实验报告（week-11）

2020111235 马靖淳

一．实验任务

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2. 折半查找
3. 二叉排序树
4. 哈希表

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1. 顺序查找

a. SequentialSearch.h

```
#ifndef SEQUENTIALSEARCH_H
#define SEQUENTIALSEARCH_H

#include <stdlib.h>
#include "Status.h"

#define MAX_SIZE 20

typedef int KeyType;
typedef struct {
    KeyType key;
    char name;
}ElemType;

typedef struct
{
    ElemType* elem;//数据元素空间基址
```

```
    int length;//表的长度
}SSTable;

Status CreateST(SSTable* ST);
int Search_Seq1(SSTable ST, KeyType key);//无监视哨
int Search_Seq2(SSTable ST, KeyType key);//有监视哨

#endif
```

b. SequentialSearch.c

```
#define _CRT_SECURE_NO_WARNINGS
#include "SequentialSearch.h"
#include "Status.h"
#include <stdio.h>
#include <malloc.h>

Status CreateST(SSTable *ST)
{
    int i, n;
    printf("输入顺序查找表的长度:");
    scanf("%d", &n);
    getchar();
    (*ST).length = n + 1;
    (*ST).elem = (ElemType*)malloc((n+1)*sizeof(ElemType));
    printf("输入每个关键字的信息：\n");
    for (i = 1; i < (*ST).length; i++)
    {
        printf("输入第%d个关键字的信息：", i);
        scanf("%d", &(*ST).elem[i].key);//关键字信息
        getchar();
    }
    return OK;
}//CreateST

int Search_Seq1(SSTable ST, KeyType key)//无监视哨
{
    int i = ST.length;
    while (i > 0 && ST.elem[i].key != key)
        i--;
    return i;
}

int Search_Seq2(SSTable ST, KeyType key)//有监视哨
{
```

```
    int i = ST.length;
    ST.elem[0].key = key;//监视哨
    while (ST.elem[i].key != key)
        i--;
    return i;
}
```

c. test.c

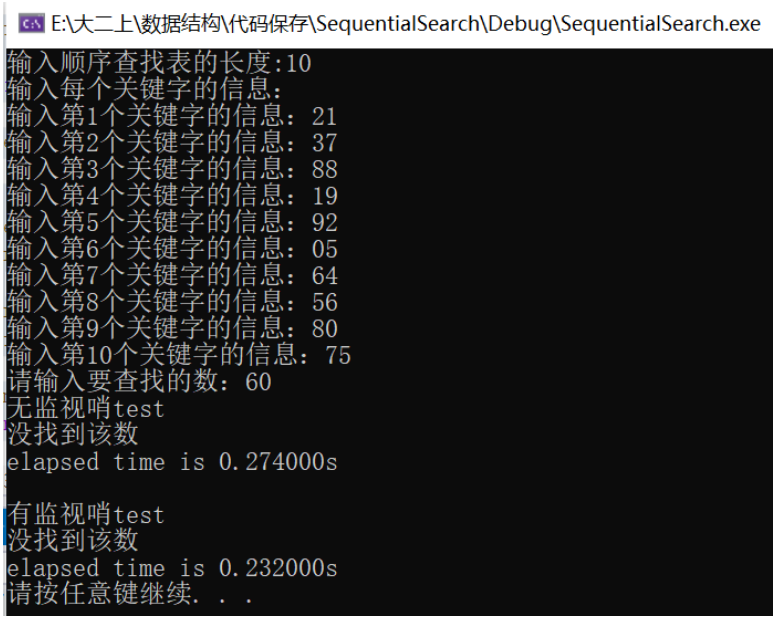
```
#define _CRT_SECURE_NO_WARNINGS
#include <stdio.h>
#include "SequentialSearch.h"
#include <time.h>

int main()
{
    SSTable ST;
    CreateST(&ST);
    int search_num;

    clock_t tic, toc;
    int nn = 10000000;

    printf("请输入要查找的数：");
    scanf("%d", &search_num);



    printf("无监视哨test\n");
    tic = clock();
    for (int i = 1; i <= nn; i++)
    {
        Search_Seq1(ST, search_num);
    }
    toc = clock();
    if (Search_Seq1(ST, search_num))
        printf("所查找数位于第%d位\n", Search_Seq1(ST, search_num));
    else
        printf("没找到该数\n");
    printf("elapsed time is %fs\n", (double)(toc - tic) / CLOCKS_PER_SEC);
    printf("\n");

    printf("有监视哨test\n");
    tic = clock();
    for (int i = 1; i <= nn; i++)
```

```
    {
        Search_Seq2(ST, search_num);
    }
    toc = clock();
    if (Search_Seq2(ST, search_num))
        printf("所查找数位于第%d位\n", Search_Seq1(ST, search_num));
    else
        printf("没找到该数\n");
    printf("elapsed time is %fs\n", (double)(toc - tic) / CLOCKS_PER_SEC);

    system("pause");
    return 0;
}
```

能查找到

```
E:\大二上\数据结构\代码保存\SequentialSearch\Debug\SequentialSearch.exe
输入顺序查找表的长度:10
输入每个关键字的信息:
输入第1个关键字的信息: 21
输入第2个关键字的信息: 37
输入第3个关键字的信息: 88
输入第4个关键字的信息: 19
输入第5个关键字的信息: 92
输入第6个关键字的信息: 05
输入第7个关键字的信息: 64
输入第8个关键字的信息: 56
输入第9个关键字的信息: 80
输入第10个关键字的信息: 75
请输入要查找的数: 64
无监视哨test
所查找数位于第7位
elapsed time is 0.200000s

有监视哨test
所查找数位于第7位
elapsed time is 0.185000s
请按任意键继续. . .
```

查找不到



2. 折半查找

a. SequentialSearch.h

b. SequentialSearch.c

```
int Search_Bin1(SSTable ST, KeyType key)//折半查找的非递归算法
{
    //在有序表ST中折半查找其关键字等于key的数据元素
    //若找到，则函数值为该元素在表中的位置，否则为0
    int low, high, mid;
    low = 1;
    high = ST.length;
    while (low <= high)
    {
        mid = (low + high) / 2;
        if (ST.elem[mid].key == key)
            return mid;//找到待查元素
        else if (ST.elem[mid].key > key)
            high = mid - 1;//继续在前半区间进行查找
        else
            low = mid + 1;//继续在后半区间进行查找
    }
    return 0;
}//Search_Bin
//时间复杂度O（log n）

int Search_Bin2(SSTable ST, int low, int high, KeyType key)
{
    //递归实现
    int mid = 0;
    if (low > high)
```

```
        return 0;
    else
    {
        mid = (low + high) / 2;
        if (ST.elem[mid].key > key)
            return Search_Bin2(ST, low, mid - 1, key);
        else if (ST.elem[mid].key < key)
            return Search_Bin2(ST, mid + 1, high, key);
        else
            return mid;
    }
}//Search_Bin2
//时间复杂度O（log n)
```

c. test.c

```
#define _CRT_SECURE_NO_WARNINGS
#include <stdio.h>
#include "SequentialSearch.h"
#include <time.h>

int main()
{
    SSTable ST;
    CreateST(&ST);
    int search_num;

    clock_t tic, toc;
    int nn = 10000000;

    printf("请输入要查找的数：");
    scanf("%d", &search_num);


    printf("折半查找非递归test\n");
    tic = clock();
    for (int i = 1; i <= nn; i++)
    {
        Search_Seq1(ST, search_num);
    }
    toc = clock();
    if (Search_Bin1(ST, search_num))
        printf("所查找数位于第%d位\n", Search_Bin1(ST, search_num));
    else
```

```
        printf("没找到该数\n");
    printf("elapsed time is %fs\n", (double)(toc - tic) / CLOCKS_PER_SEC);
    printf("\n");

    printf("折半查找递归test\n");
    tic = clock();
    for (int i = 1; i <= nn; i++)
    {
        Search_Seq1(ST, search_num);
    }
    toc = clock();
    if (Search_Bin2(ST, 1, ST.length-1, search_num))
        printf("所查找数位于第%d位\n", Search_Bin2(ST, 1, ST.length - 1, search_num));
    else
        printf("没找到该数\n");
    printf("elapsed time is %fs\n", (double)(toc - tic) / CLOCKS_PER_SEC);
    printf("\n");


    system("pause");
    return 0;
}
```

- 有序查找表

i	1	2	3	4	5	6	7	8	9	10	11
ST.elem	05	13	19	21	37	56	64	75	80	88	90

```
E:\大二上\数据结构\代码保存\SequentialSearch\Debug\SequentialSearch.exe
输入顺序查找表的长度:11
输入每个关键字的信息:
输入第1个关键字的信息: 05
输入第2个关键字的信息: 13
输入第3个关键字的信息: 19
输入第4个关键字的信息: 21
输入第5个关键字的信息: 37
输入第6个关键字的信息: 56
输入第7个关键字的信息: 64
输入第8个关键字的信息: 75
输入第9个关键字的信息: 80
输入第10个关键字的信息: 88
输入第11个关键字的信息: 90
请输入要查找的数: 21
折半查找非递归test
所查找数位于第4位
elapsed time is 0.227000s

折半查找递归test
所查找数位于第4位
elapsed time is 0.217000s

请按任意键继续. . .
```

3. 二叉排序树

a. BinarySortTree.h

```
#ifndef SEQUENTIALSEARCH_H
#define SEQUENTIALSEARCH_H

#include <stdlib.h>
#include "Status.h"

typedef int KeyType;
typedef char OtherInfoType;
typedef int TElemType;
typedef struct
{
    KeyType key;
    OtherInfoType info;
}ElemType;

typedef struct BiTNode
{
    ElemType data;
    struct BiTNode* lchild, * rchild;
}BiTNode, * BiTree;

void InitBiTree(BiTree* T);
Status SearchBST(BiTree T, KeyType key, BiTree f, BiTree* p);
Status InsertBST(BiTree* T, ElemType e);
Status Visit(TElemType e);
```

```
Status InOrderTraverse(BiTree T, Status(*Visit)(TElemType));
Status DeleteBST(BiTree* T, KeyType key);
void Delete(BiTree* p);

#endif
```

b. BinarySortTree.c

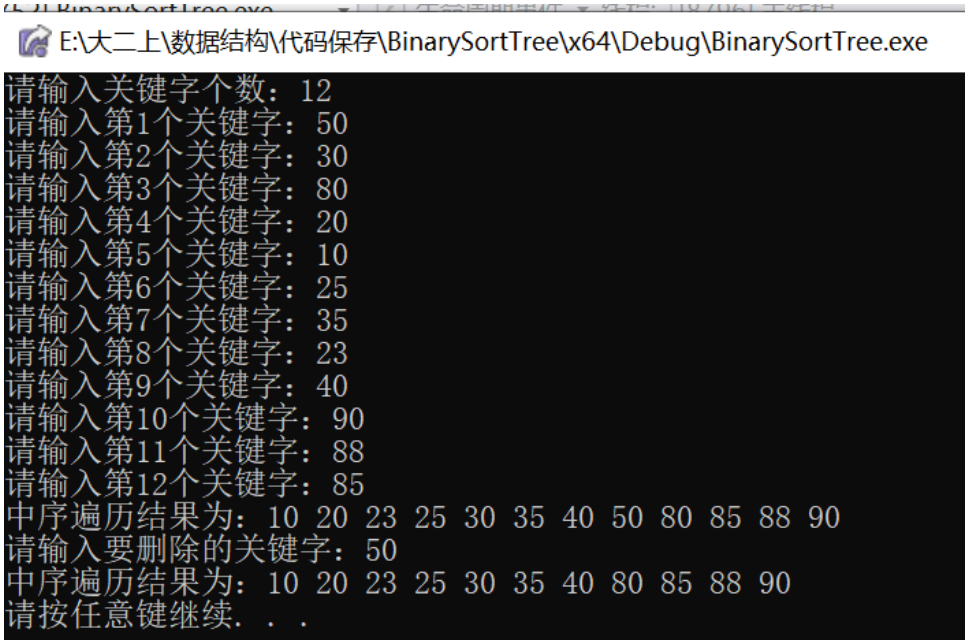
```
#define _CRT_SECURE_NO_WARNINGS
#include "BinarySortTree.h"
#include "Status.h"
#include <stdio.h>
#include <malloc.h>

void InitBiTree(BiTree* T)
{
    *T = NULL;
}

Status SearchBST(BiTree T, KeyType key, BiTree f, BiTree* p)
{
    if (!T)//查找不成功
    {
        *p = f;
        return FALSE;
    }
    else if (key == T->data.key)//查找成功
    {
        *p = T;
        return TRUE;
    }
    else if (key < T->data.key)
        return SearchBST(T->lchild, key, T, &(*p));
    else
        return SearchBST(T->rchild, key, T, &(*p));
}

Status InsertBST(BiTree* T, ElemType e)
{
    BiTree p,s;
    if (!SearchBST(*T, e.key, NULL, &p))
    {
        s=(BiTree)malloc(sizeof(BiTNode));//新节点s
        s->data = e;
        s->lchild = s->rchild = NULL;
```

```
        if (!p)
            *T = s;//插入s为新的根节点
        else if (e.key < p->data.key)
            p->lchild = s;//插入*s为*p的左孩子
        else
            p->rchild = s;//插入*s为*p的右孩子
        return TRUE;
    }
    return FALSE;//树中已有结点，不再插入
}//InsertBST

Status Visit(TElemType e)
{
    printf("%d ", e);
    return OK;
}

Status InOrderTraverse(BiTree T, Status(*Visit)(TElemType))
{
    //采用二叉链表存储结构，中序遍历二叉树T的递归算法
    if (T)
    {
        if (InOrderTraverse(T->lchild, Visit))
            if (Visit(T->data.key))
                if (InOrderTraverse(T->rchild, Visit))
                    return OK;
        return ERROR;
    }
    else
        return OK;
}//InOrderTraverse

Status DeleteBST(BiTree* T, KeyType key)
{
    if (!(*T))
        return FALSE;//不存在关键字等于key的数据元素
    else
    {
        if (key == (*T)->data.key)
        {
            Delete(&(*T));
            return TRUE;
        }
        else if (key < (*T)->data.key)
```

```
            DeleteBST(&((*T)->lchild), key);
        else
            DeleteBST(&((*T)->rchild), key);
    }
}//DeleteBST

void Delete(BiTree* p)
{
    //从二叉排序树中删除结点p，并重接它的左子树或右子树
    BiTree q, s;
    if (!(*p)->rchild)
    {
        //右子树为空树则只需重接它的左子树
        q = (*p);
        (*p) = (*p)->lchild;
        free(q);
    }
    else if (!(*p)->lchild)
    {
        //左子树为空树只需重接它的右子树
        q = (*p);
        (*p) = (*p)->rchild;
        free(q);
    }
    else
    {
        //左右子树都不空
        q = (*p);
        s = (*p)->lchild;
        while (s->rchild)
        {
            //s指向被删结点的前驱
            q = s;
            s = s->rchild;
        }
        (*p)->data = s->data;
        if (q != p)
            q->rchild = s->lchild;
        else
            q->lchild = s->lchild;//重接*q的左子树
        free(s);
    }
}//Delete
```

c. test.c

```c
#define _CRT_SECURE_NO_WARNINGS
#include <stdio.h>
#include "BinarySortTree.h"

int main()
{
    BiTree T, f, p;
    int num = 0;
    KeyType key;
    ElemType e;

    InitBiTree(&T);
    printf("请输入关键字个数：");
    scanf("%d", &num);
    getchar();
    for (int i = 0; i < num; ++i)
    {
        printf("请输入第%d个关键字：", i + 1);
        scanf("%d", &key);
        getchar();
        e.key = key;
        InsertBST(&T, e);
    }

    //InOrderTraverse test
    printf("中序遍历结果为：");
    InOrderTraverse(T, Visit);
    printf("\n");

    printf("请输入要删除的关键字：");
    scanf("%d", &key);
    getchar();
    DeleteBST(&T, key);

    //InOrderTraverse test
    printf("中序遍历结果为：");
    InOrderTraverse(T, Visit);
    printf("\n");


    system("pause");
    return 0;
}
```



4. 哈希表

a. HashSearch.h

```
#ifndef HASHSEARCH_H
#define HASHSEARCH_H

#include <stdlib.h>
#include "Status.h"

#define N 10

typedef int KeyType;
typedef struct{
    KeyType key;
}ElemType;
typedef struct{
    ElemType* elem;//数据元素存储基址，动态分配数组
    int count;//当前数据元素个数
    int sizeindex;//hashsize[sizeindex]为当前容量
}HashTable;

Status InitHash(HashTable* H);
void DestroyHash(HashTable* H);
void collision(int* p, int d);
Status SearchHash(HashTable H, KeyType K, int* p, int* c);
Status InsertHash(HashTable* H, ElemType e);
void RecreateHashTable(HashTable* H);
void TraverseHash(HashTable H, void(*Vi)(int, ElemType));
void print(int p, ElemType r);
```

```
#endif
```

b. HashSearch.c

```
#define _CRT_SECURE_NO_WARNINGS
#include "HashSearch.h"
#include "Status.h"
#include <stdio.h>
#include <malloc.h>

int m = 0;
int hashsize[] =
{ 11,13,17,19,23,29,31,37,41,43,47,53,59,61,67,71,73,79,83,89,97,101,103,107,109,113,12
7,131,137,139,149,151,157,163,167,173,179,181,191,193,197,199,211,223,227,229,233,239,2
41,251,257,263,269,271,277,281,283,293,307,311,313,317,331,337,347,349,353,359,367,373,
379,383,389,397,401,409,419,421,431,433,439,443,449,457,461,463,467,479,487,491,499,503
,509,521,523,541,547,557,563,569,571,577,587,593,599,601,607,613,617,619,631,641,643,64
7,653,659,661,673,677,683,691,701,709,719,727,733,739,743,751,757,761,769,773,787,797,8
09,811,821,823,827,829,839,853,857,859,863,877,881,883,887,907,911,919,929,937,941,947,
953,967,971,977,983,991,997 };
//哈希表容量递增表，一个合适的素数序列

Status InitHash(HashTable* H)
{
    (*H).count = 0;
    (*H).sizeindex = 0;
    m = hashsize[0];
    (*H).elem = (ElemType*)malloc(m * sizeof(ElemType));
    if (!(*H).elem)
        return OVERFLOW;
    for (int i = 0; i < m; i++)
    {
        (*H).elem[i].key = NULLKEY;
    }
    return OK;
}//初始化哈希表

void DestroyHash(HashTable* H)
{
    free((*H).elem);
    (*H).elem = NULL;
    (*H).count = 0;
    (*H).sizeindex = 0;
}//销毁哈希表
```

```
unsigned Hash(KeyType K)
{
    return K % m;
}

void collision(int* p, int d)
{
    *p = (*p + d) % m;
}//处理冲突函数

Status SearchHash(HashTable H, KeyType K, int* p, int* c)
{
    //在开放定址哈希表H中查找关键码为K的元素，若查找成功，以p指示待查数据元素在表中的位置；
    //否则，以p指示插入位置。c用以计冲突次数，其初置值零，供建表插入时参考
    *p = Hash(K);//求得哈希地址
    while (H.elem[*p].key != NULL && !(K == H.elem[*p].key))
    {
        (*c)++;
        if (*c < m)
            collision(p, *c);//求得下一探查地址p
        else
            break;
    }
    if (K == H.elem[*p].key)
        return SUCCESS;//查找成功，返回待查数据元素位置p
    else
        return UNSUCCESS;//查找不成功
}//SearchHash


Status InsertHash(HashTable* H, ElemType e)
{
    //查找不成功时插入数据元素e到开放定址哈希表H中；若冲突次数过大，则重建哈希表
    int c = 0;
    int p;
    if (SearchHash(*H, e.key, &p, &c))
        return DUPLICATE;//表中已有与e有关键字的元素
    else if (c < hashsize[(*H).sizeindex] / 2)
    {
        //冲突次数c未达到上限（阈值c可调）
        (*H).elem[p] = e;
        ++(*H).count;
        return OK;//插入e
```

```
    }
    else
    {
        RecreateHashTable(H);//重建哈希表
        return UNSUCCESS;
    }
}//InsertHash

void RecreateHashTable(HashTable* H) //重建哈希表
{
    int i = (*H).count;
    int count = (*H).count;
    ElemType* p = (ElemType*)malloc(count * sizeof(ElemType));
    ElemType* elem = (ElemType*)malloc(count * sizeof(ElemType));
    p = elem;
    printf("重建哈希表\n");
    for (i = 0; i < m; i++)
        if (((*H).elem + i)->key != NULLKEY)
            *p++ = *((*H).elem + i);
    (*H).count = 0;
    (*H).sizeindex++;//增大存储容量
    m = hashsize[(*H).sizeindex];
    p = (ElemType*)realloc((*H).elem, m * sizeof(ElemType));
    if (!p)
        exit(0);
    (*H).elem = p;
    for (i = 0; i < m; i++)
        (*H).elem[i].key = NULLKEY;
    for (p = elem; p < elem + count; p++)
        InsertHash(H, *p);
}//RecreateHashTable


void TraverseHash(HashTable H, void(*Vi)(int, ElemType)) //遍历函数
{
    int i;
    printf("哈希地址0~%d\n", m - 1);
    for (i = 0; i < m; i++)
        if (H.elem[i].key != NULLKEY)
            Vi(i, H.elem[i]);
}//TraverseHash

int Find(HashTable H, KeyType K, int* p)
{
```

```
    int c = 0;
    *p = Hash(K);//求得哈希地址
    while (H.elem[*p].key != NULLKEY && !(K == H.elem[*p].key))
    { //该位置中填有记录，并且关键字不相等
        c++;
        if (c < m)
            collision(p, c);//求得下一探查地址p
        else
            return UNSUCCESS; //查找不成功(H.elem[p].key==NULLKEY)
    }
    if (K == H.elem[*p].key)
        return SUCCESS; //查找成功，p返回待查数据元素位置
    else
        return UNSUCCESS; //查找不成功(H.elem[p].key==NULLKEY)
}

void print(int p, ElemType r)//打印函数
{
    printf("%d %d\n", r.key, p);
}
```

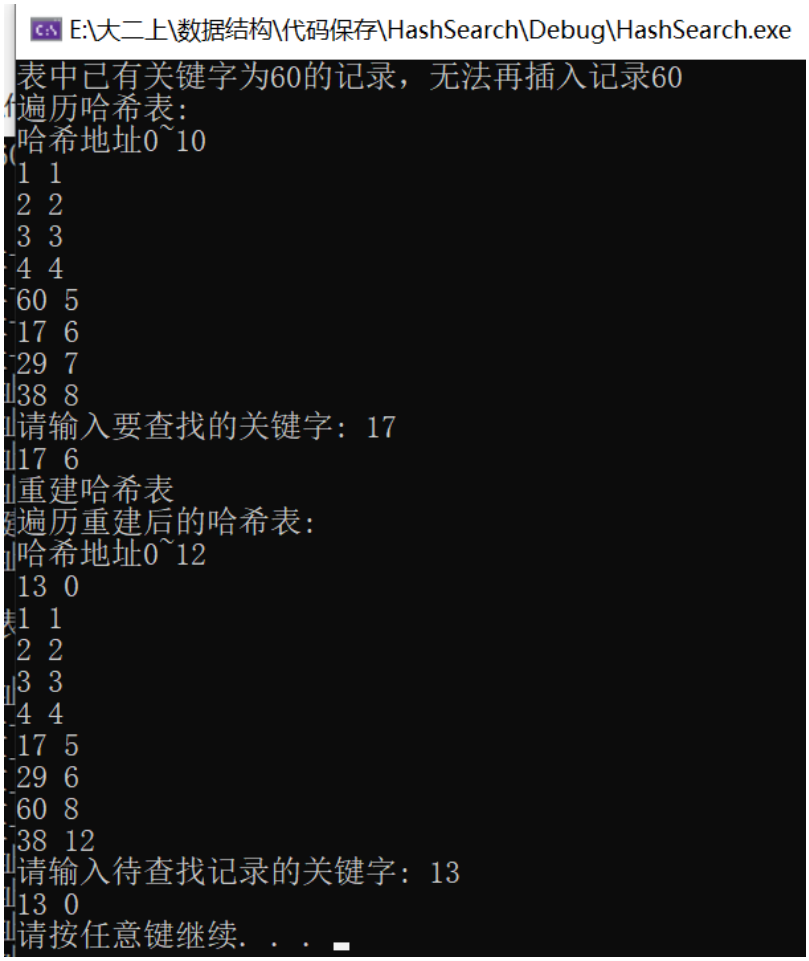
c. Status.h

```
#ifndef     STATUS_H
#define  STATUS_H

#define  TRUE         1
#define  FALSE        0
#define      YES      1
#define      NO           0
#define  OK           1
#define  ERROR        0
#define      SUCCESS  1
#define      UNSUCCESS    0
#define  INFEASIBLE   -1
#define  OVERFLOW     -2
#define      UNDERFLOW    -3
#define      DUPLICATE    -1
#define      NULLKEY      0

/* 状态码类型 */
typedef int Status;
#endif
```

d. test.c

```
#define _CRT_SECURE_NO_WARNINGS
```

```c
#include <stdio.h>
#include "HashSearch.h"


int main()
{
    ElemType r[N] = { 17,60,29,38,1,2,3,4,60,13 };
    HashTable H;
    int i, j, p;
    KeyType K;
    InitHash(&H);
    for (i = 0; i < N - 1; i++)
    {
        //插入前N-1个记录
        j = InsertHash(&H, r[i]);
        if (j == DUPLICATE)
            printf("表中已有关键字为%d的记录，无法再插入记录%d\n", r[i].key, r[i].key);

    }//for
    printf("遍历哈希表:\n");
    TraverseHash(H, print);
    printf("请输入要查找的关键字: ");
    scanf("%d", &K);
    j = Find(H, K, &p);
    if (j == SUCCESS)
        print(p, H.elem[p]);
    else
        printf("没找到该关键字\n");
    j = InsertHash(&H, r[i]);//插入第N个记录
    if (j == 0)//重建哈希表
        j = InsertHash(&H, r[i]);//重建哈希表后重新插入第N个记录
    printf("遍历重建后的哈希表:\n");
    TraverseHash(H, print);
    printf("请输入待查找记录的关键字: ");
    scanf("%d",&K);
    j = Find(H, K, &p);
    if (j == SUCCESS)
        print(p, H.elem[p]);
    else
        printf("没找到\n");
    DestroyHash(&H);
    system("pause");
    return 0;
}
```



五．实验总结

1. 通过比较时间复杂度，发现无论所查数是否在查找表中，有监视哨的算法所需时间都更短（见上面第一条的截图）
2. 在写二叉排序树的时候，本来创建函数 CreateBFT,后来发现每次调用 Insert 函数都会改变二叉排序树的基地址，后改为在 main 函数中实现对二叉排序树的构建
3. 在编写哈希表查找时，发现提供的伪代码有错误，导致后续哈希表插入无法正常实现

   修改为

```
while (H.elem[*p].key != NULL && !(K == H.elem[*p].key))
{
    (*c)++;
    if (*c < m)
        collision(p, *c);//求得下一探查地址p
    else
        break;
}
```

在调断点过程中发现按原来编写后续 c 值无法被改变，就无法继续实现重建哈希表的操作