I am sorry about my poor English ability.

1. 簡單描述何為 huffman encoding 及其用途

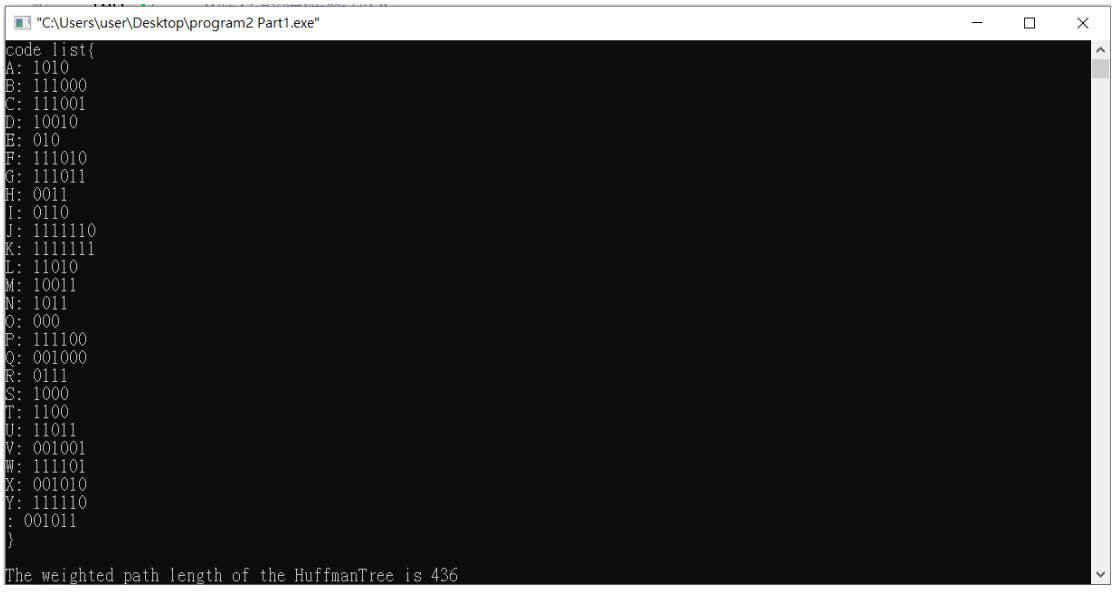
Huffman coding is used to code and compress datas,and the followings are the processes of Huffman coding:

(1)According to the frequency that characters appear,we construct Huffman tree.

(2)We code the data by the Huffman tree.

Because of using Huffman coding,we can greatly decrease the complexity of the data and increase the efficiency of compressing.Huffman coding is a character coding way which can waste smallest data space.

2.Part 1 的結果



The code list from A to Z is:

A: 1010,B: 111000,C: 111001, D: 10010, E: 010, F: 111010,

G: 111011, H: 0011, I: 0110, J: 1111110, K: 1111111,L: 11010

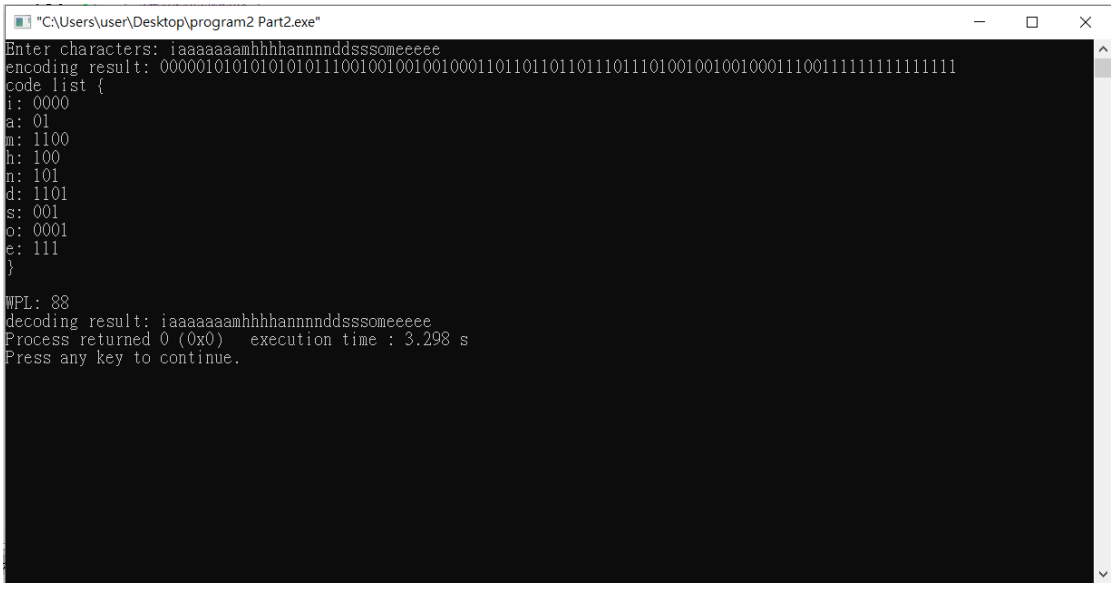
M: 10011,N: 1011,O: 000,P: 111100,Q: 001000,R: 0111,S: 1000

T: 1100,U: 11011,V: 001001,W: 111101,X: 001010,Y: 111110

Z: 001011

The WPL is 436.

1. Part 2 的結果



The encoding result:

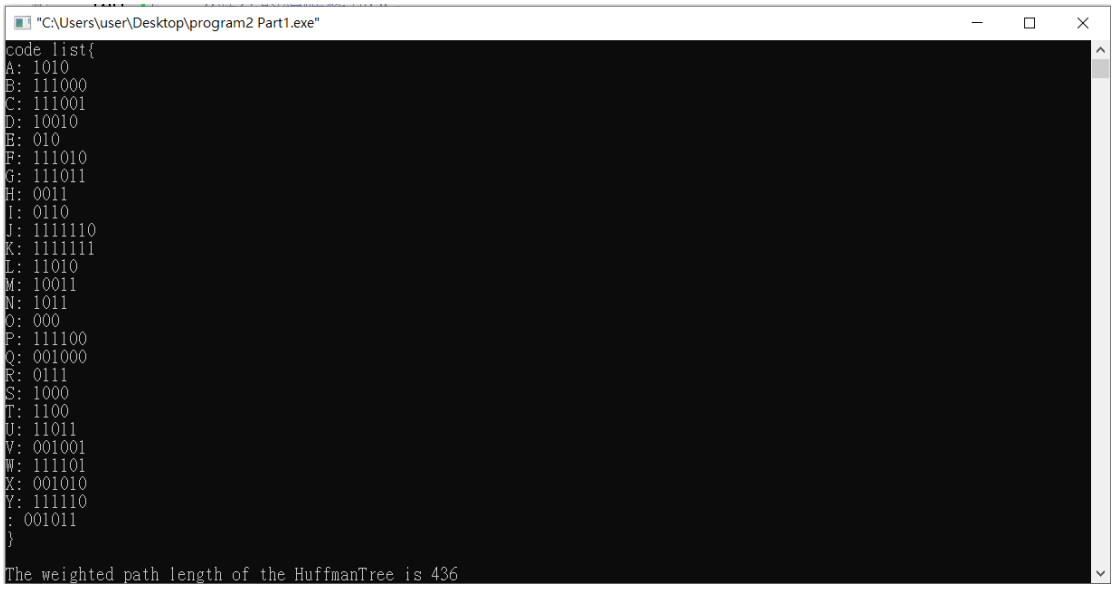
00000101010101010111001001001001000110110110110111011100100100100011100111111111111111

Code list: i: 0000,a: 01,m: 1100,h: 100,n: 101,d: 1101,s: 001

o: 0001,e: 111

WPL:88

Decording result: iaaaaaaamhhhhannnnddsssomeeeee



The encoding result: 01101011111111101110000001100110110101010010

Code list: h: 0110, o: 10, w: 111, a: 0111, r: 00, e: 1100, y: 1101

u: 010

WPL: 42

Decording result: howwwarrreyooou

4. 如何使用程式碼實作 huffman encoding 並得到 Part 1 和 Part 2 的結果

Part1: (1)define a structure including weight, left and right child node

```
typedef struct huffNode {
    double weight;              /*權重*/
    int lchild, rchild, parent;   /*左右子節點和父節點*/
} HTNode, * HuffTree;
```

(2)Input two tables:one for characters A to Z, one for the frequwncies

```
N = 26;  //共26字母
//第0個保留不用
ElemType data[N] = {"0", "A","B","C","D","E","F","G","H","I","J","K","L","M","N","O","P","Q","R","S","T","U","V","W","X","Y","Z"};
//第0個保留不用
double w[N] = { 0,7,2,2,3,11,2,2,6,6,1,1,4,3,7,9,2,1,6,6,8,4,1,2,1,2,1 };
```

(3)Create the huffmantree:

```
void createHT(HuffTree& HT, HuffCode& HC, double* w, int n) {
    int s1, s2, m = 2 * n - 1;              //m: 由n個節點組成的赫夫曼會有2n-1個節點
    char* code;                             //暫存
    HT = new HTNode[m + 1];                 //第0個不使用

    for (int i = 1; i <= n; i++) {
        //處理初始化前的第0個節點
        HT[i] = { w[i], 0, 0, 0 };
    }

    for (int i = n + 1; i <= m; i++) {
        //處理初始化後n-1個節點 (找出最小兩節點的父節點)
        HT[i] = { 0, 0, 0, 0 };
    }

    //赫夫曼樹建構
    for (int i = n + 1; i <= m; i++) {
        //找出前i-1個節點中權值最小的節點
        select(HT, i - 1, s1, s2);
        HT[s1].parent = i;
        HT[s2].parent = i;
        HT[i].lchild = s1;
        HT[i].rchild = s2;
        HT[i].weight = HT[s1].weight + HT[s2].weight;
    }
```

```
    HC = new char* [n];
    /*這裡以下我真的不知道自己在幹嘛*/
    code = new char[n];


    for (int i = 1; i <= n; i++) {
        //k: 現在的節點，用0和1表示, f: k的父節點, j: 記錄編碼的位置
        int k = i, f = HT[k].parent, j = 0;
        //從葉子到根走一遍
        while (f != 0) {
            if (HT[f].lchild == k) {
                code[j] = '0';
            }
            else if (HT[f].rchild == k) {
                code[j] = '1';
            }
            k = HT[k].parent;
            f = HT[k].parent;
            j++;
        }
        //標記尾巴位置
        code[j] = '\0';
        reverseChars(code, j);
        //站存的編碼移到HC
        HC[i] = new char[n];
        strcpy(HC[i], code);
    }
}
```

(4)Show the Huffman code

(5)Use DFS to calculate WPL

```
int getWPL(HuffTree& HT, int idx, int depth) {
    //執行dfs直到遇到葉子
    if (HT[idx].lchild == 0 && HT[idx].rchild == 0) {
        return HT[idx].weight * depth;
    }
    return getWPL(HT, HT[idx].lchild, depth + 1) + getWPL(HT, HT[idx].rchild, depth + 1);
}
```

(6)Show WPL

Part2: (1)Initialize the frequency=0

(2)Find the frequency of every characters and array them from low to high

```
void frequent(string str)
{
    int length = str.length();    /*長度*/
    minnode* node = new minnode[length];    /*宣告最0節點*/
    int i, j;
    for (i = 0; i < length; i++)    /*初始化頻度*/
    {
        node[i].ch_num = 0;
    }
    int char_type_num = 0;  /*初始化為0種字元*/
    for (i = 0; i < length; i++)
    {
        for (j = 0; j < char_type_num; j++)
        {
            if (str[i] == node[j].ch || (node[j].ch >= 'a' && node[j].ch <= 'z' && str[i] + 32 == node[j].ch))
            {
                break;
            }
        }
        if (j < char_type_num)
        {
            node[j].ch_num++;
        }
        else
        {
            if (str[i] >= 'A' && str[i] <= 'Z')
            {
                node[j].ch = str[i] + 32;
            }
```

```
    /*按照頻度從小到大排列*/
    for (i = 0; i < char_type_num; i++)
    {
        for (j = i; j < char_type_num; j++)
        {
            if (node[j].ch_num < node[j + 1].ch_num)  /*如果前一個小於後面一個 兩者交換*/
            {
                int temp;
                char ch_temp;
                temp = node[j].ch_num;
                ch_temp = node[j].ch;
                node[j].ch_num = node[j + 1].ch;
                node[j].ch = node[j + 1].ch;
                node[j].ch_num = temp;
                node[j].ch = ch_temp;
            }
        }
    }
```

(3)Initialize the nodes

```
huffmanTree* huff = new huffmanTree[2 * char_type_num - 1]; /*位於確定char_type_num*/
huffmanTree temp;
string* code = new string[2 * char_type_num - 1];
for (i = 0; i < 2 * char_type_num - 1; i++)   /*節點初始化*/
{
   huff[i].parent = -1;
   huff[i].lchild = -1;
   huff[i].rchild = -1;
   huff[i].flag = -1;
}
for (j = 0; j < char_type_num; j++)  /*將排序後的第0個節點權重值賦予樹節點*/
{
   huff[j].weight = node[j].ch_num;
}
int min1, min2;
for (int k = char_type_num; k < 2 * char_type_num - 1; k++)  /*賦予0級以上的節點值*/
{
   coding(length, huff, k, min1, min2);
   huff[min1].parent = k;
   huff[min2].parent = k;
   huff[min1].flag = "0";
   huff[min2].flag = "1";
   huff[k].lchild = min1;
   huff[k].rchild = min2;
   huff[k].weight = huff[min1].weight + huff[min2].weight;
}
```

(4)Give every nodes values

```
for (i = 0; i < char_type_num; i++) {
   temp = huff[i];
   while (1) {
      code[i] = temp.flag + code[i];
      temp = huff[temp.parent];
      if (temp.parent == -1)break;
   }
}
```

(5)Use DFS to calculate WPL

(6)Show all results

```
int main(void)
{
   int length = 0;   /*字串長度*/
   string str;       /*目標字串*/
   cout << "Enter characters: ";
   cin >> str;
   frequent(str);   /*求各個字串頻度*/
   cout << endl;
   cout << "decoding result: "<<str;
   return 0;
}
```