

CS10 The Beauty and Joy of Computing

Lecture #11 : Recursion II

UC Berkeley EECS Lecturer SOE Dan Garcia

2011-03-02

Hello to **Yue Li**, CS Associate Prof, Nat. U of Defense Technology, Hunan, **CHINA**

IPAD 2 ANNOUNCED TODAY

Will Apple continue to thrall its users with outstanding technology amidst tons of competition from its Android Rivals? Will Steve Jobs make an appearance? Will you buy one?



How the Computer Works ... n!

- Factorial(n) = n!
 Inductive definition:
 - □ **n! = 1** , **n** = **0**
 - □ **n! = n * (n-1)!**, **n > 0**

• Let's act it out...

"Little people", or
 "subcontractor" model

n!

	U

0	1
1	1
2	2
3	6
4	24
5	120





UC Berkeley CS10 "The Beauty and Joy of Computing" : Recursion II (2)



en.wikipedia.org/wiki/Fibonacci number www.ics.uci.edu/~eppstein/161/960109.html How the Computer Works ... fib(n) **Inductive definition:** $\begin{array}{c|c} \mathbf{n} & \mathbf{fib}(n) = \mathbf{n} \\ \mathbf{n} & \mathbf{fib}(n) = \mathbf{fib}(n-1) + \mathbf{fib}(n-2), \mathbf{n} > 1 \end{array} \qquad F(n) \coloneqq \begin{cases} 0 & \text{if } n = 0; \\ 1 & \text{if } n = 1; \\ F(n-1) + F(n-2) & \text{if } n > 1. \end{cases}$ Let's act it out... "contractor" model fibîn □ fib(5) n) < 2 FF report (else fib(n) n 问 fib (n - 1) + fib (n 0 0 report 1 1 2 1 3 2 3 4 Let's now: trace... (gif from Leonardo de Pisa 5 5 Ybungalobill@wikimedia) Garcia, Spring 2011 aka, Fibonacci UC Berkeley CS10 "The Beauty and Joy of Computing" ; Recursion II (3)

Order of growth of # of calls of fib(n)

- a) Constant
- b) Logarithmic
- c) Linear
- d) Quadratic
- e) Exponential

Chimney of Turku Energia, Turku, Finland featuring Fibonacci sequence in 2m high neon lights. By Italian artist <u>Mario Merz</u> for an environmental art project.







UC Berkeley CS10 "The Beauty and Joy of Computing" : Recursion II (4)

Counting Change (thanks to BH)

- Given coins {50, 25, 10, 5, 1} how many ways are there of making change?
 - □ 5: 2 (N,5 P)
 - **10**
 - 4 (D, 2N, N 5P, 10P)
 - 15
 - 6 (DN,D5P,3N,2N5P,1N10P, 15P)
 - 100?

	and the second se
Cou	Int Change amount using coins
if	amount < 0 or empty? coins
report	
if 📢	mount) = 0
report	
report	
10	Count Change amount using
	ll but first of coins
	Count Change (amount) - item 🚺 of (colns)
	using coins





Call Tree for "Count Change 10 (10 5 1)"



Summary

- It's important to understand the machine model
- Recursion is a very powerful idea, and one way to separate good from great

<image>





UC Berkeley CS10 "The Beauty and Joy of Computing" : Recursion II (7)

Menger Cube by Dan Garcia