, printf)
16: (DELIMITER, ()
16: (STRING, "请输入你的名字: ")
16: (DELIMITER, ))
16: (DELIMITER, ;)
19: (id, fgets)
19: (DELIMITER, ()
19: (id, name)
19: (DELIMITER, ,)
19: (id, MAX_LENGTH)
19: (DELIMITER, ,)
19: (id, stdin)
19: (DELIMITER, ))
19: (DELIMITER, ;)
22: (id, size_t)
22: (id, len)
22: (OPERATOR, =)
22: (id, strlen)
22: (DELIMITER, ()
22: (id, name)
22: (DELIMITER, ))
22: (DELIMITER, ;)
23: (keyword, if)
23: (DELIMITER, ()
23: (id, name)
23: (DELIMITER, [)
```




```
1: (OPERATOR, #)
1: (keyword, include)
1: (OPERATOR, <)
1: (id, stdio)
1: (OPERATOR, .)
1: (id, h)
1: (OPERATOR, >)
2: (OPERATOR, #)
2: (keyword, include)
2: (OPERATOR, <)
2: (id, string)
2: (OPERATOR, .)
2: (id, h)
2: (OPERATOR, >)
5: (OPERATOR, #)
5: (keyword, define)
5: (id, MAX_LENGTH)
5: (int, 100)
8: (keyword, void)
8: (id, print_greeting)
8: (DELIMITER, ()
8: (keyword, const)
8: (keyword, char)
8: (OPERATOR, *)
8: (id, name)
8: (DELIMITER, ))
```

```
8: (DELIMITER, ;)
11: (keyword, int)
11: (id, main)
11: (DELIMITER, ()
11: (DELIMITER, ))
11: (DELIMITER, {)
13: (keyword, char)
13: (id, name)
13: (DELIMITER, [)
13: (id, MAX_LENGTH)
13: (DELIMITER, ])
13: (DELIMITER, ;)
16: (id, printf)
16: (DELIMITER, ()
16: (STRING, "请输入你的名字：")
16: (DELIMITER, ))
16: (DELIMITER, ;)
19: (id, fgets)
19: (DELIMITER, ()
19: (id, name)
19: (DELIMITER, ,)
19: (id, MAX_LENGTH)
19: (DELIMITER, ,)
19: (id, stdin)
19: (DELIMITER, ))
19: (DELIMITER, ;)
22: (id, size_t)
22: (id, len)
22: (OPERATOR, =)
22: (id, strlen)
22: (DELIMITER, ()
22: (id, name)
22: (DELIMITER, ))
22: (DELIMITER, ;)
23: (keyword, if)
23: (DELIMITER, ()
23: (id, name)
23: (DELIMITER, [)
23: (id, len)
23: (OPERATOR, -)
23: (int, 1)
23: (DELIMITER, ])
23: (OPERATOR, ==)
23: (CHAR, '\n')
23: (DELIMITER, ))
23: (DELIMITER, {)
24: (id, name)
24: (DELIMITER, [)
24: (id, len)
24: (OPERATOR, -)
24: (int, 1)
24: (DELIMITER, ])
24: (OPERATOR, =)
24: (CHAR, '\0')
```

```
24: (DELIMITER, ;)
25: (DELIMITER, })
28: (id, print_greeting)
28: (DELIMITER, ()
28: (id, name)
28: (DELIMITER, ))
28: (DELIMITER, ;)
31: (keyword, return)
31: (int, 0)
31: (DELIMITER, ;)
32: (DELIMITER, })
35: (keyword, void)
35: (id, print_greeting)
35: (DELIMITER, ()
35: (keyword, const)
35: (keyword, char)
35: (OPERATOR, *)
35: (id, name)
35: (DELIMITER, ))
35: (DELIMITER, {)
37: (id, printf)
37: (DELIMITER, ()
37: (STRING, "你好, %s! 欢迎使用这个简单的 C 程序。\n")
37: (DELIMITER, ,)
37: (id, name)
37: (DELIMITER, ))
37: (DELIMITER, ;)
38: (DELIMITER, })
```

可以看到，识别出了各种类型的符号，包括关键字、标识符、操作符、分隔符、字符串、字符等，能够正确识别出各种类型的符号

2. test2.txt

下面修改了test1.txt中的一些内容，使得其出现了一些错误，如下：

```
Char 1name[MAX_LENGTH];
```

预期能识别画出Keyword大小写错误和ID首字母错误。

实际输出如下：

```
11: (DELIMITER, ))
11: (DELIMITER, {)
13: (ERROR, Char --- Keyword should be lower case)
13: (ERROR, 1name --- ID should start with a letter)
13: (DELIMITER, [)
13: (id, MAX_LENGTH)
13: (DELIMITER, ])
13: (DELIMITER, ;)
```

可以看到，识别出了大小写错误的关键字和ID首字母错误，并且输出为红色

```
1: (OPERATOR, #)
1: (keyword, include)
1: (OPERATOR, <)
1: (id, stdio)
1: (OPERATOR, .)
1: (id, h)
1: (OPERATOR, >)
```

```
2: (OPERATOR, #)
2: (keyword, include)
2: (OPERATOR, <)
2: (id, string)
2: (OPERATOR, .)
2: (id, h)
2: (OPERATOR, >)
5: (OPERATOR, #)
5: (keyword, define)
5: (id, MAX_LENGTH)
5: (int, 100)
8: (keyword, void)
8: (id, print_greeting)
8: (DELIMITER, ()
8: (keyword, const)
8: (keyword, char)
8: (OPERATOR, *)
8: (id, name)
8: (DELIMITER, ))
8: (DELIMITER, ;)
11: (keyword, int)
11: (id, main)
11: (DELIMITER, ()
11: (DELIMITER, ))
11: (DELIMITER, {)
13: (ERROR, Char --- Keyword should be lower case)
13: (ERROR, 1name --- ID should start with a letter)
13: (DELIMITER, [)
13: (id, MAX_LENGTH)
13: (DELIMITER, ])
13: (DELIMITER, ;)
16: (id, printf)
16: (DELIMITER, ()
16: (STRING, "请输入你的名字：")
16: (DELIMITER, ))
16: (DELIMITER, ;)
19: (id, fgets)
19: (DELIMITER, ()
19: (id, name)
19: (DELIMITER, ,)
19: (id, MAX_LENGTH)
19: (DELIMITER, ,)
19: (id, stdin)
19: (DELIMITER, ))
19: (DELIMITER, ;)
22: (id, size_t)
22: (id, len)
22: (OPERATOR, =)
22: (id, strlen)
22: (DELIMITER, ()
22: (id, name)
22: (DELIMITER, ))
22: (DELIMITER, ;)
23: (keyword, if)
```

```
23: (DELIMITER, ()
23: (id, name)
23: (DELIMITER, [)
23: (id, len)
23: (OPERATOR, -)
23: (int, 1)
23: (DELIMITER, ])
23: (OPERATOR, ==)
23: (CHAR, '\n')
23: (DELIMITER, ))
23: (DELIMITER, {)
24: (id, name)
24: (DELIMITER, [)
24: (id, len)
24: (OPERATOR, -)
24: (int, 1)
24: (DELIMITER, ])
24: (OPERATOR, =)
24: (CHAR, '\0')
24: (DELIMITER, ;)
25: (DELIMITER, })
28: (id, print_greeting)
28: (DELIMITER, ()
28: (id, name)
28: (DELIMITER, ))
28: (DELIMITER, ;)
31: (keyword, return)
31: (int, 0)
31: (DELIMITER, ;)
32: (DELIMITER, })
35: (keyword, void)
35: (id, print_greeting)
35: (DELIMITER, ()
35: (keyword, const)
35: (keyword, char)
35: (OPERATOR, *)
35: (id, name)
35: (DELIMITER, ))
35: (DELIMITER, {)
37: (id, printf)
37: (DELIMITER, ()
37: (STRING, "你好, %s! 欢迎使用这个简单的 C 程序。\n")
37: (DELIMITER, ,)
37: (id, name)
37: (DELIMITER, ))
37: (DELIMITER, ;)
38: (DELIMITER, })
```

实验总结

1. 通过本次实验，我学会了如何设计一个简单的词法分析器，能使用C++语言识别出各种类型的符号，包括关键字、标识符、操作符、分隔符、字符串、字符等
2. 通过本次实验，我学会了如何使用状态机设计词法分析器，通过状态机的状态转移来识别各种类型的符号
3. 通过本次实验，我学会了如何使用C++语言读取文件内容，并将输出重定向到指定的输出文件
4. 通过本次实验，我学会了如何实现超前搜索，用于识别++、--等符号
5. 通过本次实验，我学会了如何修改输出颜色，使得错误输出为红色