



Estructura de datos I

García Cruz Iván Alejandro

Código: 220790822

Clave I5886 NRC 59883 D12

Actividad 13: El Árbol AVL, implementación dinámica

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Tabla de autoevaluación

Autoevaluación			
Concepto	Sí	No	Acumulación
Bajé el trabajo de internet o alguien me lo pasó (aunque sea de forma parcial)	-100 pts	0 pts	0
Incluí el código fuente en formato de texto (sólo si funciona cumpliendo todos los requerimientos)	+25 pts	0 pts	25
Incluí las impresiones de pantalla (sólo si funciona cumpliendo todos los requerimientos)	+25 pts	0 pts	25
Incluí una portada que identifica mi trabajo (nombre, código, materia, fecha, título)	+25 pts	0 pts	25
Incluí una descripción y conclusiones de mi trabajo	+25 pts	0 pts	25
Suma:			100

Introducción

Durante esta actividad vimos los árboles AVL que es una nueva implementación de un árbol binario en la cual consiste en mantener el árbol ordenado y balanceado, y esto se consigue a través de calcular su factor de equilibrio el cual se calcula con la altura del subárbol derecho menos la altura del subárbol izquierdo, y si este factor de equilibrio tiene un valor de -1 a 1 se puede considerar que el árbol está equilibrado en caso de tener un valor de 2 o -2 el árbol se considera desbalanceado y por lo tanto debemos de aplicar rotaciones para que nuestro árbol quede balanceado. Hay diversos casos en los que el árbol puede que este desbalanceado y depende de esa situación es el tipo de rotación que aplicaremos. El primer caso es que el árbol este desbalanceado hacía la izquierda por lo tanto haremos una rotación simple hacía la derecha, el segundo caso es que este desbalanceado hacía la derecha por lo tanto se aplica una rotación a la izquierda, después están los casos en los que el hijo derecho, del hijo izquierdo y viceversa está desbalanceado tenemos que aplicar una rotación doble y de esta forma nuestro árbol queda balanceado matemáticamente.

Código Fuente

Main

```
#include <iostream>

#include "Menu.h"

int main()
{
    Menu M;
    M.Menu_P();
    return 0;
}
```

Menu.h

```
#ifndef MENU_H
#define MENU_H

#include<iostream>
#include <random>
#include <chrono>
#include <functional>

#include "ArbolB.h"

class Menu
{
public:
    Menu();

    void Menu_P();

private:
};

#endif // MENU_H
```

Menu.cpp

```
#include "Menu.h"

using namespace std;

Menu::Menu() {}

void Menu::Menu_P()
{
    default_random_engine
generator(chrono::system_clock::now().time_since_epoch().count());
    uniform_int_distribution<int> distribution(0, 100000);
    auto dice = bind(distribution, generator);

    ArbolB<int> Arbol;
    int valor, aux, opc;

    do
    {
        system("CLS");
        cout<<" \t\t Arbol AVL"<<endl;
        cout<<"1-Insertar elementos"<<endl;
        cout<<"2-Recorrido PreOrder"<<endl;
        cout<<"3-Recorrido InOrder"<<endl;
        cout<<"4-Recorrido PostOrder"<<endl;
        cout<<"5-Mostrar elemento menor"<<endl;
```

```

    cout<<"6-Mostrar elemento mayor"<<endl;
    cout<<"7-Mostrar altura SubArbol Izquierdo"<<endl;
    cout<<"8-Mostrar altura SubArbol Derecho"<<endl;
    cout<<"9-Salir"<<endl;
    cin>>opc;

    switch (opc)
    {
        case 1:
            system("CLS");
            cout<<"Ingresa la cantidad de valores a generar"<<endl;
            cin>>aux;

            for(int i(0); i < aux; i++)
            {
                valor = dice();

                cout<<"Insertando: "<<valor<<endl;

                Arbol.Insertar(valor);
            }

            system("pause");
            break;
        case 2:
            system("CLS");
            cout<<"Recorrimiento PreOrder"<<endl;
            Arbol.RecorridoPreOrder();
            cout<<endl;
            system("pause");
            break;
        case 3:
            system("CLS");
            cout<<"Recorrimiento InOrder"<<endl;
            Arbol.RecorridoInOrder();
            cout<<endl;
            system("pause");
            break;
        case 4:
            system("CLS");
            cout<<"Recorrimiento PostOrder"<<endl;
            Arbol.RecorridoPostOrder();
            cout<<endl;
            system("pause");
            break;
        case 5:
            system("CLS");
            cout<<"El valor menor es: "<<Arbol.Recupera(Arbol.Menor());
            cout<<endl;
            system("pause");
            break;
        case 6:
            system("CLS");

```

```

        cout<<"El valor mayor es: "<<Arbol.Recupera(Arbol.Mayor());
        cout<<endl;
        system("pause");
    break;
    case 7:
        system("CLS");
        cout<<"La altura del subarbol izquierdo: "<<Arbol.getAltura();
        cout<<endl;
        system("pause");
    break;
    case 8:
        system("CLS");
        cout<<"La altura del subarbol derecho: "<<Arbol.getAltura();
        cout<<endl;
        system("pause");
    break;
}
}
while(opc != 9);
}

```

Arbol.h

```

#ifndef ARBOLB_H
#define ARBOLB_H

#include <exception>
#include <string>
#include <iostream>

template <class T>
class ArbolB
{
    private:
        class Nodo
        {
            private:
                T* dataPtr;
                Nodo* Izquierda;
                Nodo* Derecha;

            public:
                class Exception: public std::exception
                {
                    private:
                        std::string msg;

                    public:
                        explicit Exception(const char* message):
msg(message) {}

```

```

        explicit Exception(const std::string& message):
msg(message) {}

        virtual ~Exception() throw () {}

        virtual const char* what() const throw () {
            return msg.c_str();
        }
    };

    Nodo();
    Nodo(const T&);
    ~Nodo();

    T* getDataPtr() const;
    T getData() const;
    Nodo*& getIzquierda();
    Nodo*& getDerecha();

    void setDataPtr(T*);
    void setData(const T&);
    void setIzquierda(Nodo*&);
    void setDerecha(Nodo*&);
};

public:
    typedef Nodo* Posicion;

private:
    Posicion root;

    void Insertar(Posicion&, const T&);

    Posicion& Localiza(Posicion&, const T&);

    Posicion& Menor(Posicion&);
    Posicion& Mayor(Posicion&);

    void RecorridoPreOrder(Posicion&);
    void RecorridoInOrder(Posicion&);
    void RecorridoPostOrder(Posicion&);

public:
    class Exception: public std::exception
    {
    private:
        std::string msg;

    public:
        explicit Exception(const char* message): msg(message) {}

```

```

        explicit Exception(const std::string& message):
msg(message) {}

        virtual ~Exception() throw () {}

        virtual const char* what() const throw () {
            return msg.c_str();
        }
    };

    ArbolB();
    ~ArbolB();

    bool Vacia() const;
    void Insertar(const T&);
    void Eliminar(Posicion&);
    T Recupera(Posicion&) const;
    int getAltura(Posicion&);
    Posicion& Localiza(const T&);
    Posicion& Menor();
    Posicion& Mayor();

    bool es_hoja(Posicion&) const;
    int getAltura();
    void Anula();

    void RecorridoPreOrder();
    void RecorridoInOrder();
    void RecorridoPostOrder();

    //Arbol AVL

    int getBalanceFactor(Nodo*&);

    void simpleLeftRot(Nodo*&);
    void simpleRightRot(Nodo*&);
    void doubleLeftRot(Nodo*&);
    void doubleRightRot(Nodo*&);

    void doBalancing(Nodo*&);

};

template <class T>
ArbolB<T>::Nodo::Nodo() : dataPtr(nullptr), Izquierda(nullptr),
Derecha(nullptr) {}

template <class T>
ArbolB<T>::Nodo::Nodo(const T& e) : dataPtr(new T(e)),
Izquierda(nullptr), Derecha(nullptr)
{
    if(dataPtr == nullptr)
    {

```

```

        throw Exception("Memoria insuficiente");
    }
}

template <class T>
ArbolB<T>::Nodo::~~Nodo()
{
    delete dataPtr;
}

template <class T>
T* ArbolB<T>::Nodo::getDataPtr() const
{
    return dataPtr;
}

template <class T>
T ArbolB<T>::Nodo::getData() const
{
    if(dataPtr == nullptr)
    {
        throw Exception("Dato inexistente");
    }

    return *dataPtr;
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Nodo::getIzquierda()
{
    return Izquierda;
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Nodo::getDerecha()
{
    return Derecha;
}

template <class T>
void ArbolB<T>::Nodo::setDataPtr(T* p)
{
    dataPtr = p;
}

template <class T>
void ArbolB<T>::Nodo::setData(const T& e)
{
    if(dataPtr == nullptr)
    {
        if((dataPtr = new T(e)) == nullptr)
        {
            throw Exception("Memoria no disponible");
        }
    }
}

```



```

        }
    }
    else
    {
        *dataPtr = e;
    }
}

template <class T>
void ArbolB<T>::Nodo::setIzquierda(Posicion& p)
{
    Izquierda = p;
}

template <class T>
void ArbolB<T>::Nodo::setDerecha(Posicion& p)
{
    Derecha = p;
}

template <class T>
ArbolB<T>::ArbolB() : root(nullptr){}

template <class T>
ArbolB<T>::~~ArbolB()
{
    //Anula();
}

template <class T>
bool ArbolB<T>::Vacía() const
{
    return root == nullptr;
}

template <class T>
void ArbolB<T>::Insertar(const T& e)
{
    Insertar(root, e);
}

template <class T>
void ArbolB<T>::Insertar(Posicion& r, const T& e)
{
    if(r == nullptr)
    {
        try
        {
            if((r = new Nodo(e)) == nullptr)
            {
                throw Exception("Memoria no disponible");
            }
        }
    }
}

```

```

    }
    catch (typename Nodo::Exception ex)
    {
        throw Exception(ex.what());
    }
}
else
{
    if (e < r->getData())
    {
        Insertar(r->getIzquierda(), e);
    }
    else
    {
        Insertar(r->getDerecha(), e);
    }

    doBalancing(r);
}
}

template <class T>
int ArbolB<T>::getBalanceFactor(Nodo*& r)
{
    return getAltura(r->getDerecha()) - getAltura(r->getIzquierda());
}

template <class T>
void ArbolB<T>::simpleLeftRot(Nodo*& r)
{
    Nodo* aux1(r->getDerecha());
    Nodo* aux2(aux1->getIzquierda());

    r->setDerecha(aux2);
    aux1->setIzquierda(r);
    r = aux1;
}

template <class T>
void ArbolB<T>::simpleRightRot(Nodo*& r)
{
    Nodo* aux1(r->getIzquierda());
    Nodo* aux2(aux1->getDerecha());

    r->setIzquierda(aux2);
    aux1->setDerecha(r);
    r = aux1;
}

template <class T>
void ArbolB<T>::doubleLeftRot(Nodo*& r)
{
    simpleRightRot(r->getDerecha());
}

```

```

        simpleLeftRot(r);
    }

    template <class T>
    void ArbolB<T>::doubleRightRot(Nodo *& r)
    {
        simpleLeftRot(r->getIzquierda());
        simpleRightRot(r);
    }

    template <class T>
    void ArbolB<T>::doBalancing(Nodo*& r)
    {
        switch(getBalanceFactor(r))
        {
            case -2:
                if(getBalanceFactor(r->getIzquierda()) == -1)
                {
                    std::cout<<"RSD: "<< r->getData()<<std::endl;
                    simpleRightRot(r);
                }
                else
                {
                    std::cout<<"RDD: "<< r->getData()<<std::endl;
                    doubleRightRot(r);
                }
                break;

            case 2:
                if(getBalanceFactor(r->getDerecha()) == 1)
                {
                    std::cout<<"RSI: "<< r->getData()<<std::endl;
                    simpleLeftRot(r);
                }
                else
                {
                    std::cout<<"RDI: "<< r->getData()<<std::endl;
                    doubleLeftRot(r);
                }
                break;

        }
    }

    template <class T>
    void ArbolB<T>::Eliminar(Posicion& r)
    {
        Posicion Pos_replazo;

        if(root == nullptr or r == nullptr)
        {
            throw Exception("Posicion invalida");
        }
    }

```

```

    if(es_hoja(r))
    {
        delete(r);
        r = nullptr;
    }
    else
    {
        if(r->Izquierda != nullptr)
        {
            Pos_reemplazo = Mayor(r->Izquierda);
        }
        else
        {
            Pos_reemplazo = Menor(r->Derecha);
        }

        r->dataPtr = Pos_reemplazo->dataPtr;
        Eliminar(Pos_reemplazo);
    }
}

template <class T>
T ArbolB<T>::Recupera(Posicion& r) const
{
    return r->getData();
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Localiza(const T& e)
{
    return Localiza(root,e);
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Localiza(Posicion& r, const T& e)
{
    if(r == nullptr or r->getData() == e)
    {
        return r;
    }
    if(e < r->getData())
    {
        return Localiza(r->getIzquierda(),e);
    }

    return Localiza(r->getDerecha(),e);
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Menor()
{
    return Menor(root);
}

```

```

}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Menor(Posicion& r)
{
    if(r == nullptr or r->getIzquierda() == nullptr)
    {
        return r;
    }

    return Menor(r->getIzquierda());
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Mayor()
{
    Mayor(root);
}

template <class T>
typename ArbolB<T>::Posicion& ArbolB<T>::Mayor(Posicion& r)
{
    if(r == nullptr or r->getDerecha() == nullptr)
    {
        return r;
    }

    return Mayor(r->getDerecha());
}

template <class T>
bool ArbolB<T>::es_hoja(Posicion& r) const
{
    return r != nullptr and r->getIzquierda() == r->getDerecha();
}

template <class T>
int ArbolB<T>::getAltura()
{
    return getAltura(root);
}

template <class T>
int ArbolB<T>::getAltura(Posicion& r)
{
    if(r == nullptr)
    {
        return 0;
    }

    int lH(getAltura(r->getIzquierda()));
    int rH(getAltura(r->getDerecha()));

```

```

        return (lH > rH ? lH : rH) + 1;
    }

    template <class T>
    void ArbolB<T>::RecorridoPreOrder()
    {
        RecorridoPreOrder(root);
    }

    template <class T>
    void ArbolB<T>::RecorridoPreOrder(Posicion& r)
    {
        if(r == nullptr)
        {
            return;
        }

        std::cout << r->getData() << ", ";
        RecorridoPreOrder(r->getIzquierda());
        RecorridoPreOrder(r->getDerecha());
    }

    template <class T>
    void ArbolB<T>::RecorridoInOrder()
    {
        RecorridoInOrder(root);
    }

    template <class T>
    void ArbolB<T>::RecorridoInOrder(Posicion& r)
    {
        if(r == nullptr)
        {
            return;
        }

        RecorridoInOrder(r->getIzquierda());
        std::cout << r->getData() << ", ";
        RecorridoInOrder(r->getDerecha());
    }

    template <class T>
    void ArbolB<T>::RecorridoPostOrder()
    {
        RecorridoPostOrder(root);
    }

    template <class T>
    void ArbolB<T>::RecorridoPostOrder(Posicion& r)
    {
        if(r == nullptr)
        {
            return;
        }
    }

```

```

    }

    RecorridoPostOrder(r->getIzquierda());
    RecorridoPostOrder(r->getDerecha());
    std::cout<< r->getData() <<" ";
}

template<class T>
void ArbolB<T>::Anula()
{
    Eliminar(root);
    root = nullptr;
}

#endif // ARBOLB_H

```

Ejecuciones de programa

Prueba 1

C:\Users\ivan_\OneDrive\Documentos\EDI\Arbol\bin\Debug\Arbol.exe

```

Ingresa la cantidad de valores a generar
1000
Insertando: 98627
Insertando: 62138
Insertando: 19902
RSD: 98627
Insertando: 85555
Insertando: 75554
RSD: 98627
Insertando: 98299
RSI: 62138
Insertando: 55668
Insertando: 81306
Insertando: 73009
Insertando: 28519
RDI: 19902
Insertando: 4887
RSD: 85555
Insertando: 48414
Insertando: 72570
Insertando: 46492
RSD: 55668
Insertando: 74669
Insertando: 18386
RDD: 19902
Insertando: 1884
Insertando: 68985
RSD: 75554
Insertando: 96145
RSD: 98627

```

Seleccionar C:\Users\ivan_\OneDrive\Documentos\EDI\Arbol\bin\Debug\Arbol.exe

```

RDD: 25978
Insertando: 38910
Insertando: 47059
Insertando: 5338
Insertando: 27734
Insertando: 12583
RSD: 12982
Insertando: 79967
Insertando: 64798
Insertando: 18628
Insertando: 78747
RSD: 78865
Insertando: 65435
RDI: 65328
Insertando: 33586
Insertando: 59889
Insertando: 22366
RDD: 22401
Insertando: 90802
RDI: 90621
Insertando: 60354
Insertando: 41021
Insertando: 22145
Insertando: 82384
Insertando: 81511
Insertando: 10891
Insertando: 40640
RSD: 41170
Insertando: 25845
Insertando: 70810

```

C:\Users\Ivan_OneDrive\Documents\EDI\Arbol\bin\Debug\Arbol.exe

Recorrimiento PreOrder

```
62138, 28519, 16588, 6984, 4403, 1884, 872, 132, 19, 3, 41, 486, 158, 246, 702, 756, 1456, 1107, 994, 1108, 1666, 1625, 1478, 1804, 3015, 2462, 2230, 1976, 2131, 2399, 2230, 2427, 2574, 2561, 2586, 2851, 366
3489, 3359, 3283, 3652, 3659, 3905, 3924, 4067, 3993, 4050, 4241, 4072, 5675, 4887, 4470, 4424, 4799, 4591, 4875, 5235, 4980, 5249, 5338, 5632, 6001, 5873, 5693, 5684, 5822, 5897, 5888, 6223, 6019, 6004
305, 6231, 6461, 6730, 6728, 6880, 6896, 11476, 9284, 8133, 7451, 7231, 7064, 7369, 7981, 7701, 7457, 7918, 8109, 8530, 8380, 8233, 8250, 8431, 8400, 8478, 8848, 8666, 8565, 8789, 9224, 9072, 9292, 9260, 1
416, 9730, 9544, 9383, 9519, 9553, 9677, 10216, 9995, 10188, 10302, 10218, 10414, 11090, 10774, 10424, 11052, 10891, 11234, 11092, 11391, 13422, 12405, 12112, 11602, 11488, 12028, 12062, 12306
2159, 12401, 13216, 13104, 12936, 12583, 12982, 13151, 13412, 13400, 14235, 13968, 13472, 13453, 13868, 13600, 14071, 14001, 14019, 14088, 14084, 15753, 14624, 14350, 14244, 14363, 14837, 14693, 1500
11532, 16133, 15772, 15786, 16280, 19902, 18378, 17477, 17230, 17186, 17184, 17382, 17266, 17427, 17768, 17607, 17519, 17565, 17675, 17750, 17986, 17955, 17958, 18156, 18274, 19475, 18656, 18414, 1
86, 18602, 18628, 18765, 18738, 19406, 18794, 19505, 19478, 19840, 19704, 19879, 24691, 22120, 21038, 20478, 20214, 20136, 20093, 20460, 20916, 20688, 20839, 20923, 21339, 21295, 21091, 21305, 22013
1773, 21577, 22069, 22048, 22114, 23444, 22554, 22366, 22128, 22145, 22401, 22672, 22554, 23098, 23399, 23819, 23496, 23461, 23456, 23599, 23507, 23731, 24290, 24189, 23868, 24213, 24489, 24304, 245
2, 26193, 25574, 24998, 24934, 25011, 25276, 25041, 25824, 25640, 25580, 25760, 25978, 25845, 26028, 26122, 26061, 26156, 27615, 26627, 26342, 26328, 26307, 26487, 26424, 27401, 27223, 27138, 27387, 2
57, 27432, 28059, 27871, 27734, 27734, 28001, 28461, 28206, 28176, 28428, 28488, 48414, 41360, 35319, 32896, 31055, 29951, 29236, 28594, 28571, 28550, 28960, 28689, 29016, 29317, 29260, 29789, 29370
9836, 30602, 30066, 30019, 30014, 30258, 30300, 30631, 30603, 30702, 30651, 30783, 31982, 31580, 31138, 31125, 31136, 31267, 31207, 31842, 31771, 31917, 31908, 32470, 32116, 32001, 32354, 32237, 3238
3, 32499, 32875, 34020, 33464, 33254, 33200, 33327, 33342, 33606, 33488, 33586, 33965, 34659, 34193, 34137, 34099, 34174, 34277, 34248, 34369, 34552, 35142, 35003, 34980, 35028, 35174, 35178, 37553, 36
53, 35987, 35511, 35442, 35392, 35332, 35450, 35727, 35514, 35618, 35818, 35929, 36083, 36030, 36325, 36228, 36330, 36817, 36781, 36577, 36520, 36765, 36814, 37402, 37242, 37216, 37377, 37474, 38875
8141, 37948, 37625, 37608, 37690, 38032, 38113, 38507, 38458, 38211, 38747, 38609, 38793, 40053, 39777, 39579, 39476, 38910, 39690, 39975, 39946, 40013, 40216, 40189, 40147, 40191, 40512, 40448, 410
4, 40640, 41170, 45138, 42523, 42108, 41948, 41835, 41763, 41613, 41906, 42048, 41957, 42022, 42104, 42398, 42149, 42122, 42156, 42500, 43866, 43250, 43221, 43017, 43222, 43609, 43507, 43353, 43809, 4
71, 44002, 43931, 44105, 44079, 44652, 44616, 45046, 44886, 46492, 46235, 45564, 45301, 45209, 45359, 45882, 45824, 46223, 46333, 46353, 47719, 46970, 46933, 46896, 46962, 47192, 47136, 47059, 47597
7369, 48012, 47760, 47972, 48214, 48149, 48303, 48255, 56916, 53018, 51692, 50045, 49751, 49165, 48693, 48441, 48864, 49646, 49320, 49652, 49998, 49843, 49773, 50010, 50586, 50311, 50206, 50491, 5144
5, 51423, 50601, 51651, 51592, 52121, 51865, 51694, 52102, 52100, 52542, 52287, 52191, 52424, 52811, 52971, 55668, 55172, 53777, 53125, 53722, 54970, 54432, 54158, 55086, 55416, 55370, 55267, 55248, 55
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El valor mayor es: 99859
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La altura del subarbol derecho: 12
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Resumen personal

Con esta actividad nos ayudo a ver una nueva implementación de un árbol y ver lo interesante que es este tipo de TDA ya que siempre se busca mantener el orden y la forma que tiene un árbol de verdad, a través de operaciones que hacen de gran uso de la recursividad y ver que tan importante puede llegar a ser dentro de la programación.