DISCUSSION 04

Tree Recursion, Python Lists

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LOGISTICS 

- Homework 03 due today Thu 09/22
  - There's an optional contest in the homework! - Not worth any credit, but if you want to have fun with higher order functions, go for it 😼
- CATS is released 😽😽😽
  - Try out the game here: cats.cs61a.org (not now lol)
  - Checkpoint 1 due next Tue 09/27
  - The whole project due next Fri 09/30
  - Submit everything by next Thu 09/29 for one extra credit

TREE RECURSION 

TREE RECURSION

- A tree recursive function is a recursive function that makes more than one call to itself, resulting in a tree-like series of calls.
- For example, let's say we want to recursively calculate the n^{th} Fibonacci number, defined as:

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

- Now, what happens when we call `fib(4)`?
  - Each `fib(i)` node represents a recursive call to `fib`.
  - For `i >= 2`, each recursive call `fib(i)` makes another two recursive calls, which are to `fib(i - 1)` and `fib(i - 2)`.
  - Whenever we reach a `fib(0)` or `fib(1)` node, we can directly return 0 or 1, since these are our base cases.

COUNT PARTITIONS REVISIT

Given two positive integers `n` and `m`, return the number of ways in which `n` can be expressed as the sum of positive integer parts up to `m` in increasing order.

- Recursive case: Since each integer part is up to `m`, at each step, where each step generates one number in the partition, we have two choices:
    1. Use `m` to partition `n`, so that at the next step, `n` becomes `n - m`, and the largest possible part is still `m`
    2. Don't use `m`. So at the next step, `n` remains unchanged, but `m` becomes `m - 1` (we choose not to use the largest possible part, `m`, so the next largest possible one is `m - 1`)
- The two choices will result in two distinct sets of results, since in the first one we use `m` to partition, while in the second one we use at most `m - 1`
- Therefore, the total # of partitions = # partitions from choice 1 + # partitions from choice 2

COUNT PARTITIONS REVISIT

Given two positive integers `n` and `m`, return the number of ways in which `n` can be expressed as the sum of positive integer parts up to `m` in increasing order.

- Base case:
  - `n == 0` - note that since `n` and `m` are positive integers according to the problem description, when `n` is 0, it could only be the case where `n - m` results in 0 from the previous recursive call. In other words, when `n` is 0, it menas that we've successfully partitioned `n` so that there's nothing left to partition. In this case, return 1, since we found one valid parition.
  - `n < 0` - similarly, since the original input to the function must be positive integers, a negative `n` can only result from `n - m` from the last step. In this case, `m` was greater than `n` from the last step, indicating that the partition was not succeessful.
  - `m == 0` - also similarly, a negative `m` can only result from `m - 1` from the last step. Since the question requires that all parts of a partition are positive integers, such an partition is invalid.

COUNT PARTITIONS REVISIT

Given two positive integers `n` and `m`, return the number of ways in which `n` can be expressed as the sum of positive integer parts up to `m` in increasing order.

```
def count_partitions(n, m):
    if n == 0:
        return 1
    elif n < 0 or m == 0:
        return 0
    else:
        with_m = count_partitions(n-m, m)
        without_m = count_partitions(n, m-1)
        return with_m + without_m
```

WORKSHEET Q1, 2

PYTHON LISTS

[ , ]

PYTHON LISTS - INTRO

- In Python, a list is a data structure that can store multiple elements in a defined order.
- Each element can be of any type, even a list itself.
- Lists are created by wrapping square brackets around comma-separated expressions
- `len(<seq>)` is a built-in function that takes in a sequence and returns the length (i.e., the number of elements in the sequence)

```
>>> a = ['a', 'b']
>>> b = [1, 2]
>>> len(a)
2
>>> c = [a, b, [3, 4], 5]
>>> c
[['a', 'b'], [1, 2], [3, 4], 5]
>>> len(c)
4
```

PYTHON LISTS - INDEXING

- Each element has its corresponding index, starting from 0 (i.e., "zero-indexed").
  - The index of the last element is `len(lst)-1`
- When index is negative, it means starting from the end of the list
  - `-i` is equivalent to `len(lst)-i`
  - `lst[-1]` is the last element, `lst[-2]` is the second to last element, etc.

```
>>> a = ['a', 'b']
>>> b = [1, 2]
>>> a[-1]
'b'
>>> c = [a, b, [3, 4], 5]
>>> c
[['a', 'b'], [1, 2], [3, 4], 5]
>>> c[1][1]
1
```

PYTHON LISTS - OTHER OPERATIONS

- Concatenation - use `+` to concatenate multiple lists together

```
>>> a = ['say']
>>> b = ['cheese', '!']
>>> a + b # same as add(a, b)
['say', 'cheese', '!']
```

- Repetition - use `*` to duplicate a list certain times

```
>>> a = [6, 1]
>>> a * 3 # same as a + a + a, or mul(a, 3)
[6, 1, 6, 1, 6, 1]
>>> add(mul(a, 2), mul(['a'], 2)) # a * 2 + ['a'] * 2
[6, 1, 6, 1, 'a', 'a']
```

PYTHON LISTS - OTHER OPERATIONS

- Checking element existence - use `in` to check whether or not some value is contained in the list
- To check for non-existence, use `elem not in lst` or `not (elem in lst)`

```
>>> a = ['o', 'p']
>>> 'p' in a
True
>>> 'oops' in a
False
>>> 'op' not in a
True
>>> not ('op' in a)
True
```

LIST SLICING

- List slicing creates a copy of part or all of the list.

```
lst[ <start index> : <end index> : <step size> ]
```

- `start index`
  - index to start at, *inclusive*, default to 0*
- `end index`
  - index to end by, *exclusive*, default to `len(lst)`*
  - when negative, counts from the end of the list, similar to negative indexing
- `step size`
  - the difference between indices of elements to include , default to 1
  - negative steps means stepping backwards

* when step is positive (when step is negative, start index defaults to the end of the list and end index defaults to the start of the list)

LIST SLICING

```
>>> lst = [1, 2, 3, 4, 5]
>>> lst[1: ]
[2, 3, 4, 5]
>>> lst[:-2]
[1, 2, 3]
>>> lst[1::2]
[2, 4]
>>> lst[::-1] # reverse the list
[5, 4, 3, 2, 1]
>>> lst[5:9] # list slicing won't cause an index error
[]
```

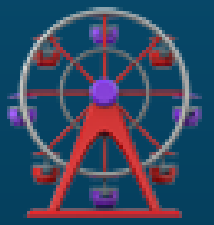
Takeaway: list slicing picks elements at indices `start`, `start + step`, `start + 2 * step`, ... and stops before `end`, and makes those selected elements into a new list

LIST COMPREHENSION

- List comprehensions are a compact and powerful way of creating new lists out of sequences.

```
[<expr> for <var> in <seq> if <cond>]
```

- In English, this translates to:
  1. For each element in the sequence `<seq>`, bind it to the variable name `<var>`.
  2. If the element satisfy the condition `<cond>` (or skip this check if there's no condition), evaluate the expression `<expr>`, and add the value from `<expr>` to the resulting list.
- Note:
  - `if <cond>` is optional.
  - `<expr>` and `<cond>` may refer to `<var>`, which is essentially every element in the sequence

RANGES AND FOR LOOPS 

RANGE

```
range(start, end, step)
```

- represents a sequence of integers
- can be converted to a list by calling the list constructor `list()`
- `start`: optional, inclusive, default to 0
- `end`: required, exclusive
- `step`: optional, default to 1

```
>>> list(range(4))
[0, 1, 2, 3]
>>> list(range(1, 6))
[1, 2, 3, 4, 5]
>>> list(range(2, 9, 2))
[2, 4, 6, 8]
```

FOR LOOPS

- For loops allow us to iterate over some sequences conveniently

```
for <name> in <sequence>:
    <suite>
```

- To iterate over the elements in a seqeunce, we can either iterate over the sequence directly or iterate through its indices and index into the sequence each time.

```
# example: print all elements in lst
for elem in lst:
    print(elem)
# this is equivalent to
for i in range(len(lst)):
    print(lst[i])
```

WORKSHEET Q3,4,5

DICTIONARIES 

DICTIONARIES

- Dictionaries maps keys to their corresponding values
- Create a dictionary
  - `{key1: val1, key2: val2, key3: val3}`
- Select from a dictionary
  - `dict[key]`
  - If `key` does not exist in `dict`, this will error
- Modify a dictionary:
  - `dict[key] = val`
  - If `key` does not exist in `dict`, this will create a new entry. Otherwise it updates the value corresponding to `key` to be `val`
- `len(dict)` returns the number of entries (key-value pairs) in the dictionary
- The key of a dictionary must be immutable (numbers, strings, tuples, but NOT lists)

WORKSHEET Q6

ATTENDANCE! 

go.cs61a.org/mingxiao-att

- The attendance form and slides are both linked on our section website!
- Once again, please do remember to fill out the form by midnight today!!