

Discussion 03

Recursion, Tree Recursion :)

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Slides available at `teaching.aditbala.com`

Announcements

- Homework 1 due today (6/30)
- Lab 2 due today (6/30)
- Hog Checkpoint due tomorrow (7/1)
- The tuition refund deadline to drop any session C summer course is July 1st.
 - There's also still lots of room in CS 10, if you're looking for a different pace than 61A—you can enroll in the class, and then reach out to cs10@berkeley.edu and they'll help catch you up.

Agenda

- Mini Lecture - Recursion
- Q2 walkthrough
- Q1
- Q3 / Q4 / Q5
- Mini Lecture - Tree Recursion
- Q7
- Q8

Recursion



An Exciting Metaphor

- The Problem
 - Want to find how many dolls are inside this doll
- What we need to do
 - Create a function that we can repeat until there is no more dolls to count
- Ideas?



Solution

- Remove one layer at a time and one to total, stop when there is no more dolls and add one

Dish Washing Example

INTERACTIVE !

- 20 dishes to wash on a Sunday morning

Recursion

- What is a recursive function?
 - A function that calls itself
 - Returns a function call of itself, not the object (different than HOF)
- Recursive Leap of Faith
 - The idea that the recursive function will work no matter what/how many test cases are passed in

Solution in Formal Terms of Recursion

- Base Case
 - smallest problem with guranteed answer, or smallest input
 - **A doll with no other dolls inside of it**
 - **One dish left**
- Recursive Call
 - A method of reducing the current problem into a smaller problem
 - **Removing each layer one by one and adding it to a total**
 - **Making a clone to wash dishes**

Recursion vs Iteration

- Recursion
 - Make problem smaller
 - Variables get reset
 - Many frames will open
 - Lot of memory taken up
 - Better for some problems
 - Recursive Data Structures (Trees, Linked Lists)
- Iteration
 - Loops happen in one frame
 - Easy to visualize
 - No additional function calls

Q2: Recursion Environment Diagram

Draw an environment diagram for the following code:

```
def rec(x, y):  
    if y > 0:  
        return x * rec(x, y - 1)  
    return 1  
  
rec(3, 2)
```

Q1: Recursive Multiplication (7 min)

Write a function that takes two numbers m and n (only positive) and returns their product. Use recursion, not `mul` or `*`

```
def multiply(m, n):  
    """ Takes two positive integers and returns  
    their product using recursion.  
>>> multiply(5, 3)  
15  
"""  
  
    """ YOUR CODE HERE """
```

Q3: Find the Bug (3 min)

Find the bug with this recursive function.

```
def skip_mul(n):  
    """Return the product of n * (n - 2) * (n - 4) * ...  
    >>> skip_mul(5) # 5 * 3 * 1  
    15  
    >>> skip_mul(8) # 8 * 6 * 4 * 2  
    384  
    """  
    if n == 2:  
        return 2  
    else:  
        return n * skip_mul(n - 2)
```

Choose your own adventure !!!

Q3 , Q4 , Q5

Tree Recursion



Tree Recursion

- What is Tree Recursion?
 - Recursion, but with more recursive calls
 - Can break down the problem in more than one way
 - With all of the options drawn out, looks like a tree of recursive calls
- When and Why?
 - Useful when the original problem can be broken down in multiple ways
 - Accumulate all sub-problems with multiple recursive calls

Recursive Fibonacci

```
def fib(n):  
    if n == 0:  
        return 0  
    elif n == 1:  
        return 1  
    else:  
        return fib(n - 1) + fib(n - 2)
```

- Need to look at `fib(n - 1)` and `fib(n-1)`
- All steps of recursion present
 - Base Case
 - Recursive Calls
 - Applying to solve problem

Q7: Count Stair Ways

How many different ways are there to go up a flight of stairs with $n = 1$ step? How about $n = 2$ steps? Try writing out some other examples and see if you notice any patterns.

```
def count_stair_ways(n):  
    """Returns the number of ways to climb up a flight of  
    n stairs, moving either 1 step or 2 steps at a time.  
    >>> count_stair_ways(4)  
    5  
    """"  
    """* * * YOUR CODE HERE * * *"""
```

Q8: Count K

Consider a special version of the `count_stair_ways` problem, where instead of taking 1 or 2 steps, we are able to take up to and including `k` steps at a time. Write a function `count_k` that figures out the number of paths for this scenario. Assume `n` and `k` are positive.

```
def count_k(n, k):  
    """  
    >>> count_k(3, 3) # 3, 2 + 1, 1 + 2, 1 + 1 + 1  
    4  
    >>> count_k(4, 4)  
    8  
    >>> count_k(10, 3)  
    274  
    >>> count_k(300, 1) # Only one step at a time  
    1  
    """
```

Slides by Aditya Balasubramanian

Thank you!

Attendance Form -> <https://tinyurl.com/adit-disc03>

Anon Feedback -> <https://tinyurl.com/adit-anon>

Study Groups -> <https://tinyurl.com/adit-study>