### 第5题：霍夫曼编码

#### 数据结构：

采用一维数组存储霍夫曼树节点，霍夫曼树的节点结构体除了包含左右子树即父结点位置下标还有是否被访问的flag及对应的字符在文章中的个数和编码串。

结构体Node如下：

typedef struct Node

{

char alpha='\0';

int num=0; //所在文章的该字符的个数

bool flag=true;//是否被访问过

string code="";

int Father=0,LChild=0,RChild=0;

}Node;

#### 算法设计思想：

先对可能存在的字符的节点初始化，然后使用ReadFromFile函数读取源文件，然后在主函数进行霍夫曼建树编码过程，期间使用SearchMin函数。再将对应编码写入对应文件，使用Encode和EncodeOutput函数，最后再解码写入对应文件。使用RecodeOutput函数。

#### 源程序：

#include <iostream>

#include <stdio.h>

#include <stdlib.h>

#include <fstream>

#include <string>

#include <algorithm>

using namespace std;

#define chNum 255

#define INF 10000

//设置为asiica码表字符个数

typedef struct Node

{

char alpha='\0';

int num=0; //所在文章的该字符的个数

bool flag=true;//是否被访问过

string code="";

int Father=0,LChild=0,RChild=0;

}Node;

Node nodes[2\*chNum];

typedef struct BiTNode

{

Node data;

BiTNode \*LChild,\*RChild;

}BiTNode,\*BiTree;

bool ReadFromFile(Node a[])

{

char ch;

int loc;

FILE \*fp;

if((fp=fopen("source.txt","r"))==NULL){

cout<<"文件打开失败！\n";

return false;

}

else

{

while(!feof(fp))

{

ch=fgetc(fp);

loc=int(ch);

a[loc].num++;

}

}

fclose(fp);

return true;

}

int SearchMin(Node a[],int n)

{

int min=INF,k;

for(int i=0;i<n;i++){

if(a[i].flag && (a[i].num<min)){

min=a[i].num;

k=i;

}

}

return k;

}

char h[20];

void Encode(Node a[])

{

string s;

for(int i=0;i<chNum+1;i++)

{

s="";

int k=0,f=-1,c=i;

while(f!=0)

{

f=a[c].Father;

if(a[f].LChild==c)

{

s+='0';

}

if(a[f].RChild==c)

{

s+='1';

}

c=f;

}

reverse(s.begin(),s.end());

a[i].code=s;

}

}

void EncodeOutput(Node a[])

{

char ch;

int x;

ifstream infile;

infile.open("source.txt");

ofstream outfile;

outfile.open("code.txt");

if(outfile&&infile)

{

while(!infile.eof()){

infile>>std::noskipws;

//使之可以读取到空格

infile>>ch;

x=int(ch);

outfile<<a[x].code;

}

}

else

{

cout<<"打开失败！\n";

}

outfile.close();

infile.close();

}

void RecodeOutput(Node a[])

{

char ch;

int x;

ifstream infile;

infile.open("code.txt");

ofstream outfile;

outfile.open("recode.txt");

if(outfile&&infile)

{

infile>>noskipws;

while(!infile.eof())

{

infile>>ch;

if((ch!='0')&&(ch!='1'))

{

outfile<<ch;

}

else if(ch==' ')

{

cout<<" ";

}

else

{

int k=2\*chNum;

while(k>chNum)

{

if(ch=='0')

{

k=a[k].LChild;

}

if(ch=='1')

{

k=a[k].RChild;

}

if(k>chNum)

{

infile>>ch;

}

}

outfile<<a[k].alpha;

}

}

}

else

{

cout<<"打开失败！\n";

}

outfile.close();

infile.close();

}

int main()

{

//初始化

for(int i=0;i<chNum+1;i++)

{

nodes[i].alpha= i;

}

if( !ReadFromFile(nodes) )return 0;

int n=chNum+1;

for(int i=0;i<chNum;i++)

{

int a1,a2;

a1=SearchMin(nodes,n);

nodes[a1].flag=false;

a2=SearchMin(nodes,n);

nodes[a2].flag=false;

nodes[n].num=nodes[a1].num+nodes[a2].num;

nodes[n].flag=true;

nodes[n].LChild=a1;

nodes[n].RChild=a2;

nodes[a1].Father=n;

nodes[a2].Father=n;

n++;

}

Encode(nodes);

EncodeOutput(nodes);

cout<<"文件编码成功！\n";

RecodeOutput(nodes);

cout<<"文件译码成功！\n";

return 0;

}

#### 测试数据和结果

##### Source.txt

When you are old and grey and full of sleep

And nodding by the fire take down this book

And slowly read and think of the soft look

Your eyes had once and of their shadows deep;

How many loved your moments of glad grace

And loved your beauty with love false or true

But one man loved the pilgrim Soul in you

And loved the sorrows of your changing face;

And bending down beside the glowing bars

Murmur a little sadly how Love fled

And paced upon the mountains overhead

And hid his face amid a crowd of stars

William Butler Yeats

To see a World in a Grain of Sand And a Heaven in a Wild Flower

Hold Infinity in the palm of your hand And Eternity in an hou

William Blake

National debate in the United States on the role played by race in college admissions culminated with the Supreme Court hearing challenges against two universities

To create a diverse student body many colleges and universities in the US consider a student s race as a factor in their admissions process Such race-conscious policies known as affirmative action have been repeatedly upheld by the nation s top court in past decades

Educators fear a ripple effect if the conservative court decides that the affirmative action policy is illegal

The baseline for permissible affirmative action programs in US higher education was established in X X X X

Citing Harvard University as the model Justice Lewis Powell said that in evaluating applicants race could not be the determinative factor but the university could use race as one of the many factors just as it uses other traits such as a special talent for music science or athletics and even the fact that an applicant s parents attended the university

In X X X the Supreme Court upheld an admissions program at the University of Texas at Austin ruling that the university could continue to consider race as a factor

This time the challenges were brought against Harvard and the University of North Carolina or UNC with the court hearing the arguments in late October

The new Supreme Court is the most conservative for X years The six justices appointed by Republican presidents and the three appointed by Democrats appeared divided along ideological lines

The court is likely to overturn some or all of such case precedents based on sharp and skeptical questioning from the conservative justices

During court argument Justice Clarence Thomas asked lawyers for the universities to define diversity He said It seems to mean everything for everyone Justice Samuel A Alito Jr asked what underrepresented minority meant

The justices are not expected to finalize their opinions until late June or early July If they rule that affirmative action is unconstitutional the number of black and Latino students would be reduced in colleges and universities nationwide particularly at elite institutions

Affirmative action is a government policy designed to help minorities and disadvantaged groups find employment gain admission to universities and obtain housing

Race-conscious policies aim to address discrimination that denies underrepresented students access to higher education

Until the X X X s and X X X s Harvard and UNC refused to admit large numbers of black students and other students of color Both schools said affirmative action allows them to select a diverse student body to create an inclusive educational environment that benefits all students

However opponents of affirmative action targeted the universities arguing that their programs violate equal protection principles and discriminate against Asian American students

Students for Fair Admissions or SFFA a conservative group that brought both challenges to the Supreme Court sued Harvard and UNC in X X X

The group alleged that Harvard intentionally discriminated against Asian American applicants by holding them to a higher standard in undergraduate admissions and specifically limiting the number of Asian Americans it admits each year

While Harvard is a private university the plaintiff said the institution was violating the X X X X Civil Rights Act that prohibits schools receiving federal funds from discriminating based on race

In the UNC case the group said the school policy is subject to the same law as well as the X Xth Amendment s guarantee of equal protection which covers state universities It said the school discriminated against white and Asian applicants by giving preference to black Hispanic and Native American students

SSFA lawyer Patrick Strawbridge accused UNC of using race behind opaque procedures in awarding mammoth racial preferences to African Americans and Hispanics

A white out-of-state male who had only a X percent chance of admission would have a X X percent chance if UNC treated him as an African American and a X X percent chance if it treated him as a Hispanic he said

In contrast to Strawbridge s suggestion US District Judge Loretta C Biggs found that the university continues to face challenges admitting and enrolling underrepresented minorities particularly African American males Hispanics and Native Americans

In October last year she ruled in favor of UNC saying it had not shown illegal bias against white and Asian American students

The university has been struggling to build a diverse student population In a state that is X X percent black just X percent of the undergraduate student population is African American

Biggs wrote in her ruling Ensuring that our public institutions of higher learning are open and available to all segments of our citizenry (is) an institutional obligation

SSFA filed an appeal at an appeals court in Richmond Virginia and at the Supreme Court In January the Supreme Court decided to hear the challenge even though the appeals court has not yet ruled

The lawsuit brought against Harvard by SSFA centers on the treatment of Asian American students who have on average better standardized test scores and grades than any other ethnic group including whites

Harvard admissions consider a student s academic extracurricular athletic and personal ratings The latter category attempts to assess how an applicant impacts people around him or her and the contributions the student might make

SFFA accused Harvard of discriminating against Asian American students by using a subjective standard to gauge traits such as likability courage and kindness

In X X X the district court ruled in favor of Harvard finding that it did not discriminate against Asian Americans In November X X an appellate court affirmed the district court decision ruling that it did not clearly err in finding that Harvard did not intentionally discriminate against Asian Americans

Harvard denied the accusation saying that Asian American enrollments have consistently risen The university s lead lawyer Seth Waxman said during the Supreme Court argument that if the school abandoned consideration of race as a factor representation of African American and Hispanic students in admissions - not white students - would decline

The X X X Asian American Voter Survey found that X X percent of Asian American voters favor affirmative action programs designed to help black people other minorities and women gain better access to higher education

Among Chinese Americans support for affirmative action stands at X X percent the lowest within the Asian American community

A Chinese American lawyer in Silicon Valley California said he opposes affirmative action because it is outdated

A long time has passed since affirmative action was created We don t need it anymore said the father of two who requested anonymity He said he fears that his children now in middle school will be disadvantaged when applying for college

Chinese for Affirmative Action an organization based in San Francisco has been trying to persuade the Chinese community that the discrimination it faces is not the result of affirmative action

Instead of focusing on affirmative action the activists called for opponents to question other areas of the admissions process such as legacy admissions and athletic preferences

According to the National Bureau of Economic Research X X percent of white students admitted to Harvard fall under the categories of recruited athletes legacy students and children of faculty and staff members This percentage also includes the dean s interest list which consists of applicants whose parents or relatives have made donations to the university

##### Code.txt

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When you are old and grey and full of sleep

And nodding by the fire take down this book

And slowly read and think of the soft look

Your eyes had once and of their shadows deep;

How many loved your moments of glad grace

And loved your beauty with love false or true

But one man loved the pilgrim Soul in you

And loved the sorrows of your changing face;

And bending down beside the glowing bars

Murmur a little sadly how Love fled

And paced upon the mountains overhead

And hid his face amid a crowd of stars

William Butler Yeats

To see a World in a Grain of Sand And a Heaven in a Wild Flower

Hold Infinity in the palm of your hand And Eternity in an hou

William Blake

National debate in the United States on the role played by race in college admissions culminated with the Supreme Court hearing challenges against two universities

To create a diverse student body many colleges and universities in the US consider a student s race as a factor in their admissions process Such race-conscious policies known as affirmative action have been repeatedly upheld by the nation s top court in past decades

Educators fear a ripple effect if the conservative court decides that the affirmative action policy is illegal

The baseline for permissible affirmative action programs in US higher education was established in X X X X

Citing Harvard University as the model Justice Lewis Powell said that in evaluating applicants race could not be the determinative factor but the university could use race as one of the many factors just as it uses other traits such as a special talent for music science or athletics and even the fact that an applicant s parents attended the university

In X X X the Supreme Court upheld an admissions program at the University of Texas at Austin ruling that the university could continue to consider race as a factor

This time the challenges were brought against Harvard and the University of North Carolina or UNC with the court hearing the arguments in late October

The new Supreme Court is the most conservative for X years The six justices appointed by Republican presidents and the three appointed by Democrats appeared divided along ideological lines

The court is likely to overturn some or all of such case precedents based on sharp and skeptical questioning from the conservative justices

During court argument Justice Clarence Thomas asked lawyers for the universities to define diversity He said It seems to mean everything for everyone Justice Samuel A Alito Jr asked what underrepresented minority meant

The justices are not expected to finalize their opinions until late June or early July If they rule that affirmative action is unconstitutional the number of black and Latino students would be reduced in colleges and universities nationwide particularly at elite institutions

Affirmative action is a government policy designed to help minorities and disadvantaged groups find employment gain admission to universities and obtain housing

Race-conscious policies aim to address discrimination that denies underrepresented students access to higher education

Until the X X X s and X X X s Harvard and UNC refused to admit large numbers of black students and other students of color Both schools said affirmative action allows them to select a diverse student body to create an inclusive educational environment that benefits all students

However opponents of affirmative action targeted the universities arguing that their programs violate equal protection principles and discriminate against Asian American students

Students for Fair Admissions or SFFA a conservative group that brought both challenges to the Supreme Court sued Harvard and UNC in X X X

The group alleged that Harvard intentionally discriminated against Asian American applicants by holding them to a higher standard in undergraduate admissions and specifically limiting the number of Asian Americans it admits each year

While Harvard is a private university the plaintiff said the institution was violating the X X X X Civil Rights Act that prohibits schools receiving federal funds from discriminating based on race

In the UNC case the group said the school policy is subject to the same law as well as the X Xth Amendment s guarantee of equal protection which covers state universities It said the school discriminated against white and Asian applicants by giving preference to black Hispanic and Native American students

SSFA lawyer Patrick Strawbridge accused UNC of using race behind opaque procedures in awarding mammoth racial preferences to African Americans and Hispanics

A white out-of-state male who had only a X percent chance of admission would have a X X percent chance if UNC treated him as an African American and a X X percent chance if it treated him as a Hispanic he said

In contrast to Strawbridge s suggestion US District Judge Loretta C Biggs found that the university continues to face challenges admitting and enrolling underrepresented minorities particularly African American males Hispanics and Native Americans

In October last year she ruled in favor of UNC saying it had not shown illegal bias against white and Asian American students

The university has been struggling to build a diverse student population In a state that is X X percent black just X percent of the undergraduate student population is African American

Biggs wrote in her ruling Ensuring that our public institutions of higher learning are open and available to all segments of our citizenry (is) an institutional obligation

SSFA filed an appeal at an appeals court in Richmond Virginia and at the Supreme Court In January the Supreme Court decided to hear the challenge even though the appeals court has not yet ruled

The lawsuit brought against Harvard by SSFA centers on the treatment of Asian American students who have on average better standardized test scores and grades than any other ethnic group including whites

Harvard admissions consider a student s academic extracurricular athletic and personal ratings The latter category attempts to assess how an applicant impacts people around him or her and the contributions the student might make

SFFA accused Harvard of discriminating against Asian American students by using a subjective standard to gauge traits such as likability courage and kindness

In X X X the district court ruled in favor of Harvard finding that it did not discriminate against Asian Americans In November X X an appellate court affirmed the district court decision ruling that it did not clearly err in finding that Harvard did not intentionally discriminate against Asian Americans

Harvard denied the accusation saying that Asian American enrollments have consistently risen The university s lead lawyer Seth Waxman said during the Supreme Court argument that if the school abandoned consideration of race as a factor representation of African American and Hispanic students in admissions - not white students - would decline

The X X X Asian American Voter Survey found that X X percent of Asian American voters favor affirmative action programs designed to help black people other minorities and women gain better access to higher education

Among Chinese Americans support for affirmative action stands at X X percent the lowest within the Asian American community

A Chinese American lawyer in Silicon Valley California said he opposes affirmative action because it is outdated

A long time has passed since affirmative action was created We don t need it anymore said the father of two who requested anonymity He said he fears that his children now in middle school will be disadvantaged when applying for college

Chinese for Affirmative Action an organization based in San Francisco has been trying to persuade the Chinese community that the discrimination it faces is not the result of affirmative action

Instead of focusing on affirmative action the activists called for opponents to question other areas of the admissions process such as legacy admissions and athletic preferences

According to the National Bureau of Economic Research X X percent of white students admitted to Harvard fall under the categories of recruited athletes legacy students and children of faculty and staff members This percentage also includes the dean s interest list which consists of applicants whose parents or relatives have made donations to the university

#### 时间复杂度：

霍夫曼算法时间复杂度O(n^3)

#### 反思：

可以将建树过程编为一个函数然后在主函数调用。减少程序耦合度。

可以将获取权值最小的两个节点使用其他排序方法减少时间复杂度

#### 该题代码行：

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