思睿教育
SAVVYUNI

FALL 2020

Data Structure

CS 240

Week 1

豌豆射手

思睿教育集团荣誉出品

SavvyUni CS 240 FAQ by 豌豆射手

关于我?

- UW 4A CS AI Option 在读
- 连续三个学期没学期上（等效）7 门课
- CS 341 Algorithm: 99
- 上个 Coop Term 在一家保险公司担任 Full Stack Developer

为什么要上 CS 240 ?

- 为了学习更多解决问题的方法
- 为了面试
- 为了毕业

来参加这节课的目的是什么?

- 为了分!
- 学知识!
- 用尽可能少的时间拿尽可能高的分!
- 用尽可能少的时间拿尽可能高的分的同时还把知识学会!

CS 240 Overview

Data Structures and Data Management

Course Description

Introduction to widely used and effective methods of data organization, focusing on data structures, their algorithms, and the performance of these algorithms.

Prerequisite：CS 245, CS 246, Stat 230

- CS 136: Tree, Stack, Queue, Dictionary, Sorting, and Big-O Notation
- CS 245: Loop Invariant (并不会直接用到，但是会帮助你理解)
- CS 246: 用 C++ 写代码
- Math 137: Limit, l'Hôpital（洛必达）
- Stat 230: Probability, Expectation, and Binomial Distribution

Topic

- Asymptotic Analysis (Formal Definition of Big-O Notation)

除了 Asymptotic Analysis, 其他章节相互独立

Data Structure (Extended from CS 136)

Queue	→	Priority Queue and Heap
Sorting	→	Selection, Radix Sort, and Interpolation Search
BST	→	AVL-Tree and B-Tree
Dictionary(map)	→	Tries, Skip Lists, Ordering, and Hashing

Algorithm

- Range Search
- String Matching
- Data Compression

Marks Breakdown

Written Assignment	40%	
Programming	5%	
Mini Test	20%	
Midterm Assessment	10%	Oct 26 - Oct 27
Final Assessment	25%	TBD

Terminology

Problem Desired _______/ _________ relationship

- Example: Sorting Problem 排序问题
- Input: A sequence of __________________________________
- Output: A reordering ____

Instance of a Problem An ______ satisfy all __________

Solution of a Problem ______ for specified __________

Size of an instance A ________________ that measure of the size of the instance

- Example:
- For sorting problem, the size is defined to be the _____ of the input array
- For some numerical computation(Fibonacci Number), the size is defined to be ________________

Algorithm A ___________ of _________________ that transform _____ to ______

Correctness An algorithm is said to be correct if for ____________, it halts correct output.

- An incorrect algorithm may ___________ on some input, or
- halt with ________ output

Program An ____________ of an algorithm using a special programming language

Data Structure A way to _______ and _________ data

- No single Data Structure is ________
- It is important to know their ________ and _________

Pseudocode An method of __________________ an _________ to ____________

Pseudocode

Use most clear and concise to specify an algorithm

- Sometime ______________ Clear
- Sometime ______________ Clear
- Avoid __________________ Concise
- Avoid __________________ Concise

伪代码是给人看的，所以每个人写的伪代码可能不太一样，会有自己的特点

Some Conventions

while, if-else has the same meaning in C, C++

for has different meaning in C, C++. It is flexible, for example

- for i = 0 to n - 1: print(i)
- for x in A. (Similar to for (auto x: vector))

Indentation indicates block structure

// 你看不见这一行，因为 // 后面跟的是注释

Array indexing is similar in C, C++

-
-

Variable refers array or object are passed by reference

- If an variable refer to ________, we give it special value ____________

其他习惯问题

- 有的人用← 当 assignment，本讲义里用 =
- 有的人用 = 做 equality testing，本讲义里用 ==

Example: Binary Searh in Array

Iterative version Binary Search in C Language

```
int binary_search(const int arr[], int start, int end,
                  int key) {
    int ret = -1;
    int mid;
    while (start <= end) {
        mid = (start + end) / 2;
        if (arr[mid] < key) {
            start = mid + 1;
        } else if (arr[mid] > key) {
            end = mid - 1;
        } else {
            ret = mid;
            break;
        }
    }
    return ret
}
```

Iterative version Binary Search Pseudocode

```
BinarySearch(A, start, end, key)
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
```

Analyze an algorithm

In CS 240, Analyze an algorithm means

- Analyze the _______________ of given algorithm
- Analyze the _______________ of given algorithm

Step to Analyze Running time of Algorithm

1. Express algorithm in ___________
2. Identify __________________ in pseudocode
3. Express running time as a ___________ that _______ primitive operations where ___ is the input size.
4. Determine _____________ of ____ with ___________________

Example of Primitive Operations

Arithemetic

- Addition
- Subtraction
- Multiplication
- Division
- Remainder
- Floor
- Ceiling

Assignment

Control Flow

- If-else
- For, while
- Function Call
- Return

Array Indexing

Example:

Category A - For loop (Easy)

```
Sum(A)
A:array of size n
i = 0
acc = 0
for i = 0 to n - 1
    acc += A[i]
return acc
```

Category B: Recursion (Easy)

```
BinarySearch(A, start, end, key)
if (start > end)
    return "Did not found"
mid = (start + end) / 2
if (A[mid] > key)
    return BinarySearch(A, start, mid - 1, key)
else if (Arr[mid] < key)
    return BinarySearch(arr, mid + 1, end, key)
else:
    return mid
```

Category C: While - loop (Hard)

```
BinarySearch(A, start, end, key)
while (start < end)
    mid = (start + end) / 2
    if (A[mid] > key)
        start = mid + 1
    else if (A[mid] < key)
        end = mid - 1
    else
        return mid
return "Did not found"
```

Exercise

For loop 1

```
m = 0
for i = 1 to 3n
    m = m * 4
    for j = 1025 to 2048
        for k = 4i + 1 to 6i
            m = m + 4 * k
```

For loop 2 (give an upper bound)

```
x = 0
for i = 1 to floor(log n))
    for j = 1 to 2^i
        x = x + i * j
```

Exercise

while loop 1

```
i = 0
j = 0
k = 1
while(2*j + k ≤ n)
    i = i + 1
    j = j + i
    k = k + 1
```

iter	t	i	j	k	2j+k

Nested loop (give an upper bound)

```
x = 0
for i = 1 to n
    j = i
    while (i > 0)
        i = i / 2
```

Asymptotic Notation

Big-O Notation

Meaning

- O(g(n)) is a ___
- It is a set of function whose growth rate is _____ or _____ than g
- If __________, we say ___ is an _______________________ of ___

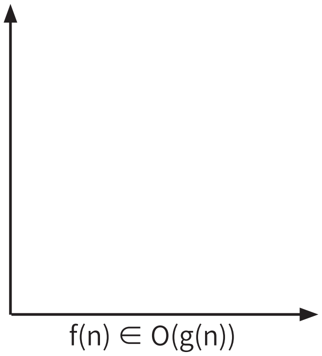
当输入规模无限增加时，算法的运行时间如何随着输入规模的变大而增加?

Formal Definition __________if ____________ constants _____ and _____ such that ______________ for all ________

有时候我们也会用 f(n) = O(g(n)) 代替 f(n) ∈ O(g(n)) 来方便递归计算

Example

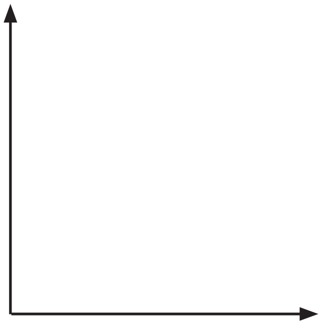
Proof ________________ from first principle



Definition 有时也叫 First Principle

Proof ________________ from first principle

Proof ________________ from first principle



f(n) ∈ Ω(g(n))

Big-Ω Notation

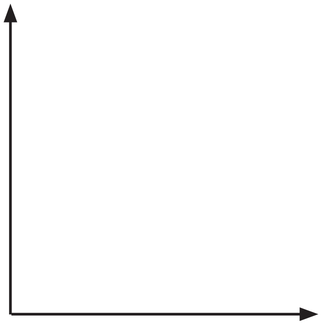
Meaning

- Ω(g(n)) is a set of function whose growth rate is _____ or _____ than g
- If __________, we say ___ is an _____________________ of ___

Formal Definition _________if ___________ constants _____ and _____ such that ___________ for all _______

Example

Proof _________________ from first principle



f(n) ∈ Θ(g(n))

Big-Θ Notation

Meaning

- Θ(g(n)) is a set of function whose growth rate is _____ to g
- If __________, we say ___ is an _____________________ of ___

Formal Definition _________if ___________ constants _____ and _____ such that __________________ for all _______.

Example

Proof _________________ from first principle

Example

Proof ________________ from first principle

Proof ________________ from first principle

Example

Proof ________________ from first principle

Proof ________________ from first principle

Summary

- Basic Concept about Data Structure & Algorithm
- Pseudocode
- How to analyze an algorithm
- Asymptotic Notation (O, Ω, Θ)

Three level in Mastering CS 240

- Known basic concept and able to directly apply algorithm.
- Find property of DS/Algortihm with given input, or find specific input that satisfy some requirement.
- Analyze variation of DS/Algorithm and design new DS/Algorithm.

思睿教育
滑铁卢校区

小助手微信

微信公众号

课程服务咨询电话

+1(647)926-9109
+1(226)978-6660

有爱有科技
有你有未来