Data_structure_note

Thursday, May 30, 2024 2:42 PM

1. **Data Structure** => is a way of organizing data different ways of storing data on your computer
EX: is like preparing for cooking you slice up vegetables

2. Algorithm => the process that does something to data to produce the output operations on different data structure
data structure + algorithm = programming

Steps to learn:
- a.. Big O notation => is the language of analyzing algorithms and data structures.
- b. Data structures list:
  - 1.Arrays
  - 2. Linked Lists
  - 3.Queues and Stacks
  - 4. Trees
  - 5. Graphs
  - 6. Hash Maps
  - 7. pointers
  - 8. Memory => 1 byte = 8 bits
- c. Algorithms:
  - 1. recursion
  - 2. sorting algorithms
  - 3. Graph search algorithms
  - 4. Dynamic programming
  - 5. common problem solving patterns

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3. Memory (RAM) vs. Storage
After turning off the computer, Storage is permanent, and memory will disappear.

int a =1; => 32 bits for int
4 bytes = 32 bits = 1 integer

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4. classes and objects

```
//class
class Robot {
    string name;
    string color;
    int weight;
//constructors
    Robot(String n, String c, int w){
        this.name = n;
        this.color = c;
        this.weight = w;
    }
//function
    void introduceSelf(){
        system.out.println("My name is " + this.name);
```

```
    }
}
```

```
//to use contructors and functions
Robot r1 = new robot("Leo", "Red", "37");
r1.introduceSelf();
```

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5. Linked List

6 -> 3 -> 4 -> 2 -> 1 -> null

```
class Node{
    int data;
    Node next;
    Node prev;
    //contructor
    Node(int data){
        this.data = data;
    }
}

Node head = new Node(6);
Node nodeB = new Node(3);
Node nodec = new Node(4);
...

head.next = nodeB
nodeB.next = nodeC
...

//count how many nodes we have
int countNodes(Node head){
    //assuming head != null
    int count = 1;
    Node current = head;
    while(current.next != null){
    current = current.next;
    count += 1;
    }
}
```

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6. Recursion

//factorial

n! = n. (n-1)!   if n >= 1

   1   otherwise (if n = 0)

Ex: 4! = 4 x 3 x 2 x 1 = 24

```
int fact(int n){
    //assume that n is a positive integer or 0
    if (n >= 1) {
        return n * fact(n-1);
```

```
    } else {
        return 1;
    }
}
```

// Fibonacci sequence
Ex: 1, 1, 2, 3, 5, 8

```
int fib(int n){
  if (n  >= 3){
        return fib(n-1) * fib(n-2);
   } else {
      return 1;
}
```

google interview problem
Recursive staircase problem
num_way(N) = num_ways(N-1) + num_ways(N-2)
num_way(0) = 1
num_way(1) = 1

//python
//this wont work if n =2

```
def num_ways(n):
    if n == 0 or n == 1:
        return 1
    else:
        return num_ways(n-1) + num_ways(n-2)
```

//fixed

```
def num_ways_bottom_up(n):
   if n == 0 or n == 1:
      return 1
   nums = [0] * (n + 1)
   nums[0] = 1
   nums[1] = 1
   for i in range(2, n + 1):
      nums[i] = nums[i - 1] + nums[i - 2]
   return nums[n]

# Example usage
total_feet = 11
print(f"Number of ways to jump {total_feet} feet: {num_ways_bottom_up(total_feet)}")
```

//variation problems
X = {1,3,5}

```
def num_ways_X(n):
    if n == 0
        return 1
    total = 0;
    for each i in {1,3,5}:
```

```
            if n -i >= 0:
                total += num_ways_X(n-i)
        return total
```

//fixed

```
def num_ways_bottom_up_X(n):
    if n == 0:
        return 1
    nums = [0] * (n + 1)
    nums[0] = 1
    for i in range(1, n + 1):
        total = 0
        for j in {1, 3, 5}:
            if i - j >= 0:
                total += nums[i - j]
        nums[i] = total
    return nums[n]
```

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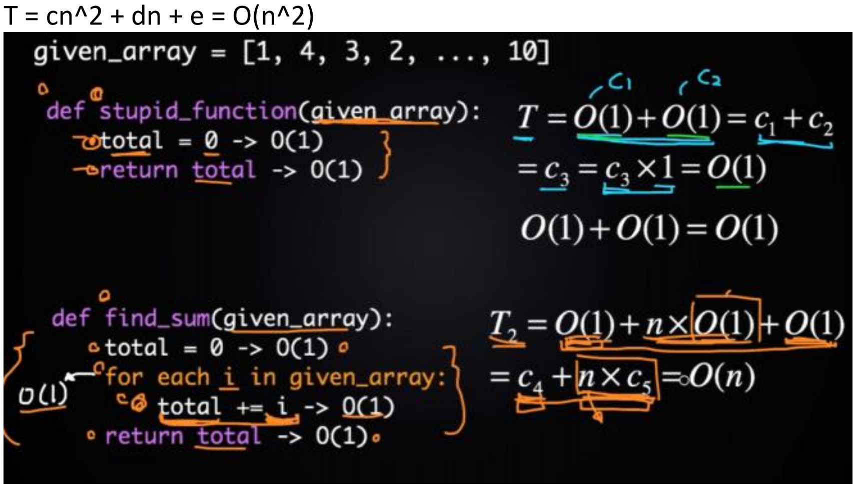
7. Big O notation

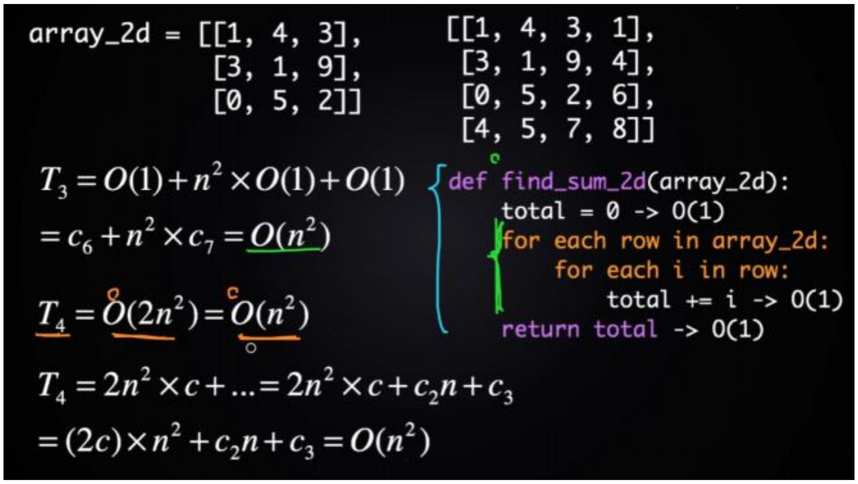
a. runtime = time to takes to execute a piece of code

linear time = O(n)
constant time = O(1)
quadratic time = O(n^2)

1. find the fastest growing term
2. take out the coefficient

T = an + b = O(n)
T = cn^2 + dn + e = O(n^2)





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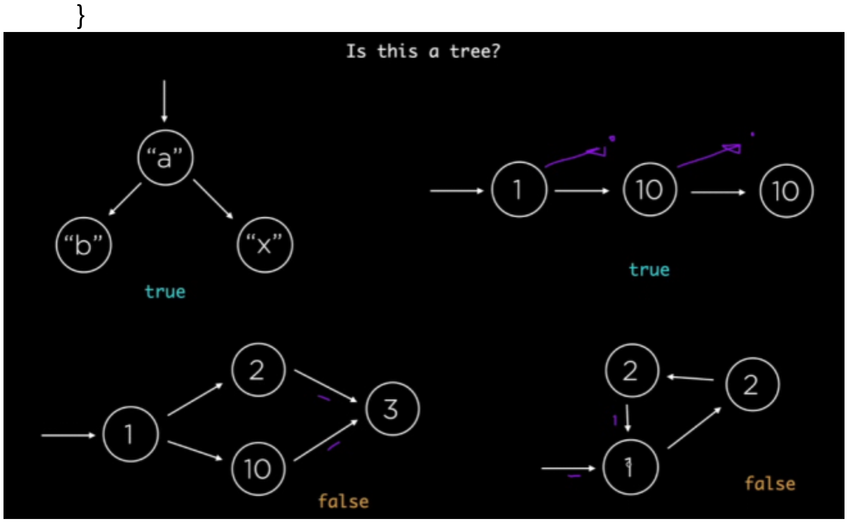
8. **Tree** =>

Class Node{
    Int data
    Node left
    Node right
}



Binary Tree =>
is a data structure in which each node has at most two children, referred to as the left child and the right child.

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9. **Sorting**

   a. **Linear search = O(n) = O(n/2) =** It works by checking each element in the list, one by one, until the desired element is found or the end of the list is reached

```
def linear_search(arr, target):
    for i in range(len(arr)):
        if arr[i] == target:
            return i  # Return the index of the target element
    return -1  # Return -1 if the target is not found

# Example usage
arr = [34, 17, 23, 35, 45, 9, 1]
```

```python
    target = 23
    result = linear_search(arr, target)

    if result != -1:
        print(f"Element found at index {result}")
    else:
print("Element not found")
```

a. **Binary search:**
   Arr[-50 ~ 50]
   Target = 20

   40 -> 20 -> 10 -> … -> 1

   N -> $\frac{n}{2} \to \frac{n}{4} \to \frac{n}{8} \to \cdots \to 1$

   $n \to \frac{n}{2} \to \frac{n}{2^2} \to \frac{n}{2^3} \to \cdots \to \frac{n}{2^x} \approx 1$

   $\frac{n}{2^x} \approx 1 \Rightarrow n = 2^x \Rightarrow log_2(n) = x = \boldsymbol{O}(\mathbf{log}(\boldsymbol{n}))$

```python
def search(arr, target):
    left = 0
    right = len(arr) - 1
    while left <= right:
        mid = (left + right) // 2 # make sure to round it down
        if arr[mid] == target:
            return mid
        elif target < arr[mid]:
            right = mid - 1
        else:
            left = mid + 1
    return -1
arr1 = [-2, 3, 4, 7, 8, 9, 11, 13]
assert search(arr1, 11) == 6
assert search(arr1, 13) == 7
assert search(arr1, -2) == 0
assert search(arr1, 8) == 4
assert search(arr1, 6) == -1
assert search(arr1, 14) == -1
assert search(arr1, -4) == -1
arr2 = [3]
assert search(arr2, 6) == -1
assert search(arr2, 2) == -1
assert search(arr2, 3) == 0
print("If you didn't get an assertion error, this program has run 
successfully.")
```

1. Quicksort is typically the fastest for large datasets due to its low overhead and excellent average-case performance.

2. Mergesort is a good choice when stability is required and for data that doesn't fit in memory (external sorting).

3. Heapsort provides reliable O(nlogn) performance with in-place sorting but is generally

outperformed by quicksort and mergesort.

4. Timsort is highly efficient for real-world data and is used in many standard libraries due to its adaptive nature and stability.