Laboratory practice No. 2: Big O Notation

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1) CODE FOF ARRAYSUM, ARRAYMAX, INSERTIONSORT, MERGESORT WITH RANDOM ARRAYS

The `.java` file can be found in the "codigo" folder.

2) ONLINE EXERCISES (CODINGBAT)

2.a. Array II

i.

```
public int[] zeroFront(int[] nums) {              // c0
    boolean [] used = new boolean [nums.length]; // c1
    int cont = 0;                                 // c2
    for (int i = 0; i < nums.length; i++) {       // c3*n
      if(nums[i] == 0) {                          // c4*n
        if (i != cont) {                          // c5*n
          nums[i] = nums[cont];                   // c6+n
          nums[cont] = 0;                         // c7*n
        }
        cont++;                                   // c8*n
      }
    }
    return nums;                                  // c9
  }
```

Therefore, `zeroFront` is $O(c_0 + c_1 + c_2 + c_9 + (c_3 + c_4 + c_5 + c_6 + c_7 + c_8)n)$. Applying the sum and product properties, `zeroFont` is $O(n)$.

ii.

```
public int[] notAlone(int[] nums, int val) {      // c0
    for(int i = 1; i < nums.length-1; i++) {      // c1*n
      if(nums[i] == val && nums[i-1] != val
```

```
            && nums[i+1] != val) {                    // c2*n
            if (nums[i-1] > nums[i+1])                // c3*n
              nums[i] = nums[i-1];                    // c4*n
            else                                      // c5*n
              nums[i] = nums[i+1];                    // c6*n
          }
        }
        return nums;                                  // c7
      }
```

Therefore, `notAlone` is $O(c_0 + c_7 + (c_1 + c_2 + c_3 + c_4 + c_5 + c_6)n)$. Applying the sum and product properties, `notAlone` is $O(n)$.

iii.

```
public boolean tripleUp(int[] nums) {             // c0
  for (int i = 0; i < nums.length - 2; i++) {     // c1*(n-2)
    if(nums[i] + 1 == nums[i+1] && nums[i]
     + 2 == nums[i+2]) return true;               // c2*(n-2)
  }
  return false;                                   // c3
}
```

`tripleUp` is $O(c_0 + c_3 + (c_1 + c_2)(n-2))$. When we apply the product and sum properties, `tripleUp` is $O(n)$.

iv.

```
public int[] tenRun(int[] nums) {                 // c0
  int tempMult = 0;                               // c1
  boolean used = false;                           // c2
  for(int i = 0; i < nums.length; i++) {          // c3*n
    if (nums[i] % 10 == 0) {                      // c4*n
      used = true;                                // c5*n
      tempMult = nums[i];                         // c6*n
    }
    if(used)                                      // c7*n
      nums[i] = tempMult;                         // c8*n
  }
  return nums;                                    // c9
}
```

`tenRun` is $O(c_0 + c_1 + c_2 + c_9 + (c_3 + c_4 + c_5 + c_6 + c_7 + c_8)n)$. When we apply the product and sum properties of the $big - O$ notation, yields that `tenRun` is $O(n)$.

v.

```
public int[] shiftLeft(int[] nums) {              // c0
  int [] mod = new int[nums.length];              // c1
  if (nums.length==1) return nums;                // c2
  for (int i=1; i<nums.length; i++) {             // c3*n
```

```
      mod[nums.length-1]=nums[0];                    // c4*n
      mod[i-1]=nums[i];                              // c5*n
    }
    return mod;                                      // c6
  }
```

`shiftleft` is $O(c_0+c_1+c_2+c_6+(c_3+c_4+c_5)n)$, which implies that `shiftLeft` is $O(n)$.

2.b. Array III

i.

```
  public int[] seriesUp(int n) {                     // c0
    int no = n*(n+1)/2;                              // c2
    int [] nums = new int [no];                      // c3
    int a = 0;                                       // c4
    for (int i = 1; i <= n; i++) {                   // c5*n
      for (int j = 1; j <= i; j++) {                 // c6*n*n
        nums[a] = j;                                 // c7*n*n
        a++;                                         // c8*n*n
      }
    }
    return nums;                                     // c9
  }
```

`seriesUp` is $O(c_0+c_1+c_2+c_3+c_4+c_9+c_5n+(c_6+c_7+c_8)n^2)$, then `seriesUp` is $O(n^2)$.

ii.

```
  public int countClumps(int[] nums) {               // c0
    int c = 0;                                       // c1
    for (int i = 0; i < nums.length-1; i++) {        // c2*n
      if (nums[i] == nums[i+1]) {                    // c3*n
        for (int j = i; j < nums.length; j++) {      // c4*n*n
          if (nums[j] != nums[i]) {                  // c5*n*n
            i = j;                                   // c6*n*n
            c++;                                     // c7*n*n
          }
          if (c == 0 && j == nums.length-1) {        // c8*n*n
            c++;                                     // c9*n*n
          }
        }
      }
    }
    return c;                                        // c10
  }
```

`countClumps` is $O(c_0+c_1+c_10+(c2+c_3)n+(c_4+c_5+c_6+c_7+c_8+c_9)n^2)$, then `countClumps` is $O(n^2)$.

iii.

```
public boolean linearIn(int[] outer,
  int[] inner) {                                    // c1
  int j = 0;                                        // c2
  int c = 0;                                        // c3
  if (inner.length == 0) return true;               // c4
  for (int i = 0; i < outer.length; i++) {          // c5*n
    if (inner[j] == outer[i]) {                     // c6*n
      j++;                                          // c7*n
      if (j==inner.length) {                        // c8*n
        return true;                                // c9*n
      }
    }
  }
  return false;                                     // c10
}
```

`linearIn` is $O(c_1+c_2+c_3+c_4+c_10+(c_5+c_6+c_7+c_8+c_9)n)$, this implies that `linearIn` is $O(n)$.

iv.

```
public int[] fix45(int[] nums) {                    // c1
  boolean [] arr = new boolean[nums.length];        // c2
  for (int i = 0; i < nums.length-1; i++) {         // c3*n
    if (nums[i] == 4 && nums[i+1] == 5) {           // c4*n
      arr[i+1] = true;                              // c5*n
    } else  if (nums[i] == 4 && nums[i+1] != 5) {   // c6*n
      for (int j = 0; j < nums.length; j++) {       // c7*n*n
        if (nums[j] == 5 && arr[j] == false) {      // c8*n*n
          nums[j] = nums[i+1];                      // c9*n*n
          nums[i+1] = 5;                            // c10*n*n
          arr[i+1] = true;                          // c11*n*n
          break;                                    // c12*n*n
        }
      }
    }
  }
  return nums;                                      // c13
}
```

`fix45` is $O(c_1+c_2+c_13+(c_3+c_4+c_5+c_6)n+(c_7+c_8+c_9+c_10+c_11+c_12)n^2)$, this implies that `fix45` is $O(n^2)$.

v.

```
public boolean canBalance(int[] nums) {             // c0
  int sumRight;                                     // c1
```

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```
    int sumLeft;                                          // c2
    for (int i = 1; i < nums.length; i++) {               // c3*n
      sumLeft = 0;                                        // c4*n
      sumRight = 0;                                       // c5*n
      for (int j = 0; j < i; j++) {                       // c6*n*n
        sumLeft += nums[j];                               // c7*n*n
      }
      for (int j = i; j < nums.length; j++) {             // c8*n*n
        sumRight += nums[j];                              // c9*n*n
      }
      if (sumRight == sumLeft) {                          // c10*n
        return true;                                      // c11*n
      }
    }
    return false;                                         // c12
  }
```

`canBalance` is $O(c_0 + c_1 + c_2 + (c_3 + c_4 + c_5 + c_10 + c_11)n + (c_6 + c_7 + c_8 + c_9)n^2)$, therefore `canBalance` is $O(n^2)$.

3) SIMULATION OF PROJECT PRESENTATION QUESTIONS

3.a. Time for algorithms

Input/Time(ns)	10	100	1000	100000
ArrayMax	5000	25000	450000	6250000
ArraySum	6000	22000	348000	6410000
MergeSort	31000	291000	3734000	45673000
InsertionSort	10000	445000	47573000	4655923000

Table 1: My caption

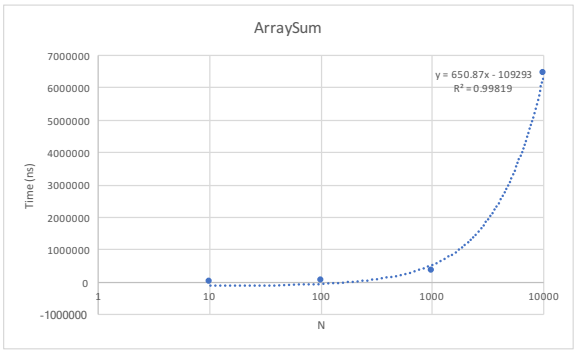
3.b. Plots for execution time

3.c.

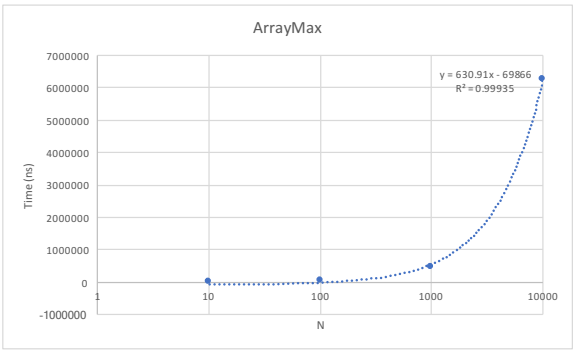
As we see in the graphics and the values, insertion sort has a asymptotical complexity of n^2. In this manner, we can see that if we use insertion sort for big numbers it will take a enourmous amount of time, so it will not be efficient in any shape or form.

3.d. How does `maxSpan` work?

```
def maxSpan(array):
        arr = []
```

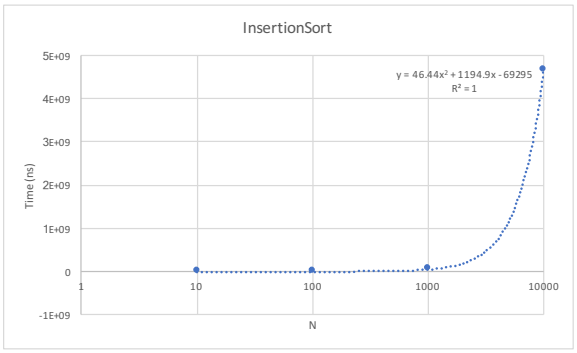


(a) Time vs N for ArraySum

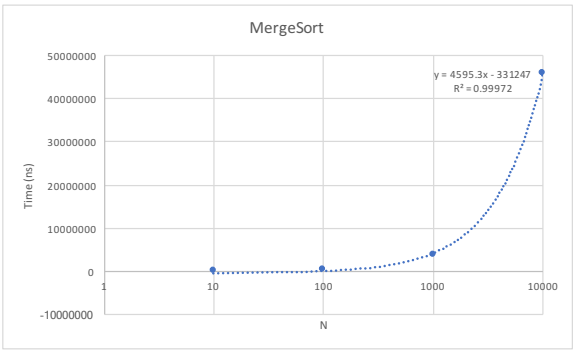


(b) Time vs N for ArrayMax

Figure 1: Array algorithms



(a) Time vs N for InsertionSort



(b) Time vs N for MergeSort

Figure 2: Sort algorithms

```
max = 0
for i in range(len(array)):
        for j in range(i,len(array)):
                if array[i] == array[j]:
                        c = j-i+1
        arr.append(c)
for i in range(len(arr)):
        if arr[i] > max:
                max = arr[i]
return max
```

It works fairly easy. First for every data in the array of integers it moves through the same array to the same index through the end of the array searching for the number again. If it finds it again it sets the variable "c" to the numbers it has between them; it does this until the array ends. Then, it searches the array to find the biggest span and returns that number.

4) EXAM SIMULATION

i. c) $O(n + m)$

ii. d) $O(n * m)$

iii. b) $O(ancho)$

iv. b) $O(n^3)$

v. d) $O(n^2)$

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References

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