云南大学数学与统计学院
《运筹学通论实验》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：**
指导教师： 李建平	**姓名：** 刘鹏	**专业：** 信息与计算科学
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：** 2018-07-07
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

$$c_i=\begin{cases}\dfrac{a_i}{b_i}, & b_i\neq 0\\ \mathrm{NaN}, & b_i=0\end{cases},\qquad i=1,2,\cdots,n.$$

2. 求最小值及所有最小值的下标，其中最小值为

$$\mathbf{min}\left\{\frac{a_i}{b_i}\mid b_i>0,\quad i=1,2,\cdots,n.\right\}$$

三、 实验平台

Windows 10 Pro 1803；

Cygwin GCC 编译器。

四、 算法设计[1]

Algorithm: **DIV**, find the minimal value and all its(their) indexes

Input: $\boldsymbol{a}=(a_1,a_2,\cdots,a_n)$ and $\boldsymbol{b}=(b_1,b_2,\cdots,b_n)$.

Output: list $\boldsymbol{c}$, minimal value pivot and their indexes.

Begin

Step 1: DEFINE $\mathbf{INT}\ /\ 0=\ \mathbf{NaN}$

Step 2: $\boldsymbol{c}=\boldsymbol{a}\ ./\ \boldsymbol{b}$

Step 3: $\boldsymbol{C}$ is a set who contains all the elements in $\boldsymbol{c}$ whose $b_i>0$

Step 4: sort $\boldsymbol{C}$ incrementally, let pivot the first element of the sorted $\boldsymbol{C}$

Step 5: find all elements in $\boldsymbol{c}$ whose $b_i>0$ and equal to pivot then put their indexes into $\mathbf{Index}$.

End

1 此处的伪代码中，矩阵运算符的意义均与 MATLAB 语言一致，如矩阵的左除、右除和点除等。

五、 程序代码

1.1 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：负号直接跳过，最后乘−1；单个的数字与小数点直接归入队列，与此同时，队列的头号元素，跟随着一个从1开始的索引，该索引按照增序排到队列的末尾——遇到的第一个分号。如此之后，可以通过遍历一次，找到小数点所在位置对应的索引，然后利用对称的坐标变换公式，把其他数字符号与小数点的距离转化为10的指数，然后通过 pow 函数算出具体的数值，完成字符到数值的转化。

在整个过程中要注意保护头指针与 work 指针的归位。一个数字一旦算出，就交给动态数组保存。整个字符串的切割，一直做到\0。这个过程一直中，一直保持着保存操作。当解释程序返回一个浮点数就要存入，返回 NULL 就结束归入。当遇到\0 之后，也就得到了一个存有输入信息的双精度数组。

拿到了两个动态数组之后，就可以做除法、排序与查找了。

1.2 程序代码

```
1   /*
2   * Copyright (c) 2018, Liu Peng, School of Mathematics and Statistics, YNU
3   * Apache License.
4   *
5   * 文件名称：Source.cpp
```

```
6    * 文件标识：见配置管理计划书
7    * 摘 要：Prim 算法
8    *
9    * 当前版本：1.0
10   * 作 者：刘鹏
11   * 创建日期：2018 年 3 月 14 日
12   * 完成日期：2018 年 6 月 25 日
13   *
14   * 取代版本：
15   * 原作者 ：刘鹏
16   * 完成日期：
17   */
18
19   /*
20   * A function like division which can execuate with some conditions.
21   */
22
23   #include<stdio.h>
24   #include<stdlib.h>
25   #include<string.h>
26   #include<math.h>
27
28   // The following type is a container for creating a stack.
29   typedef struct char_LinkedList {
30       char_LinkedList *head;
31       char elements;          // partition must be integer less than 10
32       int times;              // container
33       char_LinkedList *next;
34   }char_LinkedList;
35
36   typedef struct Dynamic_Array {
37       double *A;              // low-level array
38       int capacity;           // the capacity
39       int n;                 // used room
40   }Dynamic_Array;
41
42   typedef struct Div {
43       double up;
44       double down;
45       double value;
46       char state[10];         // NaN or Negative or Normal
47   }Div;
48
49   typedef struct Div_Dynamic_Array {
50       Div *A;                // 底层结构体数组的头指针，不能动!
51       int capacity;           // 底层结构体数组的容量
52       int n;                 // 底层数组的占用量
53   }Div_Dynamic_Array;
54
```

```
55  void Div_Resize(Div_Dynamic_Array *D) {
56      int i = 0;
57      Div *tmp = (Div *)calloc(2 * D->capacity, sizeof(Div));
58      if (tmp == NULL) {
59          printf("Cannot get memory, crash!\n");
60          return;
61      }
62      for (i = 0; i < D->capacity; i++) {
63          (tmp + i)->up = (D->A + i)->up;
64          (tmp + i)->down = (D->A + i)->down;
65          (tmp + i)->value = (D->A + i)->value;
66          strcpy((tmp + i)->state, (D->A + i)->state);
67      }
68      free(D->A);
69      D->A = tmp;
70      tmp = NULL;
71
72      D->capacity *= 2;
73  }
74
75  void Div_Append(Div_Dynamic_Array *D, Div e) {
76      if (D->n == D->capacity) {
77          Div_Resize(D);
78      }
79      (D->A + D->n)->up = e.up;
80      (D->A + D->n)->down = e.down;
81      (D->A + D->n)->value = e.value;
82      strcpy((D->A + D->n)->state, e.state);
83      D->n += 1;
84      //int i;
85      //for (i = 0; i <= D->n; i++) {
86      //  printf("%s\t", (D->A + i)->state);
87      //}
88      //printf("\n");
89  }
90
91  void Div_print(Div_Dynamic_Array *d) {
92      int i;
93      printf("The answer C = (");
94      for (i = 0; i < d->n; i++) {
95          if (!strcmp((d->A + i)->state, "NaN")) {
96              printf("%s ", "NaN");
97          }
98          else {
99              double value = (d->A + i)->value;
100             printf("%2.2f ", value);
101         }
102         if (i == d->n - 1) {
103             printf("");
```

```
104         }
105         else {
106             printf(", ");
107         }
108     }
109     printf(")\n");
110 }
111 
112 void Div_onArray(Dynamic_Array *a, Dynamic_Array *b, Div_Dynamic_Array *ans) {
113     if (a->n != b->n) {
114         printf("length should be the same.");
115         return;
116     }
117 
118     int i;
119     for (i = 0; i < a->n; i++) {
120         if (*(b->A + i) == 0) {
121             Div tmp;
122             tmp.up = NULL;
123             tmp.down = NULL;
124             tmp.value = NULL;
125             char c[] = "NaN";
126             strcpy(tmp.state, c);
127             Div_Append(ans, tmp);
128         }
129         else {
130             if (*(b->A + i) < 0.) {
131                 Div tmp;
132                 tmp.up = *(a->A + i);
133                 tmp.down = *(b->A + i);
134                 tmp.value = tmp.up / tmp.down;
135                 char c[] = "Negative";
136                 strcpy(tmp.state, c);
137                 Div_Append(ans, tmp);
138             }
139             else {
140                 Div tmp;
141                 tmp.up = *(a->A + i);
142                 tmp.down = *(b->A + i);
143                 tmp.value = tmp.up / tmp.down;
144                 char c[] = "Normal";
145                 strcpy(tmp.state, c);
146                 Div_Append(ans, tmp);
147             }
148         }
149     }
150 }
151 
152 // output a Double array
```

```c
void print(int n, Dynamic_Array *d) {
    printf(/* "argument %d is \n*/"(");
    int i;
    for (i = 0; i < d->n - 1; i++) {
        printf("%2.2f, ", *(d->A + i));
    }
    printf("%2.2f", *(d->A + i));
    printf(")\n\n");
}

// Output a double-array with integer format
void print_int(int n, Dynamic_Array *d) {
    printf(/* "argument %d is \n*/"(");
    int i;
    for (i = 0; i < d->n - 1; i++) {
        printf("%2.0f, ", *(d->A + i));
    }
    printf("%2.0f", *(d->A + i));
    printf(")\n\n");
}

void Resize(Dynamic_Array *D) {
    int i = 0;
    double *tmp = (double *)calloc(2 * D->capacity, sizeof(double));
    if (tmp == NULL) {
        printf("Cannot get memory, crash!\n");
        return;
    }
    for (i = 0; i < D->capacity; i++) {
        *(tmp + i) = *(D->A + i);
    }
    D->A = tmp;
    D->capacity *= 2;
}

void Append(Dynamic_Array *D, double e) {
    if (D->n == D->capacity) {
        Resize(D);
    }
    *(D->A + D->n) = e;
    D->n += 1;
}

Dynamic_Array *Quick_sort(Dynamic_Array *a) {

    Dynamic_Array *less = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
    less->A = (double *)calloc(1, sizeof(double));
    if (!less) {
        printf("Can't get memory!");
```

```
202         return NULL;
203     }
204     less->capacity = 1;
205     less->n = 0;
206 
207     Dynamic_Array *more = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
208     more->A = (double *)calloc(1, sizeof(double));
209     if (!more) {
210         printf("Can't get memory!");
211         return NULL;
212     }
213     more->capacity = 1;
214     more->n = 0;
215 
216     Dynamic_Array *eq = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
217     eq->A = (double *)calloc(1, sizeof(double));
218     if (!eq) {
219         printf("Can't get memory!");
220         return NULL;
221     }
222     eq->capacity = 1;
223     eq->n = 0;
224 
225     int i;
226     if (a->n <= 1) {
227         return a;
228     }
229     else {
230         for (i = 0; i < a->n; i++) {
231             double pivot = *(a->A);
232             if (*(a->A + i) > pivot) {
233                 Append(more, *(a->A + i));
234             }
235             else {
236                 if (*(a->A + i) < pivot) {
237                     Append(less, *(a->A + i));
238                 }
239                 else {
240                     Append(eq, *(a->A + i));
241                 }
242             }
243         }
244     }
245     less = Quick_sort(less);
246     more = Quick_sort(more);
247     for (i = 0; i < eq->n; i++) {
248         Append(less, *(eq->A + i));
249     }
250     for (i = 0; i < more->n; i++) {
```

```
251         Append(less, *(more->A + i));
252     }
253     return less;
254 }
255 
256 void find(Div_Dynamic_Array *a) {
257 
258     Dynamic_Array *c = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
259     Dynamic_Array *d = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
260     c->A = (double *)calloc(a->n, sizeof(double));
261     if (c == NULL || d == NULL || c->A == NULL) {
262         printf("Can't get memory!\n");
263         return;
264     }
265     c->capacity = a->n;
266     c->n = 0;
267 
268     int i = 0;
269     for (i = 0; i < a->n; i++) {
270 
271         // denominator is legal
272         if (!strcmp((a->A + i)->state, "Normal")) {
273             Append(c, (a->A + i)->value);
274         }
275     }
276     d = Quick_sort(c);
277 
278     double pivot = *(d->A + 0);
279     Dynamic_Array *tmp = (Dynamic_Array *)calloc(1, sizeof(Dynamic_Array));
280     tmp->A = (double *)calloc(1, sizeof(double));
281     if (tmp == NULL || tmp->A == NULL) {
282         printf("Can't get memory!\n");
283         return;
284     }
285     tmp->capacity = 1;
286     tmp->n = 0;
287     for (i = 0; i < a->n; i++) {
288         if (!strcmp((a->A + i)->state, "Normal") && (a->A + i)->value == pivot) {
289             Append(tmp, ++i);
290         }
291     }
292     if (tmp->n == 0) {
293         printf("Sorry, no minimal value.\n");
294         return;
295     }
296     printf("Minimal Value is %2.2f , position is ", pivot);
297     print_int(tmp->n, tmp);
298 }
299 
```

```
300 // Get rid of the useless blank characters.
301 char *clean(char *string) {
302     char *head = string;
303     int count_space = 0;
304     while (*string == ' ' && *string != '\0') {
305         count_space += 1;
306         string += 1;
307     }
308     string = head;
309 
310     int len = 1;
311     while (*string != '\0') {
312         len += 1;
313         string++;
314     }
315     string = head;
316 
317     char *ans = (char *)calloc(len - count_space, sizeof(char));
318     if (ans == NULL) {
319         printf("Can't get memory!\n");
320         return NULL;
321     }
322     char *ans_head = ans;
323 
324     while (*string != '\0') {
325         if (*string != ' ') {
326             *ans = *string;
327             ans++;
328         }
329         string++;
330     }
331     *ans = *string;
332     ans = ans_head;
333     string = head;
334 
335     ans = ans + 1;
336     char *tmp;
337     for (tmp = ans; *tmp != '\0'; tmp++) {
338         if (*(tmp + 1) == '\0') {
339             *tmp = ',';
340         }
341     }
342     return ans;
343 }
344 
345 char *cut(char *string) {
346     while (*string != ',') {
347         if (*string == '\0') {
348             return NULL;
```

```
349         }
350         string++;
351     }
352     return ++string;
353 }
354 
355 // Put an new element into the stack
356 double get_Number(char *string) {
357     if (*string == '\0') {
358         return NULL;
359     }
360     double ans = 0.;
361     if (*string == '\0') {
362         return NULL;
363     }
364     if (*string != '-') {
365         char_LinkedList *work = (char_LinkedList *)malloc(sizeof(char_LinkedList));
366         if (work == NULL) {
367             printf("Can't get memory!\n");
368             return 0;
369         }
370         // container
371 
372         char_LinkedList *head = work;
373         int i = 1;
374         while (*string != ',') {
375             work->elements = *string;
376             work->times = i;
377             work->next = (char_LinkedList *)malloc(sizeof(char_LinkedList));    // malloc
378             if (work->next == NULL) {
379                 printf("Can't get memory!\n");
380                 return 0.;
381             }
382             work = work->next;                                                  // move
383             work->elements = NULL;
384             work->times = NULL;
385             string++;
386             i++;
387         }
388 
389         work->elements = *string;
390         work->times = NULL;
391 
392         string++;
393 
394         work = head;
395         int dot = 1;
396         int comma = 1;
397         int dot_index = NULL;
```

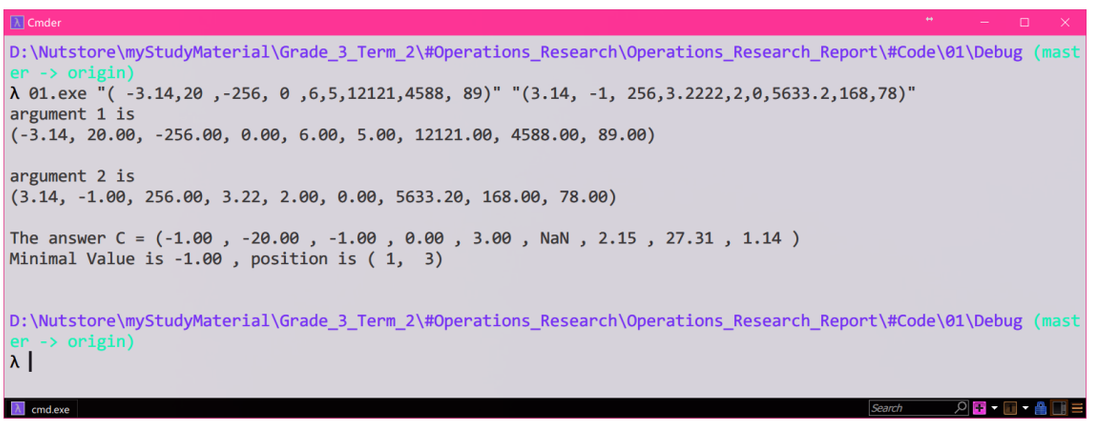
```
398         while (work->elements != ',') {
399             if (work->elements == '.') {
400                 dot_index = dot;
401                 break;
402             }
403             work = work->next;
404             dot++;
405         }
406 
407         if (dot_index == NULL) {
408             dot_index = i;
409         }
410 
411         work = head;
412 
413         while (work->times != NULL) {
414             work->times = -1 * (work->times - dot_index);
415             work = work->next;
416         }
417 
418         work = head;
419 
420         while (work->elements != ',') {
421             if (work->elements == '.') {
422                 work = work->next;
423                 continue;
424             }
425             if (work->times > 0) {
426                 ans += pow(10, work->times - 1) * double(int(work->elements) - int('0'));
427                 work = work->next;
428             }
429             else {
430                 ans += pow(10, work->times) * double(int(work->elements) - int('0'));
431                 work = work->next;
432             }
433         }
434     }
435     else {
436         string = string + 1;
437         ans = -1 * get_Number(string);
438     }
439     return ans;
440 }
441 
442 int main(int argc, char *argv[]) {
443     if (argc != 3) {
444         printf("This function needs and only needs 2 arguments.\n");
445         return 0;
446     }
```

```
447
448     char *string_1 = *(argv + 1);
449     char *string_2 = *(argv + 2);
450
451     //char string_1_tmp[] = "( -3.14,20 ,-256, 0 ,6,5,12121,4588, 89)";
452     //char *string_1 = string_1_tmp;
453
454     //char string_2_tmp[] = "(3.14, -1, 256,3.2222,2,0,5633.2,168,78)";
455     //char *string_2 = string_2_tmp;
456
457     string_1 = clean(string_1);
458     string_2 = clean(string_2);
459
460     Dynamic_Array c_1, c_2;
461     c_1.A = (double *)malloc(sizeof(double));
462     if (c_1.A == NULL) {
463         printf("Can't get memory!\n");
464         return 0;
465     }
466     c_1.capacity = 1;
467     c_1.n = 0;
468
469     c_2.A = (double *)malloc(sizeof(double));
470     if (c_2.A == NULL) {
471         printf("Can't get memory!\n");
472         return 0;
473     }
474     c_2.capacity = 1;
475     c_2.n = 0;
476
477     while (*string_1 != '\0') {
478         Append(&c_1, get_Number(string_1));
479         string_1 = cut(string_1);
480     }
481
482     while (*string_2 != '\0') {
483         Append(&c_2, get_Number(string_2));
484         string_2 = cut(string_2);
485     }
486     c_1.n -= 1;
487     c_2.n -= 1;
488
489     Div_Dynamic_Array ans;
490     ans.A = (Div *)malloc(sizeof(Div));
491     if (ans.A == NULL) {
492         printf("Can't get memory!\n");
493         return 0;
494     }
495     ans.capacity = 1;
```

```
496     ans.n = 0;
497
498     printf("argument 1 is\n");
499     print(1, &c_1);
500     printf("argument 2 is\n");
501     print(2, &c_2);
502     Div_onArray(&c_1, &c_2, &ans);
503     Div_print(&ans);
504     find(&ans);
505
506     //system("pause");
507     return 0;
508 }
```

程序代码 1

六、 运行结果



运行结果 1 （经过了反相处理）

1.3 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。

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.