61A Lecture 17

Monday, October 14

Announcements

- Homework 5 is due Tuesday 10/15 @ 11:59pm
- Project 3 is due Thursday 10/24 @ 11:59pm
- Midterm 2 is on Monday 10/28 7pm-9pm

Special Method Names

Special Method Names in Python

Certain names are special (or "magic") because they have built-in behavior.

These names always start and end with two underscores.

`__init__`	Method invoked automatically when an object is constructed.
`__len__`	Method invoked by the built-in len function.
`__getitem__`	Method invoked for element selection: sequence[index]
`__repr__`	Method invoked to display an object as a string.

```
>>> s = (3, 4, 5)
>>> len(s)
3
>>> s[2]
5
>>> s
(3, 4, 5)
```

Same behavior using methods

```
>>> s = (3, 4, 5)
>>> s.__len__()
3
>>> s.__getitem__(2)
5
>>> print(s.__repr__())
(3, 4, 5)
```

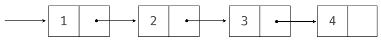
Recursive List Class

Closure Property of Data

A tuple can contain another tuple as an element.

Pairs are sufficient to represent sequences of arbitrary length.

Recursive list representation of the sequence 1, 2, 3, 4:



Recursive lists are recursive: the rest of the list is a list.

Now, we can implement the same behavior using a class called Rlist:

```
   Abstract data type (old):     rlist(1, rlist(2, rlist(3, rlist(4, empty_rlist))))

          Rlist class (new):     Rlist(1, Rlist(2, Rlist(3, Rlist(4))))
```

Recursive List Class

```
class Rlist:
    class EmptyList:
        def __len__(self):
            return 0
    empty = EmptyList()

    def __init__(self, first, rest=empty):
        assert type(rest) is Rlist or rest is Rlist.empty
        self.first = first
        self.rest = rest

    def __getitem__(self, index):
        if index == 0:
            return self.first
        else:
            return self.rest[index-1]

    def __len__(self):
        return 1 + len(self.rest)
```

There's the base case!

Calls this method with a special name

This element selection syntax

Yes, this call is recursive

Methods can be recursive too!

(Demo)

Recursive List Processing

Recursive Operations on Recursive Lists

Recursive list processing almost always involves a recursive call on the rest of the list.

```
>>> s = Rlist(1, Rlist(2, Rlist(3)))

>>> s.rest
Rlist(2, Rlist(3))

>>> extend_rlist(s.rest, s)
Rlist(2, Rlist(3, Rlist(1, Rlist(2, Rlist(3)))))


def extend_rlist(s1, s2):
    if s1 is Rlist.empty:
        return s2
    else:
        return Rlist(s1.first, extend_rlist(s1.rest, s2))
```

Higher-Order Functions on Recursive Lists

We want operations on all elements of a list, not just an element at a time.

double_rlist(s)	Double s.first, then double_rlist(s.rest)
map_rlist(s, fn)	Apply fn to s.first, then map_rlist(s.rest, fn)
filter_rlist(s, fn)	Either keep s.first or not, then filter_rlist(s.rest, fn)

In all of these functions, the base case is the empty list.

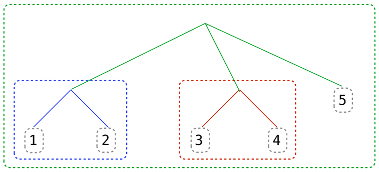
(Demo)

Trees

Tree Structured Data

Nested sequences form hierarchical structures: tree-structured data

((1, 2), (3, 4), 5)



In every tree, a vast forest

Recursive Tree Processing

Tree operations typically make recursive calls on branches.

```
count_leaves(t)      1 if t is a leaf, otherwise sum count_leaves(branch)

map_tree(t, fn)      fn(t) if t is a leaf, otherwise combine map_tree(branch, fn)
```

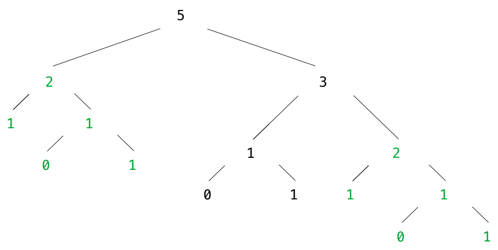
In these functions, the base case is a leaf.

(Demo)

Trees with Internal Entries

Trees with Internal Entries

Trees can have values at their roots as well as their leaves.



Trees with Internal Entries

Trees can have values at their roots as well as their leaves.

```
class Tree:
    def __init__(self, entry, left=None, right=None):
        self.entry = entry
        self.left = left
        self.right = right

def fib_tree(n):
    if n == 1:
        return Tree(0)
    if n == 2:
        return Tree(1)
    left = fib_tree(n-2)
    right = fib_tree(n-1)
    return Tree(left.entry + right.entry, left, right)
```

(Demo)

Memoization

Memoization

Idea: Remember the results that have been computed before

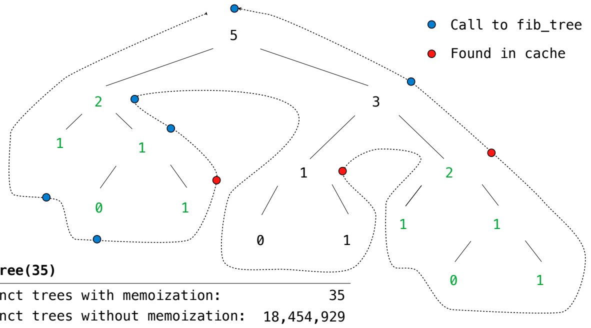
```
def memo(f):
    cache = {}
    def memoized(n):
        if n not in cache:
            cache[n] = f(n)
        return cache[n]
    return memoized
```

Keys are arguments that map to return values

Same behavior as f, if f is a pure function

(Demo)

Memoized Tree Recursion



● Call to fib_tree

🟥 Found in cache

fib_tree(35)	
Distinct trees with memoization:	35
Distinct trees without memoization:	18,454,929