云南大学数学与统计学院
上机实践报告

课程名称： 运筹学实验	**年级：** 2015 级	**上机实践成绩：**
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上机实践名称： 求给定序列的最小值及所有最小值的下标	**学号：** 20151910042	**上机实践日期：** 2018-03-21
上机实践编号： 1	**组号：**	

一、 实验目的

完成该实验，为后期的更进一步的实验做准备。

二、实验内容

给定两组数$\boldsymbol{a}=(a_1,\ a_2,\ \cdots,\ a_n)$和$\boldsymbol{b}=\{b_1,\ b_2,\ \cdots,\ b_n\}$，求

1. 一组数$\boldsymbol{c}=(c_1,\ c_2,\ \cdots,\ c_n)$，其中$c_i=a_i/b_i,\ i=1,\ 2,\ \cdots,\ n$.
2. 求最小值及所有最小值的下标，其中最小值为$\min\{a_i/b_i|\ b_i>0,\ i=1,\ 2,\ \cdots,\ n\}$.

三、实验平台

Windows 10 Pro 1703；

Microsoft© Visual Studio 2017 Enterprise。

四、算法设计

Algorithm: find the minimal value and all the indexes
Input: two list **a** and **b** and their length are n.
Output: list c, whose value is the division of a by b at the same position; minimal value and their positions.
Begin
Step 1: for i = 0 through n
        c[i] = a[i] / b[i]
    output **c**
Step 2: **tmp_c** is a set contains all the elements in **c** whose b[i] > 0;
    sort **tmp_c** incrementally, set tmp = tmp_c[0]
Step 3: for i = 0 through n
        if c[i] == a[i] and b[i] > 0
        output i
End

五、程序代码

5.1 程序描述

这个解释程序的使用方法是这样的：在 shell 中通过调用本可执行程序 div，输入两个字符串参数，然后程序自动输出c与最小值及其所有位置。如下所示：（这里隐藏了 PowerShell 的工作目录，仅用 PS >作为提示符）

```
PS > .\div.exe "( -3.14,20 ,-256, 0 ,6,5,12121,4588, 89)" "(3.14, -1, 256,3.2222,2,0,5633.2,168,78)"
argument 1 is
(-3.14, 20.00, -256.00, 0.00, 6.00, 5.00, 12121.00, 4588.00, 89.00)

argument 2 is
(3.14, -1.00, 256.00, 3.22, 2.00, 0.00, 5633.20, 168.00, 78.00)

The answer C = (-1.00 , -20.00 , -1.00 , 0.00 , 3.00 , NaN , 2.15 , 27.31 , 1.14 )
Minimal Value is -1.00 , position is (1.00, 3.00)

PS >
```

因为并没有 shell 接口，所以基本上是自己写一个 shell 来做这个与机器的交互。首先是清洗，把两个字符串进行 clean 重整，去除可能的空格之后，第一步是跳过第一个圆括号，同时把最后的圆括号变为逗号。这样一来就好多了，一个 double 数值跟着一个逗号。（这里都是对一个字符串来说的，毕竟解释得了一个就能解释两个。）

第二步就是分割，把这个字符串当作一块“长条豆腐”，每次从头部切一部分下来，直到切光。头部已经是处理好的了，所以一直切到遇到的第一个逗号，这个过程把逗号之前的字符，即可能出现的负号与小数点进行分类处理，符号的话直接跳过最后乘-1 即可，其余的数字符号与小数点就直接归入队列（其实是链表），与此同时，队列的头号元素，跟着一个索引 1，一直到队列的末尾，即遇到的第一个分号。这样的话，遍历一遍找到小数点的索引，利用对称的坐标变换公式，把数字与小数点的距离转化为 10 的指数，就可以通过 pow 函数做出这个具体的数值。同时在整个过程中要注意保护头指针与 work 指针的归位。这个数一旦算出来，就交给动态数组保存，一直读到\0，就算是读完了。这个过程一直保存，解释函数自己判断。当解释程序返回一个浮点数就归入，返回 NULL 就结束归入。

拿到了两个动态数组之后，就可以做除法、排序与查找了，有数字，有大小，C 很容易就做出来了。

5.2 程序代码

```
1    // filename: div.c
2
3    /* -*- coding: utf-8 -*-
4
```

```
5    Created on Wed Mar 14 19 : 10 : 28 2018
6
7    @author: LiuPeng
8    */
9
10   #include<stdio.h>
11   #include<stdlib.h>
12   #include<string.h>
13   #include<math.h>
14
15   // The following type is a container for creating a stack.
16   typedef struct char_LinkedList {
17       char_LinkedList *head;
18       char elements;          // partition must be integer less than 10
19       int times;             // 这是一个容器，放置一个数组，用指针作为头
20       char_LinkedList *next;
21   }char_LinkedList;
22
23   typedef struct Dynamic_Array {
24       double *A;             // 底层数组
25       int capacity;          // 底层数组的容量
26       int n;                 // 底层数组的占用量
27   }Dynamic_Array;
28
29   typedef struct Div {
30       double up;
31       double down;
32       double value;
33       char state[10];         // NaN or Negative，长度不定
34                              // 这个 state 必须是 malloc 而来的，坚决不能直接用
35   }Div;
36
37   typedef struct Div_Dynamic_Array {
38       Div *A;            // 底层结构体数组的头指针，不能动！
39       int capacity;       // 底层结构体数组的容量
40       int n;             // 底层数组的占用量
41   }Div_Dynamic_Array;
42
43   void Div_Resize(Div_Dynamic_Array *D) {
44       int i = 0;
45       Div *tmp = (Div *)calloc(2 * D->capacity, sizeof(Div));
46       if (tmp == NULL) {
47           printf("Cannot get memory, crash!\n");
48           return;
49       }
50       for (i = 0; i < D->capacity; i++) {
51           (tmp + i)->up = (D->A + i)->up;
52           (tmp + i)->down = (D->A + i)->down;
53           (tmp + i)->value = (D->A + i)->value;
```

```
54          strcpy((tmp + i)->state, (D->A + i)->state);           //不能简单复制，否则会内存出错
55      }
56      free(D->A);
57      D->A = tmp;
58      tmp = NULL;         // 避免野指针
59
60      D->capacity *= 2;
61  }
62
63  void Div_Append(Div_Dynamic_Array *D, Div e) {
64      if (D->n == D->capacity) {
65          Div_Resize(D);
66      }
67      (D->A + D->n)->up = e.up;
68      (D->A + D->n)->down = e.down;
69      (D->A + D->n)->value = e.value;
70      strcpy((D->A + D->n)->state, e.state);
71      D->n += 1;
72      //int i;
73      //for (i = 0; i <= D->n; i++) {
74      //  printf("%s\t", (D->A + i)->state);
75      //}
76      //printf("\n");
77  }
78
79  void Div_print(Div_Dynamic_Array *d) {
80      int i;
81      printf("The answer C = (");
82      for (i = 0; i < d->n; i++) {
83          if (!strcmp((d->A + i)->state, "NaN")) {
84              printf("%s ", "NaN");
85          }
86          else {
87              double value = (d->A + i)->value;
88              printf("%2.2f ", value);
89          }
90          if (i == d->n - 1) {
91              printf("");
92          }
93          else {
94              printf(", ");
95          }
96      }
97      printf(")\n");
98  }
99
100 void Div_onArray(Dynamic_Array *a, Dynamic_Array *b, Div_Dynamic_Array *ans) {
101     if (a->n != b->n) {
102         printf("length should be the same.");
```

```
103         return;
104     }
105 
106     int i;
107     for (i = 0; i < a->n; i++) {
108         if (*(b->A + i) == 0) {
109             Div tmp;
110             tmp.up = NULL;
111             tmp.down = NULL;
112             tmp.value = NULL;
113             char c[] = "NaN";
114             strcpy(tmp.state, c);
115             Div_Append(ans, tmp);
116         }
117         else {
118             if (*(b->A + i) < 0.) {
119                 Div tmp;
120                 tmp.up = *(a->A + i);
121                 tmp.down = *(b->A + i);
122                 tmp.value = tmp.up / tmp.down;
123                 char c[] = "Negative";
124                 strcpy(tmp.state, c);
125                 Div_Append(ans, tmp);
126             }
127             else {
128                 Div tmp;
129                 tmp.up = *(a->A + i);
130                 tmp.down = *(b->A + i);
131                 tmp.value = tmp.up / tmp.down;
132                 char c[] = "Normal";
133                 strcpy(tmp.state, c);
134                 Div_Append(ans, tmp);
135             }
136         }
137     }
138 }
139 
140 void print(int n, Dynamic_Array *d) {   // 输出一个动态的双精度数组
141     printf(/* "argument %d is \n*/"(");
142     int i;
143     for (i = 0; i < d->n - 1; i++) {
144         printf("%2.2f, ", *(d->A + i));
145     }
146     printf("%2.2f", *(d->A + i));
147     printf(")\n\n");
148 }
149 
150 void Resize(Dynamic_Array *D) {
151     int i = 0;
```

```
152     double *tmp = (double *)calloc(2 * D->capacity, sizeof(double));
153     if (tmp == NULL) {
154         printf("Cannot get memory, crash!\n");
155         return;
156     }
157     for (i = 0; i < D->capacity; i++) {
158         *(tmp + i) = *(D->A + i);
159     }
160     D->A = tmp;
161     D->capacity *= 2;
162 }
163 
164 void Append(Dynamic_Array *D, double e) {
165     if (D->n == D->capacity) {
166         Resize(D);
167     }
168     *(D->A + D->n) = e;
169     D->n += 1;
170 }
171 
172 Dynamic_Array *Quick_sort(Dynamic_Array *a) {
173 
174     Dynamic_Array *less = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
175     less->A = (double *)calloc(1, sizeof(double));
176     if (!less) {
177         printf("Can't get memory!");
178         return NULL;
179     }
180     less->capacity = 1;
181     less->n = 0;
182 
183     Dynamic_Array *more = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
184     more->A = (double *)calloc(1, sizeof(double));
185     if (!more) {
186         printf("Can't get memory!");
187         return NULL;
188     }
189     more->capacity = 1;
190     more->n = 0;
191 
192     Dynamic_Array *eq = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
193     eq->A = (double *)calloc(1, sizeof(double));
194     if (!eq) {
195         printf("Can't get memory!");
196         return NULL;
197     }
198     eq->capacity = 1;
199     eq->n = 0;
200 
```

```
    int i;
    if (a->n <= 1) {
        return a;
    }
    else {
        /*double pivot = 1 / 3. * (*(a->A) + ;*/

        for (i = 0; i < a->n; i++) {
            double pivot = *(a->A);
            if (*(a->A + i) > pivot) {
                Append(more, *(a->A + i));
            }
            else {
                if (*(a->A + i) < pivot) {
                    Append(less, *(a->A + i));
                }
                else {
                    Append(eq, *(a->A + i));
                }
            }
        }
    }
    less = Quick_sort(less);
    more = Quick_sort(more);
    for (i = 0; i < eq->n; i++) {
        Append(less, *(eq->A + i));
    }
    for (i = 0; i < more->n; i++) {
        Append(less, *(more->A + i));
    }
    return less;
}

void find(Div_Dynamic_Array *a) {

    Dynamic_Array *c = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
    Dynamic_Array *d = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
    c->A = (double *)calloc(a->n, sizeof(double));
    if (c == NULL || d == NULL || c->A == NULL) {
        printf("Can't get memory!\n");
        return;
    }
    c->capacity = a->n;
    c->n = 0;

    int i = 0;
    for (i = 0; i < a->n; i++) {
        if (!strcmp((a->A + i)->state, "Normal")) {     // 分母合法的就 append
            Append(c, (a->A + i)->value);
```

```
250         }
251     }
252     d = Quick_sort(c);      // 排序一下
253     //print(d->n, d);
254 
255     double pivot = *(d->A + 0);
256     printf("Minimal Value is %2.2f , position is ", pivot);
257     Dynamic_Array *tmp = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
258     tmp->A = (double *)calloc(1, sizeof(double));
259     if (tmp == NULL || tmp->A == NULL) {
260         printf("Can't get memory!\n");
261         return;
262     }
263     tmp->capacity = 1;
264     tmp->n = 0;
265     for (i = 0; i < a->n; i++) {
266         if (!strcmp((a->A + i)->state, "Normal") && (a->A + i)->value == pivot) {
267             Append(tmp, ++i);
268         }
269     }
270     print(tmp->n, tmp);
271 }
272 
273 char *clean(char *string) {     // 已经后期优化，减去了字符串中所有的空格
274     char *head = string;
275     int count_space = 0;
276     while (*string == ' ' && *string != '\0') {
277         count_space += 1;
278         string += 1;
279     }
280     string = head;
281 
282     int len = 1;    // 有'\0'，所以要+1
283     while (*string != '\0') {
284         len += 1;
285         string++;
286     }
287     string = head;
288 
289     char *ans = (char *)calloc(len - count_space, sizeof(char));
290     if (ans == NULL) {
291         printf("Can't get memory!\n");
292         return NULL;
293     }
294     char *ans_head = ans;
295 
296     while (*string != '\0') {
297         if (*string != ' ') {
298             *ans = *string;
```

```
            ans++;
        }
        string++;
    }
    *ans = *string;
    ans = ans_head;
    string = head;

    ans = ans + 1;
    char *tmp;
    for (tmp = ans; *tmp != '\0'; tmp++) {
        if (*(tmp + 1) == '\0') {
            *tmp = ',';
        }
    }
    return ans;
}

char *cut(char *string) {
    while (*string != ',') {
        if (*string == '\0') {
            return '\0';
        }
        string++;
    }
    return ++string;
}

// Put an new element into the stack
double get_Number(char *string) {
    // 传递一个完整的 clean 过的字符串进来，按需切割头部，剩下的头作为新的头。
    if (*string == '\0') {
        return NULL;
    }
    double ans = 0.;
    if (*string == '\0') {
        return NULL;
    }
    if (*string != '-') {
        char_LinkedList *work = (char_LinkedList *)malloc(sizeof(char_LinkedList));
        if (work == NULL) {
            printf("Can't get memory!\n");
            return 0;
        }
        // container

        char_LinkedList *head = work;
        int i = 1;
        while (*string != ',') {
```

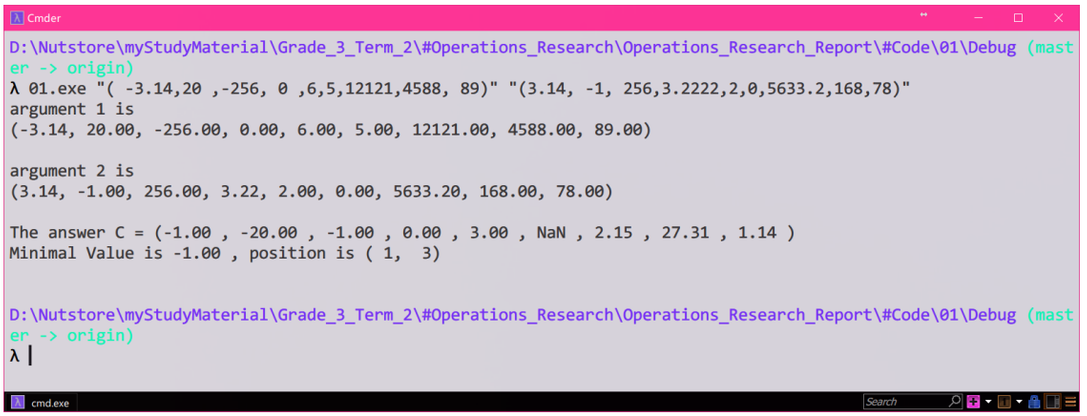
```
348             work->elements = *string;
349             work->times = i;
350             work->next = (char_LinkedList *)malloc(sizeof(char_LinkedList));    // 申请
351             if (work->next == NULL) {
352                 printf("Can't get memory!\n");
353                 return 0.;
354             }
355             work = work->next;                                                  // 移动
356             work->elements = NULL;
357             work->times = NULL;
358             string++;
359             i++;    // i 在后面还有用
360         }
361 
362         work->elements = *string;       // 逗号也要加上
363         work->times = NULL;             // 逗号的指数不能为有意义的
364 
365         string++;
366 
367         work = head;
368         int dot = 1;
369         int comma = 1;      // 逗号的用处
370         int dot_index = NULL;
371         while (work->elements != ',') {
372             if (work->elements == '.') {
373                 dot_index = dot;
374                 break;
375             }
376             work = work->next;
377             dot++;
378         }
379 
380         if (dot_index == NULL) {
381             dot_index = i;
382         }
383 
384         work = head;
385 
386         while (work->times != NULL) {
387             work->times = -1 * (work->times - dot_index);
388             work = work->next;
389         }
390 
391         work = head;
392 
393         while (work->elements != ',') {
394             if (work->elements == '.') {
395                 work = work->next;
396                 continue;
```

```
397             }
398             if (work->times > 0) {
399                 ans += pow(10, work->times - 1) * double(int(work->elements) - int('0'));
400                 work = work->next;
401             }
402             else {
403                 ans += pow(10, work->times) * double(int(work->elements) - int('0'));
404                 work = work->next;
405             }
406         }
407     }
408     else {
409         string = string + 1;
410         ans = -1 * get_Number(string);
411     }
412     return ans;
413 }
414 
415 int main(int argc, char *argv[]) {
416     if (argc != 3) {
417         printf("This function needs and only needs 2 arguments.\n");
418         return 0;
419     }
420 
421     char *string_1 = *(argv + 1);
422     char *string_2 = *(argv + 2);
423 
424     //char string_1_tmp[] = "( -3.14,20 ,-256, 0 ,6,5,12121,4588, 89)";
425     //char *string_1 = string_1_tmp;
426 
427     //char string_2_tmp[] = "(3.14, -1, 256,3.2222,2,0,5633.2,168,78)";
428     //char *string_2 = string_2_tmp;
429 
430     string_1 = clean(string_1);
431     string_2 = clean(string_2);
432 
433     Dynamic_Array c_1, c_2;
434     c_1.A = (double *)malloc(sizeof(double));
435     if (c_1.A == NULL) {
436         printf("Can't get memory!\n");
437         return 0;
438     }
439     c_1.capacity = 1;
440     c_1.n = 0;
441 
442     c_2.A = (double *)malloc(sizeof(double));
443     if (c_2.A == NULL) {
444         printf("Can't get memory!\n");
445         return 0;
```

```
446     }
447     c_2.capacity = 1;
448     c_2.n = 0;
449 
450     while (string_1 != '\0') {
451         Append(&c_1, get_Number(string_1));
452         string_1 = cut(string_1);
453     }
454 
455     while (string_2 != '\0') {
456         Append(&c_2, get_Number(string_2));
457         string_2 = cut(string_2);
458     }
459     c_1.n -= 1;     // 这也是无奈之举啊，谁让 0.0 ==NULL 呢
460     c_2.n -= 1;
461 
462     Div_Dynamic_Array ans;
463     ans.A = (Div *)malloc(sizeof(Div));
464     if (ans.A == NULL) {
465         printf("Can't get memory!\n");
466         return 0;
467     }
468     ans.capacity = 1;
469     ans.n = 0;
470 
471     printf("argument 1 is\n");
472     print(1, &c_1);
473     printf("argument 2 is\n");
474     print(2, &c_2);
475     Div_onArray(&c_1, &c_2, &ans);
476     Div_print(&ans);
477     find(&ans);
478     //system("pause");
479     return 0;
480 }
```

程序代码 1

六、运行结果



运行结果 1 （经过了反相处理）

代码分析

优势在于可以 shell 调用，不再需要修改源代码；其次，数组是动态的，所以可以大容量输入。

劣势在于没有采用并行计算，在进行大规模计算的时候，只能调用一个 CPU 核心，效率较低。

七、实验体会

Shell 的解释程序是最难的，这里用了一个原创的方式，来解释输入的字符串。

指针的操作比较复杂，需要时刻牢记 malloc 与 free 的对应 [1]，并且要对堆中申请到的地址进行排查，看是否申请成功。在进行调试的时候，时常遇到内存的读取冲突问题，查找了微软的官方 Visual C++编译器的手册，方才明白这里的局部变量必须要初始化才可以使用，这与 GNU 的 MinGW 编译器稍有区别。

八、参考文献

[1] **林锐**. 高质量 C++/C 编程指南 [M]. 1.0 ed., 2001.