МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

МОСКОВСКИЙ АВИАЦИОННЫЙ ИНСТИТУТ  
(НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ)

**ЛАБОРАТОРНАЯ РАБОТА №5**

по курсу “Объектно-ориентированное программирование”

I семестр, 2021/22 учебный год

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**Задание:** Дополнить класс-контейнер из лабораторной работы №4 умными указателями.

**Вариант №18:**

* + Фигура: Трапеция (Trapezoid)
  + Контейнер: Бинарное дерево (Binary Tree)

**Описание программы:**

Исходный код разделён на 10 файлов:

* figure.h – описание класса фигуры
* point.h – описание класса точки
* point.cpp – реализация класса точки
* trapezoid.h – описание класса трапеция
* trapezoid.cpp – реализация класса трапеция
* TBinaryTreeItem.h – описание элемента бинарного дерева
* TBinaryTreeItem.cpp – реализация элемента бинарного дерева
* TBinaryTree.h – описание бинарного дерева
* TBinaryTree.cpp – реализация бинарного дерева
* main.cpp – основная программа

**Дневник отладки:** Ошибок не возникло.

**Вывод:**

Я познакомился на практике с умными указателями, а также закрепил полученные ранее навыки работы с классами и контейнерами. Была написана программа с собственной реализацией контейнера в виде бинарного дерева с содержанием объектов фигур «по назначению», которая может вводить/выводить содержимое контейнера и удалить их при надобности, что дало мне познать преимущества использования умных указателей, такие как, борьба с утечкой памяти, разыменовыванием нулевого указателя (либо к обращению к неинициализированной области памяти) и удаление уже удаленного объекта.

**Исходный код:**

**figure.h:**

#ifndef FIGURE\_H

#define FIGURE\_H

#include "point.h"

class Figure {

public:

virtual double Area() = 0;

virtual double GetArea() = 0;

virtual void Print(std::ostream &os) = 0;

virtual size\_t VertexesNumber() = 0;

virtual ~Figure() {};

};

#endif

**Main.cpp:**

#include <iostream>

#include "trapezoid.h"

#include "TBinaryTree.h"

int main () {

Trapezoid a (std::cin);

std:: cout << "The area of your figure is : " << a.Area() << std:: endl;

Trapezoid b (std::cin);

std:: cout << "The area of your figure is : " << b.Area() << std:: endl;

Trapezoid c (std::cin);

std:: cout << "The area of your figure is : " << c.Area() << std:: endl;

TBinaryTree tree;

std:: cout << "Is tree empty? " << tree.Empty() << std:: endl;

std:: cout << "And now, is tree empty? " << tree.Empty() << std:: endl;

tree.Push(a);

tree.Push(b);

tree.Push(c);

std:: cout << "The number of figures with area in [minArea, maxArea] is: " << tree.Count(0, 100000) << std:: endl;

std:: cout << "The result of searching the same-figure-counter is: " << tree.root->ReturnCounter() << std:: endl;

std:: cout << "The result of function named GetItemNotLess is: " << tree.GetItemNotLess(0, tree.root) << std:: endl;

std:: cout << tree << std:: endl;

tree.root = tree.Pop(tree.root, a);

std:: cout << tree << std:: endl;

return 0;

}

**Point.h:**

#ifndef POINT\_H

#define POINT\_H

#include <iostream>

class Point {

public:

Point();

Point(std::istream &is);

Point(double x, double y);

double dist(Point &other);

friend bool operator == (Point& p1, Point& p2);

friend class Pentagon;

double X();

double Y();

friend std::istream& operator>>(std::istream& is, Point& p);

friend std::ostream& operator<<(std::ostream& os, Point& p);

private:

double x;

double y;

};

#endif

**Point.cpp:**

#include "point.h"

#include <cmath>

Point::Point() : x(0.0), y(0.0) {}

Point::Point(double x, double y) : x(x), y(y) {}

Point::Point(std::istream &is) {

is >> x >> y;

}

double Point::dist(Point& other) {

double dx = (other.x - x);

double dy = (other.y - y);

return std::sqrt(dx\*dx + dy\*dy);

}

double Point::X() {

return x;

};

double Point::Y() {

return y;

};

std::istream& operator>>(std::istream& is, Point& p) {

is >> p.x >> p.y;

return is;

}

std::ostream& operator<<(std::ostream& os, Point& p) {

os << "(" << p.x << ", " << p.y << ")";

return os;

}

bool operator == (Point &p1, Point& p2) {

return (p1.x == p2.x && p1.y == p2.y);

}

**TBinaryTree.cpp:**

#include "TBinaryTree.h"

template <class T>

TBinaryTree<T>::TBinaryTree () {

root = nullptr;

}

template <class T>

std::shared\_ptr<TBinaryTreeItem<T>> copy (std::shared\_ptr<TBinaryTreeItem<T>> root) {

if (!root) {

return nullptr;

}

std::shared\_ptr<TBinaryTreeItem<T>> root\_copy(new TBinaryTreeItem<T>(root->GetTrapezoid()));

root\_copy->SetLeft(copy(root->GetLeft()));

root\_copy->SetRight(copy(root->GetRight()));

return root\_copy;

}

template <class T>

TBinaryTree<T>::TBinaryTree (const TBinaryTree<T> &other) {

root = copy(other.root);

}

template <class T>

void Print (std::ostream& os, std::shared\_ptr<TBinaryTreeItem<T>> node){

if (!node){

return;

}

if(node->GetLeft()){

os << node->GetTrapezoid().GetArea() << ": [";

Print (os, node->GetLeft());

if (node->GetRight()){

if (node->GetRight()){

os << ", ";

Print (os, node->GetRight());

}

}

os << "]";

} else if (node->GetRight()) {

os << node->GetTrapezoid().GetArea() << ": [";

Print (os, node->GetRight());

if (node->GetLeft()){

if (node->GetLeft()){

os << ", ";

Print (os, node->GetLeft());

}

}

os << "]";

}

else {

os << node->GetTrapezoid().GetArea();

}

}

template <class T>

std::ostream& operator<< (std::ostream& os, TBinaryTree<T>& tree){

Print(os, tree.root);

os << "\n";

return os;

}

template <class T>

void TBinaryTree<T>::Push (T &trapezoid) {

if (root == nullptr) {

std::shared\_ptr<TBinaryTreeItem<T>> help(new TBinaryTreeItem<T>(trapezoid));

root = help;

}

else if (root->GetTrapezoid() == trapezoid) {

root->IncreaseCounter();

}

else {

std::shared\_ptr <TBinaryTreeItem<T>> parent = root;

std::shared\_ptr <TBinaryTreeItem<T>> current;

bool childInLeft = true;

if (trapezoid.GetArea() < parent->GetTrapezoid().GetArea()) {

current = root->GetLeft();

}

else if (trapezoid.GetArea() > parent->GetTrapezoid().GetArea()) {

current = root->GetRight();

childInLeft = false;

}

while (current != nullptr) {

if (current->GetTrapezoid() == trapezoid) {

current->IncreaseCounter();

}

else {

if (trapezoid.GetArea() < current->GetTrapezoid().GetArea()) {

parent = current;

current = parent->GetLeft();

childInLeft = true;

}

else if (trapezoid.GetArea() > current->GetTrapezoid().GetArea()) {

parent = current;

current = parent->GetRight();

childInLeft = false;

}

}

}

std::shared\_ptr <TBinaryTreeItem<T>> item (new TBinaryTreeItem<T>(trapezoid));

current = item;

if (childInLeft == true) {

parent->SetLeft(current);

}

else {

parent->SetRight(current);

}

}

}

template <class T>

std::shared\_ptr <TBinaryTreeItem<T>> FMRST(std::shared\_ptr <TBinaryTreeItem<T>> root) {

if (root->GetLeft() == nullptr) {

return root;

}

return FMRST(root->GetLeft());

}

template <class T>

std::shared\_ptr <TBinaryTreeItem<T>> TBinaryTree<T>:: Pop(std::shared\_ptr <TBinaryTreeItem<T>> root, T &trapezoid) {

if (root == nullptr) {

return root;

}

else if (trapezoid.GetArea() < root->GetTrapezoid().GetArea()) {

root->SetLeft(Pop(root->GetLeft(), trapezoid));

}

else if (trapezoid.GetArea() > root->GetTrapezoid().GetArea()) {

root->SetRight(Pop(root->GetRight(), trapezoid));

}

else {

//first case of deleting - we are deleting a list

if (root->GetLeft() == nullptr && root->GetRight() == nullptr) {

root = nullptr;

return root;

}

//second case of deleting - we are deleting a verex with only one child

else if (root->GetLeft() == nullptr && root->GetRight() != nullptr) {

std::shared\_ptr <TBinaryTreeItem<T>> pointer = root;

root = root->GetRight();

return root;

}

else if (root->GetRight() == nullptr && root->GetLeft() != nullptr) {

std::shared\_ptr <TBinaryTreeItem<T>> pointer = root;

root = root->GetLeft();

return root;

}

//third case of deleting

else {

std::shared\_ptr <TBinaryTreeItem<T>> pointer = FMRST(root->GetRight());

root->GetTrapezoid().area = pointer->GetTrapezoid().GetArea();

root->SetRight(Pop(root->GetRight(), pointer->GetTrapezoid()));

}

}

return root;

}

template <class T>

void RecursiveCount(double minArea, double maxArea, std::shared\_ptr<TBinaryTreeItem<T>> current, int& ans) {

if (current != nullptr) {

RecursiveCount(minArea, maxArea, current->GetLeft(), ans);

RecursiveCount(minArea, maxArea, current->GetRight(), ans);

if (minArea <= current->GetTrapezoid().GetArea() && current->GetTrapezoid().GetArea() < maxArea) {

ans += current->ReturnCounter();

}

}

}

template <class T>

int TBinaryTree<T>::Count(double minArea, double maxArea) {

int ans = 0;

RecursiveCount(minArea, maxArea, root, ans);

return ans;

}

template <class T>

T& TBinaryTree<T>::GetItemNotLess(double area, std::shared\_ptr <TBinaryTreeItem<T>> root) {

if (root->GetTrapezoid().GetArea() >= area) {

return root->GetTrapezoid();

}

else {

return GetItemNotLess(area, root->GetRight());

}

}

template <class T>

void RecursiveClear(std::shared\_ptr <TBinaryTreeItem<T>> current){

if (current!= nullptr){

RecursiveClear(current->GetLeft());

RecursiveClear(current->GetRight());

current = nullptr;

}

}

template <class T>

void TBinaryTree<T>::Clear(){

RecursiveClear(root);

root = nullptr;

}

template <class T>

bool TBinaryTree<T>::Empty() {

if (root == nullptr) {

return true;

}

return false;

}

template <class T>

TBinaryTree<T>::~TBinaryTree() {

Clear();

std:: cout << "Your tree has been deleted" << std:: endl;

}

#include "trapezoid.h"

template class TBinaryTree<Trapezoid>;

template std::ostream& operator<<(std::ostream& os, TBinaryTree<Trapezoid>& stack);

**TBinaryTree.h:**

#ifndef TBINARYTREE\_H

#define TBINARYTREE\_H

#include "TBinaryTreeItem.h"

template <class T>

class TBinaryTree {

public:

TBinaryTree();

TBinaryTree(const TBinaryTree<T> &other);

void Push(T &trapezoid);

std::shared\_ptr<TBinaryTreeItem<T>> Pop(std::shared\_ptr<TBinaryTreeItem<T>> root, T &trapezoid);

T& GetItemNotLess(double area, std::shared\_ptr<TBinaryTreeItem<T>> root);

void Clear();

bool Empty();

int Count(double minArea, double maxArea);

template <class A>

friend std::ostream& operator<<(std::ostream& os, TBinaryTree<A>& tree);

virtual ~TBinaryTree();

std::shared\_ptr <TBinaryTreeItem<T>> root;

};

#endif

**TBinaryTreeItem.cpp:**

#include "TBinaryTreeItem.h"

template <class T>

TBinaryTreeItem<T>::TBinaryTreeItem(const T &trapezoid) {

this->trapezoid = trapezoid;

this->left = this->right = nullptr;

this->counter = 1;

}

template <class T>

TBinaryTreeItem<T>::TBinaryTreeItem(const TBinaryTreeItem<T> &other) {

this->trapezoid = other.trapezoid;

this->left = other.left;

this->right = other.right;

this->counter = other.counter;

}

template <class T>

T& TBinaryTreeItem<T>::GetTrapezoid() {

return this->trapezoid;

}

template <class T>

void TBinaryTreeItem<T>::SetTrapezoid(const T& trapezoid){

this->trapezoid = trapezoid;

}

template <class T>

std::shared\_ptr<TBinaryTreeItem<T>> TBinaryTreeItem<T>::GetLeft(){

return this->left;

}

template <class T>

std::shared\_ptr<TBinaryTreeItem<T>> TBinaryTreeItem<T>::GetRight(){

return this->right;

}

template <class T>

void TBinaryTreeItem<T>::SetLeft(std::shared\_ptr<TBinaryTreeItem<T>> item) {

if (this != nullptr){

this->left = item;

}

}

template <class T>

void TBinaryTreeItem<T>::SetRight(std::shared\_ptr<TBinaryTreeItem<T>> item) {

if (this != nullptr){

this->right = item;

}

}

template <class T>

void TBinaryTreeItem<T>::IncreaseCounter() {

if (this != nullptr){

counter++;

}

}

template <class T>

void TBinaryTreeItem<T>::DecreaseCounter() {

if (this != nullptr){

counter--;

}

}

template <class T>

int TBinaryTreeItem<T>::ReturnCounter() {

return this->counter;

}

template <class T>

TBinaryTreeItem<T>::~TBinaryTreeItem() {

std::cout << "Destructor TBinaryTreeItem was called\n";

}

template <class T>

std::ostream &operator<<(std::ostream &os, TBinaryTreeItem<T> &obj)

{

os << "Item: " << obj.GetTrapezoid() << std::endl;

return os;

}

template class TBinaryTreeItem<Trapezoid>;

template std::ostream& operator<<(std::ostream& os, TBinaryTreeItem<Trapezoid> &obj);

**TBinaryTreeItem.h:**

#ifndef TBINARYTREE\_ITEM\_H

#define TBINARYTREE\_ITEM\_H

#include "trapezoid.h"

template <class T>

class TBinaryTreeItem {

public:

TBinaryTreeItem(const T& trapezoid);

TBinaryTreeItem(const TBinaryTreeItem<T>& other);

T& GetTrapezoid();

void SetTrapezoid(T& trapezoid);

std::shared\_ptr<TBinaryTreeItem<T>> GetLeft();

std::shared\_ptr<TBinaryTreeItem<T>> GetRight();

void SetLeft(std::shared\_ptr<TBinaryTreeItem<T>> item);

void SetRight(std::shared\_ptr<TBinaryTreeItem<T>> item);

void SetTrapezoid(const T& trapezoid);

void IncreaseCounter();

void DecreaseCounter();

int ReturnCounter();

virtual ~TBinaryTreeItem();

template<class A>

friend std::ostream &operator<<(std::ostream &os, const TBinaryTreeItem<A> &obj);

private:

T trapezoid;

std::shared\_ptr<TBinaryTreeItem<T>> left;

std::shared\_ptr<TBinaryTreeItem<T>> right;

int counter;

};

#endif

**Trapezoid.cpp:**

#include "trapezoid.h"

#include <cmath>

Trapezoid::Trapezoid() {}

Trapezoid::Trapezoid(std::istream &InputStream)

{

InputStream >> a;

InputStream >> b;

InputStream >> c;

InputStream >> d;

std:: cout << "Trapezoid that you wanted to create has been created" << std:: endl;

}

void Trapezoid::Print(std::ostream &OutputStream) {

OutputStream << "Trapezoid: ";

OutputStream << a << " " << b << " " << c << " " << d << std:: endl;

}

size\_t Trapezoid::VertexesNumber() {

size\_t number = 4;

return number;

}

double Trapezoid::Area() {

double k = (a.Y() - d.Y()) / (a.X() - d.X());

double m = a.Y() - k \* a.X();

double h = abs(b.Y() - k \* b.X() - m) / sqrt(1 + k \* k);

return 0.5 \* (a.dist(d) + b.dist(c)) \* h;

}

double Trapezoid:: GetArea() {

return area;

}

Trapezoid::~Trapezoid() {

std:: cout << "My friend, your trapezoid has been deleted" << std:: endl;

}

bool operator == (Trapezoid& p1, Trapezoid& p2){

if(p1.a == p2.a && p1.b == p2.b && p1.c == p2.c && p1.d == p2.d) {

return true;

}

return false;

}

std::ostream& operator << (std::ostream& os, Trapezoid& p){

os << "Trapezoid: ";

os << p.a << p.b << p.c << p.d;

os << std::endl;

return os;

}

**Trapezoid.h:**

#ifndef TRAPEZOID\_H

#define TRAPEZOID\_H

#include "figure.h"

#include <iostream>

class Trapezoid : public Figure {

public:

Trapezoid(std::istream &InputStream);

Trapezoid();

double GetArea();

size\_t VertexesNumber();

double Area();

void Print(std::ostream &OutputStream);

friend bool operator == (Trapezoid& p1, Trapezoid& p2);

friend std::ostream& operator << (std::ostream& os, Trapezoid& p);

virtual ~Trapezoid();

double area;

private:

Point a;

Point b;

Point c;

Point d;

};

#endif

**Результат работы:**

1 1 2 2 3 3 4 4

Trapezoid that you wanted to create has been created

The area of your figure is : 0

0 0 0 1 1 1 1 0

Trapezoid that you wanted to create has been created

The area of your figure is : 1

0 0 1 1 2 1 3 0

Trapezoid that you wanted to create has been created

The area of your figure is : 2

Is tree empty? 1

And now, is tree empty? 1

The number of figures with area in [minArea, maxArea] is: 3

The result of searching the same-figure-counter is: 1

The result of function named GetItemNotLess is: Trapezoid: (1, 1)(2, 2)(3, 3)(4, 4)

0: [7.90505e-323: [0]]

My friend, your trapezoid has been deleted

7.90505e-323: [0]

My friend, your trapezoid has been deleted

My friend, your trapezoid has been deleted

Your tree has been deleted

My friend, your trapezoid has been deleted

My friend, your trapezoid has been deleted

My friend, your trapezoid has been deleted

Process finished with exit code 0