2016/2017

Programming, Algorithms and Data Structures (210CT)

Coursework

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I can confirm that all work submitted is my own: Yes ■

This coursework is testing your ability to design algorithms, write pseudocode, describe their efficiency, implement various data structures and use the programming language of your choice for the implementation.

Basic in C#:

1. Shuffle

Code:

```
        static int [] shuffle(int[] array)
        {
            Random rand = new Random();               (1 times)
            for (int i = 0; i < array.Length; i++)    (n times)
            {
                int r = rand.Next(0, array.Length);
//random number between [0,tab.Length[
                int temp = array[i];
                array[i] = array[r];
//permutation of some elements randomly
                array[r] = array;
            }
            return array;                             (1 times)
        }
```

Display:

```
        static void Main(string[] args)

        {
            int[] array = {1,2,3,4,5,6,7,8,9};
            shuffle(array);
            for (int i = 0; i < array.Length; i++)
            {
                Console.Write(array[i] + "|");
            }
            Console.ReadLine();
        }
```

2. Number of zeros

Code:

```
       static int Factorielle(int n)                  (n times)
        {
            if (n == 0)
                return 1;
            else
                return n * Factorielle(n - 1);
        }
```

If a number is divisible n times by 5, it has n trailing 0s.

```
        static int zeros(int n)
        {
            int primerFactorOfFive = 0;
            while (n % 5 == 0)                        (n times)
            {                           n % 5 = 0 means n is divisible by 5
                n = n / 5;
                primerFactorOfFive++;
            }
            return primerFactorOfFive;
        }
```

Display:

```
        static void Main(string[] args)
        {
            Console.WriteLine(zeros(Factorielle(10)));        }
```

3. Perfect square

Pseudocode:

```
              PERFECT_SQUARE(n)
                for i <- n Downto 0
                    if(sqrt(i) % 1) = 0
//if sqrt(i)%1=0 => sqrt(i) is a whole number => i is a perfect square
                        return i
                    return -1
//error case: if there is not perfect square less or equal to n
```

Code:

```
        static int perfectSquare(int n)
        {
            for (int i = n; i > 0; i--)
            {
                if (Math.Sqrt(i) % 1 == 0)
                    return i;
            }
            return -1;
        }
```

Display

```
        static void Main(string[] args)
        {
            Console.WriteLine(perfectSquare(30));
            Console.ReadLine();
        }
```

4: Run time with Big O notation (week1)

Basic Task 1: 5n +2 removing constans and multipliers gives O(n).
Basic Task2: 4n +2 removing constans and multipliers gives O(n).

5: Matrix operations

Pseudocode :

```
//Because mat1 and mat2 are two quadratic matrices of the same order
//so we always have
(mat1.GetLength(0)=mat1.GetLength(1)=mat2.GetLength(0)=mat2.GetLength(1))

//we add each elements which are in the same position
            matAddition(mat1,mat2)                    O(n²)
                length <- mat1.GetLength(0)
                mat3 <- [length,length]
                for i <- 0 To length
                    for j <- 0 To length
                        mat3[i,j] <- mat1[i,j] + mat2[i,j]
                return mat3
```

```
//we substract each elements which are in the same position
            matSubtraction(mat1,mat2)                         O(n²)
                length <- mat1.GetLength(0)
                mat3 <- [length,length]
                for i <- 0 To length
                    for j <- 0 To length
                        mat3[i,j] <- mat1[i,j] - mat2[i,j]
                return mat3

//Multiply the rows of mat1 by the colums of mat2
             matMultiplication(mat1,mat2)                           O(n^3)
                 length <- mat1.GetLength(0)
                 mat3 <- [length,length]
                 for i <- 0 To length
                     for j <- 0 To length
                         for k <- 0 To length
                             mat3[i,j] <- mat3[i,j] + (mat1[i,k] * mat2[k,j])
                 return mat3

//we multiply each element of the matrix with a (integer)    O(n²)
             matTimesInt(a,mat1)
                 length <- mat1.GetLength(0)
                 mat3 <- [length,length]
                 for i <- 0 To length
                     for j <- 0 To length
                         mat3[i,j] <- a * mat1[i,j]
                 return mat3
```

Main:

```
static void Main(string[] args)
        {
           int[,] mat1 = { { 1, 2 }, { 3, 4 } }; //B
           int[,] mat2 = { { 4, 5 }, { 6, 7 } }; //C
           int[,] matAdd = matAddition(mat1, mat2); //(B+C)
           int[,] matMul = matMultiplication(mat1, mat2);//(B*C)
           matAdd = matTimesInt(2, matAdd); //2*(B+C)
           int[,] finalMat = matSubtraction(matMul, matAdd);//(B*C)-2*(B+C)
           Console.ReadLine();
        }
```

Finally we just have to display finalMat.

So the run time of the algorithm above is O(n^3).

6: Reverse a string

Pseudocode:

```
          reverseString(sentence)
               wordsArray <- [sentence.Length]
               reversed <- ""
               j <- 0
               for(i <-0 To sentence.Length)
                   if(sentence[i]!=' ')
                       wordsArray [j] <- wordsArray [j] + sentence[i]
                   else j <- j + 1
               for(i <- j Downto 0)
                   reversed <- reversed + wordsArray[i] + " "
               return reversed
```

Code:

```
static string reverseString(string sentence)
        {
            string[] wordsArray = new string[sentence.Length];
            string reversed = "";
            int j = 0;
            for (int i = 0; i < sentence.Length; i++)              (n times)
            {
                if (sentence[i] != ' ')
//Fill each cell of wordsArray with each word of the sentence
                    wordsArray[j] += sentence[i];
                else j++;
            }
            for (int i = j; i >=0; i--)                            (n times)
            {
                reversed+=wordsArray[i] + " ";      //Display of the array upside down
            }
            return reversed;
        }
```

Display (in the main) : `Console.WriteLine(reverseString("This is awesome"));`

Run time: 4 + 6n removing constans and multipliers gives O(n).

7: Prime number ?

Pseudocode:

n is prime if it’s only divisible by 2 and itself

```
prime(n,i)                //i starts at 2
    if(n = i)   //base case: all numbers between 1 and n don’t divide n
        return true
    if(n % i = 0)      //to be prime n must not be divisible by 2,…,n-1
        return false
    return prime(n, i+1)
```

Code:

```
static bool prime(int n, int i)   //i starts at 2
        {
            if (n == i)           //Base case                (n times)
                return true;
            else if (n % i == 0)                             (n times)
                return false;
            return prime(n, i+1);                            (n times)
        }
```

Display (in the main) :

```
Console.WriteLine(prime(11,2)); =>true
```

Run time:

2 + 3n removing constans and multipliers gives O(n).

8: Remove vocals from a sentence/word

Pseudocode:

I check the word letter by letter, if it's a vocal i remove it, if it's not I check the next letter.

```
removeVocals(s,i)   //i is the beginning letter
    if(i>s.Length)      //base case (all the letters have been checked)
         return s
    if(s[i]='a'||'e'||'i'||'o'||'u'||'y')
         remove letter i from s
         return removeVocals(s,i)
    else
         return removeVocals(s,i+1)
```

Code:

```
static string removeVocals(string s,int i)
        {
            if (i >= s.Length)          //Base case
                return s;
            if (s[i] == 'a' || s[i] == 'e' || s[i] == 'i' || s[i] == 'o' || s[i] ==
'u' || s[i] == 'y')
            {
                s = s.Remove(i, 1);      //Remove a letter (index, length)
                return removeVocals(s,i);
            }
            else
            {
                return removeVocals(s,i+1);
            }

        }
```

Display (in the main) :

```
Console.WriteLine(removeVocals("beautiful",0);
```

9: Binary search with an interval

Binary search of a value in tab **A** between values **a** and **b**.

Pseudocode:

```
binarySearch(A, a, b, first, last)
           if(last<first)
               return FALSE
           i = first + (last - first) / 2
           if(A[i] >= a && A[i] <=b)
               return TRUE
           if(a[i] < a)
               return binarySearch(A, a, b, i+1, last)
           else
               return binarySearch(A, a, b, first, i-1)
```

Code:

```
static bool binarySearch(int[] A, int a ,int b, int first, int last)
        {
            if (last < first)
                return false;
            int i = first + (last - first) / 2;
            if (A[i] >= a && A[i]<=b)
                return true;
            if (A[i] < a)
                return binarySearch(A, a, b, i + 1, last);
            else
                return binarySearch(A, a, b, first, i - 1);

        }
```

Display (in the main) :

```
        static void Main(string[] args)
        {
            int[] array = { 1, 2, 3, 8, 10, 15, 21 };
            Console.WriteLine(binarySearch(array, 5, 10, 0, array.Length - 1));
            Console.ReadLine();
        }
```

Result is true because the value 8 is contained is the interval [5,10]

Run time :

It's a binary search so **O(log n)**

10: Longer sub-sequence of ascending numbers

Code :

```
static int[] max_sub_sequence(int[] sequence)
        {
            int curr_length = 0;   //current length of the sub-sequence
            int max_length = 0;  //maximum length of the sub-sequence
            int end = 0;        //end index of the longer sub-sequence
            int curr_end = 0;   //end index of the current sub-sequence
            for (int i = 0; i < sequence.Length - 1; i++)
            {
                if (sequence[i] < sequence[i + 1])
//Couting the length of the current sub-sequence of ascending numbers and saving the
index of the last number
                {
                    temp_end = i + 1;
                    length++;
                }
                if (!(sequence[i] < sequence[i + 1]) || i == sequence.Length - 2)
//I put (if i=sequence.Length-2) in order to save the variables if the last number of
the sub-sequence is also the last number of the sequence.
                {
                    if (length > max_length)
//when the sub-sequence is broken (sequence[i]>sequence[i+1]), I save its length and
the index of its last number if the length is higher than the maximum length stored.
                    {
                        max_length = length;
                        end = temp_end;
                    }
                    length = 0;
//I reinitialize the length at 0 so it cans count the length of the second sub-
sequence...
                }
            }
            int[] sub_sequence = new int[max_length + 1];
//I create an array to store the longer sub-sequence found
            for (int i = 0; i <sub_sequence.Length; i++)
            {
                sub_sequence[i] = sequence[end - max_length + i];
//the first index of the sub-sequence is lastIndex - length.
            }
            for (int i = 0; i < sub_sequence.Length;i++ )
            {
                Console.Write(sub_sequence[i] + "|");
//I display the sub-sequence before return it back.
            }
                return sub_sequence;
        }
```

Main :

```
        static void Main(string[] args)
        {
            int[] sequence = {1,2,3,1,2,3,4,5,1};
            max_sub_sequence(sequence);
            Console.ReadLine();
        }
```

11: Node delete function from a double linked list in C++

```
class Node
{
public:
	int value; //Any type
	Node* next;
	Node* prev;
	Node(int val){
		std::cout << "Node constructor!" << std::endl;
		this->value = val;
		this->next = (Node*)0;
		this->prev = (Node*)0;
	}
	~Node(){
		std::cout << "Node destructor" << std::endl;
		std::cout << "I had the value " << this->value << std::endl;
	}
};

class List
{
public:
	Node* head;
	Node* tail;

	List(){
		std::cout << "List Constructor!" << std::endl;
		this->head = 0;
		this->tail = 0;
	}
	~List(){ //Destruction of each node
		std::cout << "List destructor!" << std::endl;
		Node* temp;
		while (head != 0) {
			temp = head->next;
			delete head;
			head = temp;
		}
		std::cout << "List destructed!" << std::endl;

	}
```

```
    bool remove(Node* n) { //remove a node in consideration of its position
        if (n != 0 && this->head != n && this->tail != n) {
            std::cout << "Remove node" << std::endl;
            n->next->prev = n->prev;
            n->prev->next = n->next;
            return true;
        }
        if (this->head == n) {
            std::cout << "Remove head" << std::endl;
            this->head = n->next;
            n->next->prev = 0;
            return true;
        }
        else if (this->tail == n) {
            std::cout << "Remove tail" << std::endl;
            this->tail = n->prev;
            n->prev->next = 0;
            return true;
        }
        return false; }
```

12: In order traversal of Binary Search Tree in C++

```
void in_order_iterative(BinTreeNode* tree){
    stack<BinTreeNode*> S;
    BinTreeNode* current = tree;
    S.push(current);
    current = current->left;
    while (!S.empty() || current != NULL){
//!=NULL is to go right when the root has been popped and the list is empty
        if (current != NULL) {
            S.push(current);
            current = current->left;
        }
        if (current == NULL){
            BinTreeNode* popped=S.top();
            S.pop();
            std::cout << popped->value << std::endl;
            current = popped->right;
        }
    }
}
```

13: Unweighted graph data structure

Pseudocode:

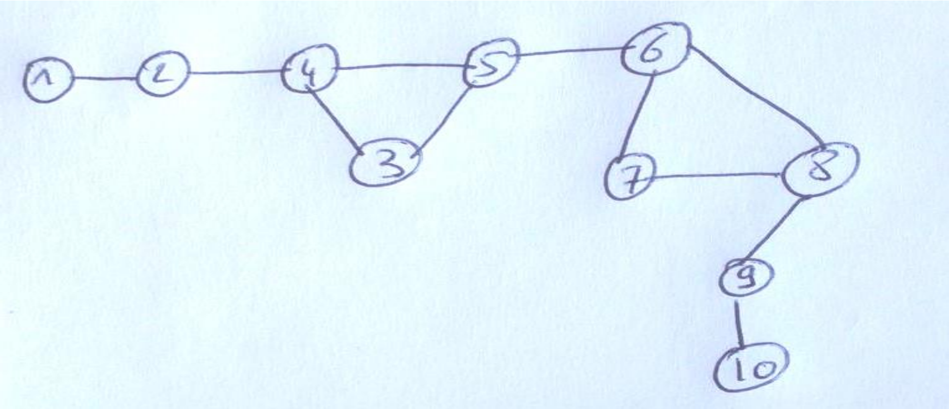
```
// I chose the adjacency list approach so I created a new class Vertex (Node) with a
label and a list of vertices representing the edges and a class Graph containing a
list of vertices.

       class Vertex
            label <- 0
            edges <- []

         addEdge(node)
            if(node!=null)
                egdes.Add.node
                return TRUE
            return FALSE
```

```
class Graph
     vertices <- []

  addNode(v)
     if(v!=null)
         vertices.Add(v)
         return TRUE
     return FALSE

Main:

one <- new Vertex
two <- new Vertex
one.label <- 1
two.label <- 2
one.addEdge(two)
two.addEdge(one)
myGraph <- new Graph
myGraph.addNode(one)
myGraph.addNode(two)
```

Code :

```
class Vertex
    {
        public int label;
        public List<Vertex> edges = new List<Vertex>();

        public Vertex()
        {
        }

        public Vertex(int data)//Constructor to Create/Add a new node
        {
            this.label = data;
        }

        //Function to add an edge, I add the node in the adjacency list of both nodes
with the other one
        public bool addEdge(Vertex node)
        {
            if (node != null)
            {
                edges.Add(node);
                return true;
            }
            return false;
         }
    }


    class Graph
    {
        public List<Vertex> vertices = new List<Vertex>();

        public Graph()
        {
        }
        //To add a node a simply add it the list of nodes
        public bool addNode(Vertex v)
        {
            if (v != null)
            {
                this.vertices.Add(v);
                return true;
            }
            return false;
        }
        //To add several nodes in one time using an array of vertices
        public void addNodes(Vertex[] v)
        {
            for (int i = 0; i < v.Length; i++)
            {
                addNode(v[i]);
            }
        }
    }

static void Main(string[] args)
        {
            Vertex one=new Vertex(1); //I create 10 nodes
            Vertex two = new Vertex(2);
            Vertex three = new Vertex(3);
            Vertex four = new Vertex(4);
            Vertex five = new Vertex(5);
            Vertex six = new Vertex(6);
            Vertex seven = new Vertex(7);
            Vertex eight = new Vertex(8);
            Vertex nine = new Vertex(9);

            one.addEdge(two); //Node 1 is linked to Node 2

            two.addEdge(one); //Node 2 is linked to Node 1 and four ...
            two.addEdge(four);

            four.addEdge(two);
            four.addEdge(three);
            four.addEdge(five);

            three.addEdge(four);
            three.addEdge(five);

            five.addEdge(three);
            five.addEdge(four);
            five.addEdge(six);

            six.addEdge(five);
            six.addEdge(seven);
            six.addEdge(eight);

            seven.addEdge(six);
            seven.addEdge(eight);

            eight.addEdge(six);
            eight.addEdge(seven);
            eight.addEdge(nine);

            nine.addEdge(eight);

            Graph myGraph = new Graph();
            Vertex[] v = { one, two, three, four, five, six, seven, eight, nine}; //I
add all the nodes to the graph
            myGraph.addNodes(v);

            Vertex ten = new Vertex(10);

            nine.addEdge(ten); //I create a new node and link it with node 9 by adding
it in the edges list of node 9 and I don't forget to add node 10 to the egdes list of
node 9
            ten.addEdge(nine);
            myGraph.addNode(ten); //I add it to the graph
        }
```

MyGraph :



14: BFS and DFS traversals

```
static List<Vertex> DFS(Graph G, Vertex v)
        {
            Console.WriteLine("DFS traversal");
            Stack<Vertex> S = new Stack<Vertex>();
            List<Vertex> visited = new List<Vertex>();
            S.Push(v);
            while (S.Count != 0)
            {
                 Vertex u = S.Pop();
                 if(!visited.Contains(u))
                 {
                    visited.Add(u);
                    foreach (Vertex e in u.edges)
                        S.Push(e);
                }
            }
            saveToText(visited,"DFS");
            return visited;
        }

static List<Vertex> BFS(Graph G, Vertex v)
        {
            Console.WriteLine("BFS traversal");
            Queue<Vertex> Q = new Queue<Vertex>();
            List<Vertex> visited = new List<Vertex>();
            Q.Enqueue(v);
            while (Q.Count != 0)
            {
                Vertex u = Q.Dequeue();
                if (!visited.Contains(u))
                {
                    visited.Add(u);
                    foreach (Vertex e in u.edges)
                        Q.Enqueue(e);
                }
            }
            saveToText(visited,"BFS");
            return visited;
        }

static void displayList(List<Vertex> l)
        {
            foreach (Vertex v in l)
                Console.WriteLine(v.label);
        }

static void saveToText(List<Vertex> vs,string fileName)
//Function to save a List of vertices in a text file
        {
            string path = @"c:\Users\Alain\Downloads\"+fileName+".txt";
//location of the file
            List<int> values = new List<int>(); //I create an list of integers and
fill it with the label of each vertex in the list of vertices
            foreach(Vertex v in vs)
            {
                values.Add(v.label);
            }
            //The File.WriteAllLines C# function needs a string array in parameter so
I convert my list of integers in a string array
            string [] array = values.Select(x => x.ToString()).ToArray();
            // This text is added only once to the file.
            if (!File.Exists(path))
            {
                // Create a file to write to.
                File.WriteAllLines(path, array);
            }
        }

static void Main(string[] args)
       {
            displayList(DFS(myGraph, one));
//Display myGraph by a DFS beginning with node one
            displayList(BFS(myGraph, one));
//Display myGraph by a DFS beginning with node one
       }
```

DFS: 1-2-4-5-6-8-9-10-7-3

BFS: 1-2-4-3-5-6-7-8-9-10

14: Dijkstra’s algorithm for a weighted graph

Not done… ☹