Make it robust.

C 程 序 设 计

C Programming

8

字符输入输出和输入验证

理论课程

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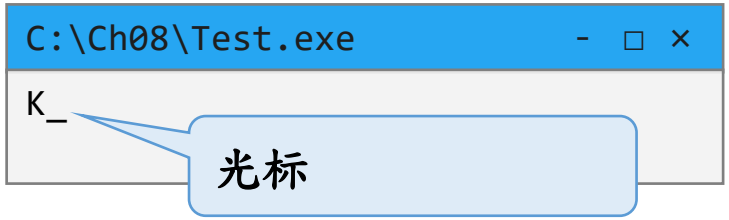
知识框架

- 输入和输出缓冲
- 创建友好的用户界面

内容纲要

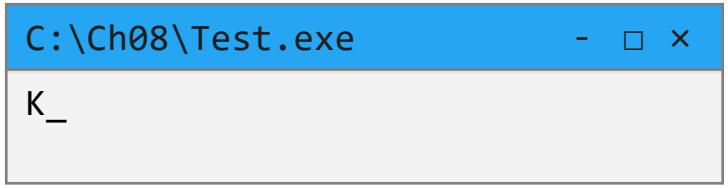
区分输入显示和输出显示

- 输入时的显示
  - 当单击键盘的可见字符时，屏幕将立即显示该字符



- 输出时的显示
  - 当程序向屏幕输出时，屏幕显示该内容

```
printf("K\n");
```



单字符 I/O

- getchar()和putchar()函数

语法	功能
ch = getchar();	每次输入一个字符，返回到返回值
new_ch = putchar(*ch*);	每次输出一个字符，并将该字符返回到返回值

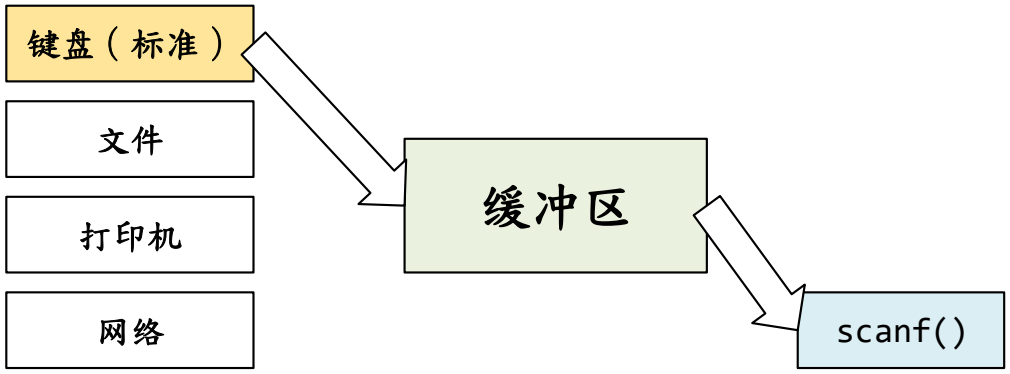
  - 注意putchar()函数仅在*ch*为回车等一并输出

```c
/* echo.c -- repeats input */
#include <stdio.h>
int main(void)
{
    char ch;

    while ((ch = getchar()) != '#')
        putchar(ch);

    return 0;
}
```

```
This is my brother.↲
This is my brother.
$#$@$#↲
$
```

输入输出缓冲

- 缓冲（ buffer ）
  - 缓冲区是物理存储器（内存）的一个区域，用于在从一个地方移动到另一个位置时临时存储数据。
  - 缓冲技术是为了协调吞吐速度相差很大的设备之间数据传送而采用的技术。
    - CPU和键盘的速度相差很大
- 输入缓冲区相关
  - 键盘缓冲区
  - 程序缓冲区



缓冲输入流的行为

- 缓冲区默认为空
- 程序从程序缓冲区中读取数据
  - 已读数据从缓冲区删除，未读取的数据仍存储于缓冲区中
- 程序读取数据而程序缓冲区为空时
  - 如果能补充缓冲，则暂停等待；否则，返回EOF继续程序
- 程序结束后，缓冲区释放

输入缓冲

- 分类（不仅输入有缓冲，输出也有缓冲）
  - 完全缓冲：遇到缓冲区满时发送并清空（文件）
  - 行缓冲：遇到回车时发送并清空（键盘）
- 优缺点
  - 允许用户在输入结束前发现错误，及时修改
  - 减少调用输入输出的负担（如：数据库）
  - 交互式程序需要非缓冲

无缓冲输入流的行为

- 当运行到需要获取输入的函数时
  - 直接读取键盘输入一个字符，并马上继续
  - 键盘不输入时，程序暂停

```
TThhiiss  iiss↲
↲
$$#↲
```

一些系统上运行程序时，输入立即回显，成为非缓冲I/O

输入缓冲

- 输入有缓冲与无缓冲的区别

键盘	输入缓存	getch()返回值（有缓冲）
H	H	暂停运行，等待缓存区清空
i	H,i	暂停运行，等待缓存区清空
!	H,i,!	暂停运行，等待缓存区清空
Enter	H,i,! ,\n	第1次调用返回字符H 第2次调用返回字符i 第3次调用返回字符! 第4次调用返回字符\n
	（空）	程序继续运行
A	A	第5次调用则等待

键盘	getch()返回值（无缓冲）
H	第1次调用返回字符H
i	第2次调用返回字符i
!	第3次调用返回字符!
Enter	第4次调用返回字符\n
A	第5次调用返回字符A

输出缓冲

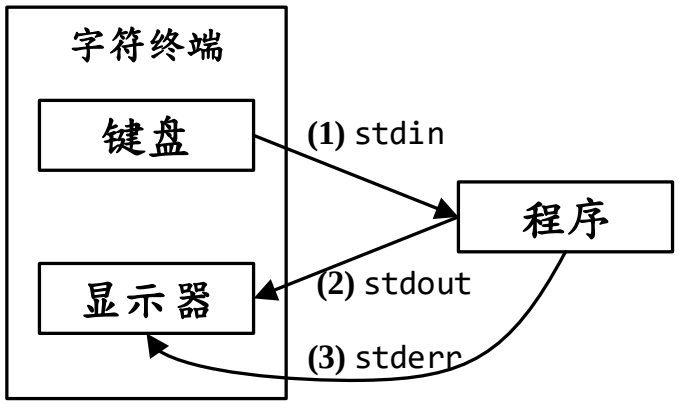
- 输出有缓冲与无缓冲的区别

putch()参数值	输出缓存	显示器（行缓冲）
H	H	无显示
i	H,i	无显示
!	H,i,!	无显示
\n	H,i,! ,\n	Hi!↲
	（空）	Hi!↲
A	A	Hi!↲

putch()参数值	显示器（无缓冲）
H	H
i	Hi
!	Hi!
\n	Hi!↲
A	Hi!↲ A

输入输出流（stream）

- 流是一段时间内可用的数据元素序列。
  - 流的概念掩盖了不同设备的底层差异，提供统一接口
    - 替用户和操作系统底层I/O打交道



常见的设备	标准流	打开(open)	关闭(close)	读取(read)	写入(write)
屏幕	标准输出流 stdout 标准错误流 stderr	自动打开	不可	不可	可
键盘	标准输入流 stdin	自动打开	不可	可	不可
打印机	打印流	可	可	不可	可
文件	文件流	可	可	可	可
网络	网络流	可	可	可	可

输入流的终止

- 输入流是可以终止的
  - 文件读取到末尾时，终止文件输入
  - 同时按下 Ctrl Z 终止键盘输入
  - 同时按下 Ctrl C 终止程序同时终止键盘输入
- 输入流终止后，流的读取函数scanf()返回值为EOF

```
#define EOF (-1)
```

```c
/* echo_eof.c -- repeats input to end of file */
#include <stdio.h>
int main(void)
{
    int ch;

    while ((ch = getchar()) != EOF)
        putchar(ch);

    return 0;
}
```

```
This is my joke.↲
This is my joke.
Ctrl + C
```

```c
// file_eof.c --open a file and display it
#include <stdio.h>
#include <stdlib.h>  // for exit()
int main()
{
    int ch;
    FILE * fp;
    char fname[50];          // to hold the file name
    printf("Enter the name of the file: ");
    scanf("%s", fname);
    fp = fopen(fname, "r"); // open file for reading
    if (fp == NULL)          // attempt failed
    {
          printf("Failed to open file. Bye\n");
          exit(1);              // quit program
    }
```

```
    // getc(fp) gets a character from the open file
    while ((ch = getc(fp)) != EOF)
        putchar(ch);
    fclose(fp);                 // close the file
    return 0;
}
```

```
Enter the name of the file: D:\***\c1-1.c↵
#include <stdio.h>                          // 这是编译预处理命令
int u();
int main( )                                 // 定义主函数
{                                           // 函数开始的标志
 printf ("This is a C program A.");         // 输出所指定的一行信息
 u();
 return 0;                                  // 函数执行完毕时返回函数值0
}
```

流的重定向

- 通过命令行将标准流重定向（redirect）到其它流
  - 输入输出可以从键盘或显示器重定向到文件
  - 输出流可以重定向至打印机

重定向的目的	命令行实例
将标准输入流（键盘）重定向到文件	*exe_path < in_file_path*
将标准输出流（屏幕）到文件	*exe_path > out_file_path*
同时重定向标准输入和输出流到不同的文件中（命令行中次序先后无关）	*exe_path < in_file_path > out_file_path*
	exe_path > out_file_path < in_file_path
将标准输出流到文件追加到文件尾	*exe_path >> out_file_path*
将标准错误流（屏幕）重定向到文件	*exe_path 1> out_file_path 2> err_file_path*

流的重定向

- 通过函数将标准流重定向到其它流
  - 参数分别为：文件名、读写模式、流

```
FILE * freopen(const char * filename, const char * mode, FILE * stream);
```

  - 用法

重定向的目的	命令行实例
将标准输入流（键盘）定向到文件	freopen("in.txt", "r", stdin);
将标准输出流（屏幕）定向到文件	freopen("out.txt", "w", stdout);
将标准错误流（屏幕）重定向到文件	freopen("err.txt", "w", stderr);
将标准错误流追加重定向到文件尾	freopen("err.txt", "a", stderr);

内容纲要

1	输入和输出缓冲
2	创建友好的用户界面
3	总结

创建一个更友好的用户界面

- 软件工程更应该注重的地方
  - 主体功能是基础
  - 软件在用户各种可能的输入下不崩溃也很重要
- 应解决初级用户的输入错误
  - 需要解决多余回车的问题
  - 需要解决不慎按错键的问题

```
/*************************************************************
* Input the initial velocity, acceleration and time,
* calculates the shift, by the equation
*    s = v0*t + 1.0 / 2 * a*t*t;
* Author:  Wei Huang <whuang@xmu.edu.cn>
* Version: 1.0 [Jun. 11, 2014]
* Version: 2.0 [Oct. 27, 2016]
*************************************************************/
#include <stdio.h> /* Standard I/O header */

double getDouble(const char *message); // prototype

int main(void)
{
      double v0 = 0; //initial velocity
      double a = 0;  //acceleration
      double t = 0;  //time
      double s = 0;  //shift
```

```
        v0 = getDouble("Enter the Initial Velocity (m/s): ");
        a = getDouble("Enter the Acceleration (m/(s*s)): ");
        t = getDouble("Enter the Time (s): ");
        if (t < 0) //time cannot be negative
        {
                printf("The time CANNOT be negative.\n");
                return -1; //error code -1: time<0
        }
        s = v0*t + 1.0 / 2 * a*t*t; //main equation
        printf("The total shift is %.3lf m.\n", s);
        return 0; //return code 0: no error
}

/*
      Read input from keyboard and scan as a double variable.
If users type wrong characters, it will be ignored.
        Parameters:
                message --- Welcome message
```

```
        Return:
                a double variable that the user entered.
*/
double getDouble(const char *message)
{
        double dbl;
        printf("%s", message);
        while (scanf("%lf", &dbl) == 0)
        {
                char c;
                while (scanf("%c", &c) == 1 && c != '\n');
                printf("%s\n%s", "Error input.", message);
        }
        return dbl;
}
```

```c
/* guess.c -- an inefficient and faulty number-guesser */
#include <stdio.h>
int main(void)
{
    int guess = 1;
    printf("Pick an integer from 1 to 100. I will try to
guess ");
    printf("it.\nRespond with a y if my guess is right and
with");
    printf("\nan n if it is wrong.\n");
    printf("Uh...is your number %d?\n", guess);
    while (getchar() != 'y') /* get response, compare to y */
        printf("Well, then, is it %d?\n", ++guess);
    printf("I knew I could do it!\n");

    return 0;
}
```

```
Pick an integer from 1 to 100. I will try to guess it.
Respond with a y if my guess is right and with
an n if it is wrong.
Uh...is your number 1?
n↲
Well, then, is it 2?
Well, then, is it 3?
↲
Well, then, is it 4?
↲
Well, then, is it 5?
2↲
Well, then, is it 6?
Well, then, is it 7?
y↲
I knew I could do it!
```

```c
/* showchar1.c -- program with a BIG I/O problem */
#include <stdio.h>
void display(char cr, int lines, int width);
int main(void)
{
    int ch;              /* character to be printed    */
    int rows, cols;      /* number of rows and columns */
    printf("Enter a character and two integers:\n");
    while ((ch = getchar()) != '\n')
    {
        scanf("%d %d", &rows, &cols);
        display(ch, rows, cols);
        printf("Enter another character and two integers;\n");
        printf("Enter a newline to quit.\n");
    }
    printf("Bye.\n");
    return 0;
}
```

```c
void display(char cr, int lines, int width)
{
    int row, col;

    for (row = 1; row <= lines; row++)
    {
        for (col = 1; col <= width; col++)
            putchar(cr);
        putchar('\n');  /* end line and start a new one */
    }
}
```

```
Enter a character and two integers:
c 1 4↲
cccc
Enter another character and two integers;
Enter a newline to quit.
Bye.
```

```c
/* showchar2.c -- prints characters in rows and columns */
#include <stdio.h>
void display(char cr, int lines, int width);
int main(void)
{
    int ch;              /* character to be printed      */
    int rows, cols;      /* number of rows and columns   */
    printf("Enter a character and two integers:\n");
    while ((ch = getchar()) != '\n')
    {
        if (scanf("%d %d",&rows, &cols) != 2)
            break;
        display(ch, rows, cols);
        while (getchar() !=  '\n')
            continue;
        printf("Enter another character and two integers;\n");
        printf("Enter a newline to quit.\n");
    }
```

```
    printf("Bye.\n");
    return 0;
}

void display(char cr, int lines, int width)
{
    int row, col;
    for (row = 1; row <= lines; row++)
    {
        for (col = 1; col <= width; col++)
            putchar(cr);
        putchar('\n');  /* end line and start a new one */
    }
}
```

```
Enter a character and two integers:
c 1 3↲
ccc
Enter another character and two integers;
Enter a newline to quit.
* 2 3↲
***
***
Enter another character and two integers;
Enter a newline to quit.
↲
Bye.
```

```c
// checking.c -- validating input
#include <stdio.h>
#include <stdbool.h>
// validate that input is an integer
long get_long(void);
// validate that range limits are valid
bool bad_limits(long begin, long end,
                long low, long high);
// calculate the sum of the squares of the integers
// a through b
double sum_squares(long a, long b);
int main(void)
{
    const long MIN = -10000000L;  // lower limit to range
    const long MAX = +10000000L;  // upper limit to range
    long start;                   // start of range
    long stop;                    // end of range
    double answer;
```

```
    printf("This program computes the sum of the squares of "
           "integers in a range.\nThe lower bound should not "
           "be less than -10000000 and\nthe upper bound "
           "should not be more than +10000000.\nEnter the "
           "limits (enter 0 for both limits to quit):\n"
           "lower limit: ");
    start = get_long();
    printf("upper limit: ");
    stop = get_long();
    while (start !=0 || stop != 0)
    {
        if (bad_limits(start, stop, MIN, MAX))
            printf("Please try again.\n");
        else
        {
            answer = sum_squares(start, stop);
            printf("The sum of the squares of the integers ");
```

```
        printf("from %ld to %ld is %g\n", start, stop,
answer);
        }
        printf("Enter the limits (enter 0 for both "
               "limits to quit):\n");
        printf("lower limit: ");
        start = get_long();
        printf("upper limit: ");
        stop = get_long();
    }
    printf("Done.\n");
    return 0;
}

long get_long(void)
{
    long input;
    char ch;
```

```
    while (scanf("%ld", &input) != 1)
    {
        while ((ch = getchar()) != '\n')
            putchar(ch);  // dispose of bad input
        printf(" is not an integer.\nPlease enter an ");
        printf("integer value, such as 25, -178, or 3: ");
    }
    return input;
}

double sum_squares(long a, long b)
{
    double total = 0;
    long i;
    for (i = a; i <= b; i++)
        total += (double)i * (double)i;
    return total;
}
```

```
bool bad_limits(long begin, long end, long low, long high)
{
    bool not_good = false;
    if (begin > end)
    {
        printf("%ld isn't smaller than %ld.\n", begin, end);
        not_good = true;
    }
    if (begin < low || end < low)
    {
        printf("Values must be %ld or greater.\n", low);
        not_good = true;
    }
    if (begin > high || end > high)
    {
        printf("Values must be %ld or less.\n", high);
        not_good = true;
    }
```

```
    return not_good;
}
```

```
This program computes the sum of the squares of integers
in a range.
The lower bound should not be less than -10000000 and
the upper bound should not be more than +10000000.
Enter the limits (enter 0 for both limits to quit):
lower limit: 1973↲
upper limit: 2931↲
The sum of the squares of the integers from 1973 to 2931
is 5.8393e+009
Enter the limits (enter 0 for both limits to quit):
lower limit: 0↲
upper limit: 0↲
Done.
```

菜单浏览

- 显示一个菜单，并接受用户输入一个选项
- 根据选项执行相应操作

```c
/* menuette.c -- menu techniques */
#include <stdio.h>
char get_choice(void);
char get_first(void);
int get_int(void);
void count(void);
int main(void)
{
    int choice;
    void count(void);

    while ( (choice = get_choice()) != 'q')
    {
        switch (choice)
        {
            case 'a' :  printf("Buy low, sell high.\n");
                break;
```

```
            case 'b' :  putchar('\a');  /* ANSI */
                break;
            case 'c' :  count();
                break;
            default  :  printf("Program error!\n");
                break;
        }
    }
    printf("Bye.\n");

    return 0;
}

void count(void)
{
    int n,i;
    printf("Count how far? Enter an integer:\n");
    n = get_int();
```

```
    for (i = 1; i <= n; i++)
        printf("%d\n", i);
    while ( getchar() != '\n')
        continue;
}

char get_choice(void)
{
    int ch;

    printf("Enter the letter of your choice:\n");
    printf("a. advice           b. bell\n");
    printf("c. count            q. quit\n");
    ch = get_first();
    while (  (ch < 'a' || ch > 'c') && ch != 'q')
    {
        printf("Please respond with a, b, c, or q.\n");
        ch = get_first();
    }
```

```
    return ch;
}

char get_first(void)
{
    int ch;
    ch = getchar();
    while (getchar() != '\n')
        continue;
    return ch;
}

int get_int(void)
{
    int input;
    char ch;
```

```
Enter the letter of your choice:
a. advice           b. bell
c. count            q. quit
c↲
Count how far? Enter an integer:
5↲
1
2
3
4
5
Enter the letter of your choice:
a. advice           b. bell
c. count            q. quit
b↲
Enter the letter of your choice:
a. advice           b. bell
c. count            q. quit
q↲
Bye.
```

```
    while (scanf("%d", &input) != 1)
    {
        while ((ch = getchar()) != '\n')
            putchar(ch);  // dispose of bad input
        printf(" is not an integer.\nPlease enter an ");
        printf("integer value, such as 25, -178, or 3: ");
    }

    return input;
}
```

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谢谢

理论课程

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