ICS-LAB2 实验报告

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实验目的：

学会并掌握 LC-3 汇编语言的使用。

实验要求：

编写一个程序，对给定的 60 个数据进行排序并按条件归类。

实验过程：

使用冒泡排序法对数据进行排序。

在原处排好序后将数据存储在指定的 X4000 开始的序列中。

逐个判断数据的范围并对应地改变 A,B,C,D 四类的数目。

实验过程中遇到的问题：

以为本次试验需要的时间较少，故在 ddl 前 5 个小时开始写，导致优化效果不佳。

使用冒泡排序时的 swap 与 str 的不熟练

刚开始忘记控制指令中 JSR 会改变 R7 值，导致后面花一些时间调试。

实验代码：

```
;copyright@Jin Zewen of C.S. Schl. of USTC
            .ORIG x3000

            AND     R0,R0,#0        ;R0-i=0
LOOP1       ADD     R0,R0,#1        ;i++
            LD      R7, COUNT59
            ADD     R7,R7,R0        ;R7 = R0 - 59
COND1       BRP     SAVE1
            LD      R5, START
            ADD     R5, R5, R0
            ADD     R6, R5, #-1     ;R6=i-1
            AND     R1, R0, #0      ;R1-j=i;R1 = 0

LOOP2       ADD     R1, R1, #1      ;j++
            LD      R7, COUNT60
            ADD     R7, R7, R1      ;R7 = R1 - 60
COND2       BRP     LOOP1
            LDR     R2, R6, #0      ;R2 = [R6]
            ADD     R6, R6, #1      ;R6++
            LDR     R3, R6, #0      ;R3 = [R6]
            NOT     R4, R3
            ADD     R4, R4, #1
            ADD     R4, R4, R2      ;R4 = R2-R3
COND3       BRN     SWAP
            BRNZP     LOOP2

SWAP        STR     R2, R6, #0      ;[R6] = R2
            STR     R3, R6, #-1     ;[R6-1] = R3
            ADD     R7, R2, #0
            ADD     R2, R3, #0
            ADD     R3, R1, #0
            BRNZP     LOOP2

SAVE1           AND     R0,R0,#0        ;R0-i=0
LOOP13       ADD     R0,R0,#1        ;i++
            LD      R7, COUNT59
            ADD     R7,R7,R0        ;R7 = R0 - 59
COND13       BRP     SAVE
            LD      R5, START
            ADD     R5, R5, R0
            ADD     R6, R5, #-1     ;R6=i-1
```

```
41              ADD     R6, R5, #-1     ;R6=i-1
42              AND     R1, R0, #0      ;R1-j=i;R1 = 0
43
44  LOOP23       ADD     R1, R1, #1      ;j++
45              LD      R7, COUNT60
46              ADD     R7, R7, R1      ;R7 = R1 - 60
47  COND23       BRP     LOOP13
48              LDR     R2, R6, #0      ;R2 = [R6]
49              ADD     R6, R6, #1      ;R6++
50              LDR     R3, R6, #0      ;R3 = [R6]
51              NOT     R4, R3
52              ADD     R4, R4, #1
53              ADD     R4, R4, R2      ;R4 = R2-R3
54  COND33       BRN     SWAP
55              BRNZP     LOOP23
56
57  SAVE        LD      R1, START       ;save the start_position in R1
58              LD      R2, STORE       ;save the store_position in R2
59  LOOP3       LDR     R0, R1, #0
60              BRNZ    STATISTICA
61              STR     R0, R2, #0
62              ADD     R1, R1, #1
63              ADD     R2, R2, #1
64              BRNZP     LOOP3
65
66  STATISTICA  LD      R2, STORE       ;save the store_position in R2
67              LD      R3, A           ;R3 = -85
68              LD      R4, AP          ;R4 = -18
69              AND     R1, R1, #1      ;R1 = 0
70  LOOP4       LDR     R0, R2, #0      ;R0 = [R2]
71              ADD     R0, R0, R3      ;R0 = R0 - 85
72              BRN     LOOP5
73              ADD     R1, R1, #1      ;R1++
74              ADD     R5, R1, R4      ;R5 = R1 - 18
75              BRP     LOOP6
76              ADD     R2, R2, #1      ;R2++
77              BRNZP     LOOP4
78  LOOP5       LD      R2, RANKA
79              ADD     R0, R1, #0
80              BRN     LOOP5
81              STR     R1, R2, #0
```

```
 82              BRNZP     STATISTICB
 83 LOOP6        LD      R2, RANKA
 84              ADD     R1, R1, #-1
 85              STR     R1, R2, #0
 86
 87 STATISTICB   NOT     R7, R1
 88              ADD     R7, R7, #1      ;save the -A in R7
 89              LD      R2, STORE       ;save the store_position in R2
 90              LD      R3, B           ;R3 = -75
 91              LD      R4, BP          ;R4 = -30
 92              AND     R1, R1, #1      ;R1 = 0
 93 LOOP7        LDR     R0, R2, #0      ;R0 = [R2]
 94              ADD     R0, R0, R3      ;R0 = R0 - 75
 95              BRN     LOOP8
 96              ADD     R1, R1, #1      ;R1++
 97              ADD     R5, R1, R4      ;R5 = R1 - 30
 98              BRP     LOOP9
 99              ADD     R2, R2, #1      ;R2++
100              BRNZP     LOOP7
101 LOOP8        LD      R2, RANKB
102              ADD     R0, R1, #0
103              BRN     LOOP8
104              ADD     R1, R1, R7
105              STR     R1, R2, #0
106              BRNZP     STATISTICD
107 LOOP9        LD      R2, RANKB
108              ADD     R1, R1, #-1
109              ADD     R1, R1, R7
110              STR     R1, R2, #0
111
112 STATISTICD   NOT     R6, R1
113              ADD     R6, R6, #1      ;save the -B in R6
114              LD      R2, STORE       ;save the store_position in R2
115              LD      R4, STORE       ;save the store_position in R4
116              NOT     R4, R4
117              ADD     R4, R4, #1
118              LD      R3, D           ;R3 = -59
119              AND     R1, R1, #1      ;R1 = 0
120 LOOP10       LDR     R0, R2, #0      ;R0 = [R2]
```

```
120  LOOP10      LDR     R0, R2, #0      ;R0 = [R2]
121              ADD     R2, R2, #1      ;R2++
122              ADD     R0, R0, R3      ;R0 = R0 - 59
123              BRP     LOOP10
124              ADD     R5, R2, R4      ;R5 = R2 - STORE
125              ADD     R5, R5, R3      ;R5 = (R2-STORE)-59
126              ADD     R5, R5, #-2
127              BRZP    LOOP11          ;all pass
128              ADD     R5, R2, R4      ;R5 = R2 - STORE
129              ADD     R5, R5, #-1
130              LD      R4, COUNT60
131              ADD     R5, R5, R4
132              NOT     R5, R5
133              ADD     R5, R5, #1
134              LD      R4, RANKD
135              STR     R5, R4, #0
136   ;           NOT     R5, R5
137  ;            ADD     R5, R5, #1
138              LD      R4, RANKC
139              LD      R3, COUNT60
140              NOT     R3, R3
141              ADD     R3, R3, #1
142              ADD     R3, R5, R3
143              ADD     R3, R6, R3
144              ADD     R3, R7, R3
145              STR     R3, R4, #0
146              HALT
147
148  LOOP11      LD      R5, COUNT60
149              NOT     R5, R5
150              ADD     R5, R5, #1
151              ADD     R5, R5, R6
152              ADD     R5, R5, R7
153              LD      R4, RANKC
154              STR     R5, R4, #0
155              AND     R5, R4, #0
156              ADD     R4, R4, #1
157              STR     R5, R4, #0
158              HALT
```

```
154                 STR     R5, R4, #0
155                 AND     R5, R4, #0
156                 ADD     R4, R4, #1
157                 STR     R5, R4, #0
158                 HALT
159
160
161 START    .FILL   X3200
162 STORE    .FILL   X4000
163
164 A        .FILL   -85
165 B        .FILL   -75
166 D        .FILL   -59
167
168 AP       .FILL   -18
169 BP       .FILL   -30
170
171 RANKA    .FILL   X4100
172 RANKB    .FILL   X4101
173 RANKC    .FILL   X4102
174 RANKD    .FILL   X4103
175
176 COUNT60 .FILL   -60
177 COUNT59 .FILL   -59
178 .END
179
180
181
182
```

测试样例 1：

测试数据：60 个 60 分

结果

x4100	0000000000000000	x0000	NOP
x4101	0000000000000000	x0000	NOP
x4102	0000000000111100	x003C	NOP
x4103	0000000000000000	x0000	NOP

测试样例 2：

测试数据：

x3200	0000000000000000	x0000
x3201	0000000000000001	x0001
x3202	0000000000000011	x0003
x3203	0000000000000100	x0004
x3204	0000000000000110	x0006
x3205	0000000000001000	x0008
x3206	0000000000001001	x0009
x3207	0000000000001011	x000B
x3208	0000000000001100	x000C
x3209	0000000000001110	x000E
x320A	0000000000010000	x0010
x320B	0000000000010001	x0011
x320C	0000000000010011	x0013
x320D	0000000000010100	x0014
x320E	0000000000010110	x0016
x320F	0000000000011000	x0018
x3210	0000000000011001	x0019
x3211	0000000000011011	x001B
x3212	0000000000011100	x001C
x3213	0000000000011110	x001E
x3214	0000000000100000	x0020
x3215	0000000000100001	x0021
x3216	0000000000100011	x0023
x3217	0000000000100100	x0024
x3218	0000000000100110	x0026
x3219	0000000000101000	x0028
x321A	0000000000101001	x0029
x321B	0000000000101011	x002B
x321C	0000000000101100	x002C
x321D	0000000000101110	x002E
x321E	0000000000110000	x0030
x321F	0000000000110001	x0031
x3220	0000000000110011	x0033
x3221	0000000000110100	x0034
x3222	0000000000110110	x0036
x3223	0000000000111000	x0038
x3224	0000000000111001	x0039
x3225	0000000000111011	x003B
x3226	0000000000111100	x003C
x3227	0000000000111110	x003E
x3228	0000000001000000	x0040
x3229	0000000001000001	x0041
x322A	0000000001000011	x0043
x322B	0000000001000100	x0044
x322C	0000000001000110	x0046
x322D	0000000001001000	x0048
x322E	0000000001001001	x0049
x322F	0000000001001011	x004B
x3230	0000000001001100	x004C
x3231	0000000001001110	x004E
x3232	0000000001010000	x0050
x3233	0000000001010001	x0051
x3234	0000000001010011	x0053
x3235	0000000001010100	x0054
x3236	0000000001010110	x0056
x3237	0000000001011000	x0058
x3238	0000000001011001	x0059
x3239	0000000001011011	x005B
x323A	0000000001011100	x005C
x323B	0000000001011110	x005E
x323C	0000000000000000	x0000
x323D	0000000000000000	x0000
x323E	0000000000000000	x0000

结果：

x4000	0000000001011110	x005E	x4020	0000000000101011	x002B
x4001	0000000001011100	x005C	x4021	0000000000101001	x0029
x4002	0000000001011011	x005B	x4022	0000000000101000	x0028
x4003	0000000001011001	x0059	x4023	0000000000100110	x0026
x4004	0000000001011000	x0058	x4024	0000000000100100	x0024
x4005	0000000001010110	x0056	x4025	0000000000100011	x0023
x4006	0000000001010100	x0054	x4026	0000000000100001	x0021
x4007	0000000001010011	x0053	x4027	0000000000100000	x0020
x4008	0000000001010001	x0051	x4028	0000000000011110	x001E
x4009	0000000001010000	x0050	x4029	0000000000011100	x001C
x400A	0000000001001110	x004E	x402A	0000000000011011	x001B
x400B	0000000001001100	x004C	x402B	0000000000011001	x0019
x400C	0000000001001011	x004B	x402C	0000000000011000	x0018
x400D	0000000001001001	x0049	x402D	0000000000010110	x0016
x400E	0000000001001000	x0048	x402E	0000000000010100	x0014
x400F	0000000001000110	x0046	x402F	0000000000010011	x0013
x4010	0000000001000100	x0044	x4030	0000000000010001	x0011
x4011	0000000001000011	x0043	x4031	0000000000010000	x0010
x4012	0000000001000001	x0041	x4032	0000000000001110	x000E
x4013	0000000001000000	x0040	x4033	0000000000001100	x000C
x4014	0000000000111110	x003E	x4034	0000000000001011	x000B
x4015	0000000000111100	x003C	x4035	0000000000001001	x0009
x4016	0000000000111011	x003B	x4036	0000000000001000	x0008
x4017	0000000000111001	x0039	x4037	0000000000000110	x0006
x4018	0000000000111000	x0038	x4038	0000000000000100	x0004
x4019	0000000000110110	x0036	x4039	0000000000000011	x0003
x401A	0000000000110100	x0034	x403A	0000000000000001	x0001
x401B	0000000000110011	x0033	x403B	0000000000111100	x003C
x401C	0000000000110001	x0031	x403C	0000000000000000	x0000
x401D	0000000000110000	x0030	x403D	0000000000000000	x0000
x401E	0000000000101110	x002E	x403E	0000000000000000	x0000
x401F	0000000000101100	x002C	x403F	0000000000000000	x0000

x4100	0000000000000111	x0007	NOP
x4101	0000000000000111	x0007	NOP
x4102	0000000001010100	x0054	NOP
x4103	0000000000100110	x0026	NOP
x4104	0000000000000000	x0000	NOP

测试结果均符合预期要求