CS 61A Lecture 11

Friday, September 26

Announcements

- Midterm 1 has been graded...
  - Many of you did very well. Nice work!
  - High scores on homework and projects balance out exam scores
  - Typically, around 3 out of 4 students receive A's & B's in 61A
  - Don't fall behind! Come to class (discussion, lab, & office hours)!
  - Regrades are due by Sunday 9/29 @ 11:59pm
- Guerrilla Section 2 is on Saturday. RSVP on Piazza if you want to come!
- Homework 3 due Wednesday 10/1 @ 11:59pm
  - Homework Party on Monday 9/29, time and place TBD
- Optional Hog Contest due Wednesday 10/1 @ 11:59pm

Sequences

The Sequence Abstraction

red, orange, yellow, green, blue, indigo, violet.

0 , 1 , 2 , 3 , 4 , 5 , 6 .

There isn't just one sequence class or data abstraction (in Python or in general).

The sequence abstraction is a collection of behaviors:

> **Length.** A sequence has a finite length.
>
> **Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

There is built-in syntax associated with this behavior, or we can use functions.

A list is a kind of built-in sequence

Lists

['Demo']

Lists are Sequences

```
>>> digits = [1, 8, 2, 8]
>>> len(digits)
4
>>> digits[3]
8
```

> **Length.** A sequence has a finite length.
>
> **Element selection.** A sequence has an element corresponding to any non-negative integer index less than its length, starting at 0.

```
>>> [2, 7] + digits * 2
[2, 7, 1, 8, 2, 8, 1, 8, 2, 8]

>>> pairs = [[10, 20], [30, 40]]
>>> pairs[1]
[30, 40]
>>> pairs[1][0]
30
```


For Statements

(Demo)

Sequence Iteration

```
def count(s, value):
    total = 0
    for element in s:
        if element == value:
            total = total + 1
    return total
```

Name bound in the first frame of the current environment (not a new frame)

For Statement Execution Procedure

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

1. Evaluate the header <expression>, which must yield an iterable value (a sequence)
2. For each element in that sequence, in order:
   A. Bind <name> to that element in the current frame
   B. Execute the <suite>

Sequence Unpacking in For Statements

A sequence of fixed-length sequences

```
>>> pairs = [[1, 2], [2, 2], [3, 2], [4, 4]]
>>> same_count = 0
```

A name for each element in a fixed-length sequence

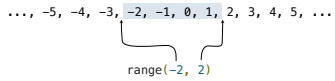
Each name is bound to a value, as in multiple assignment

```
>>> for x, y in pairs:
...     if x == y:
...         same_count = same_count + 1
...
>>> same_count
2
```


Ranges

The Range Type

A range is a sequence of consecutive integers.*



Length: ending value − starting value

Element selection: starting value + index

(Demo)

```
>>> list(range(-2, 2))
[-2, -1, 0, 1]
>>> list(range(4))
[0, 1, 2, 3]
```

List constructor

Range with a 0 starting value

* Ranges can actually represent more general integer sequences.

List Comprehensions

```
>>> letters = ['a', 'b', 'c', 'd', 'e', 'f', 'm', 'n', 'o', 'p']
>>> [letters[i] for i in [3, 4, 6, 8]]
['d', 'e', 'm', 'o']
```

List Comprehensions

[<map exp> for <name> in <iter exp> if <filter exp>]

Short version: [<map exp> for <name> in <iter exp>]

A combined expression that evaluates to a list using this evaluation procedure:

1. Add a new frame with the current frame as its parent
2. Create an empty *result list* that is the value of the expression
3. For each element in the iterable value of <iter exp>:
   A. Bind <name> to that element in the new frame from step 1
   B. If <filter exp> evaluates to a true value, then add the value of <map exp> to the result list

Higher-Order Sequence Functions

Functions that Perform List Comprehensions

```
def apply_to_all(map_fn, s):
    """Apply map_fn to each element of s.

    """
    return [map_fn(x) for x in s]
```

0, 1, 2, 3, 4

λx: x*3

0, 3, 6, 9, 12

Same number of different elements

```
def keep_if(filter_fn, s):
    """List all elements x of s for which filter_fn(x) is true.

    """
    return [x for x in s if filter_fn(x)]
```

0, 1, 2, 3, 4, 5, 6, 7, 8, 9

λx: x>5

6, 7, 8, 9

Smaller number of same elements

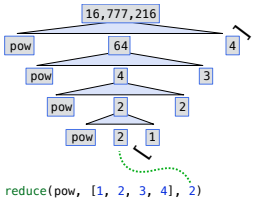
Reducing a Sequence to a Value

```
def reduce(reduce_fn, s, initial):
    """Combine elements of s pairwise using reduce_fn, starting with initial.

    E.g., reduce(mul, [2, 4, 8], 1) is equivalent to mul(mul(mul(1, 2), 4), 8).

    >>> reduce(mul, [2, 4, 8], 1)
    64
    """
    reduced = initial
    for x in s:
        reduced = reduce_fn(reduced, x)
    return reduced
```

`reduce_fn` is ...
  a two-argument function
`s` is ...
  a sequence of values that can be the second argument
`initial` is ...
  a value that can be the first argument



`reduce(pow, [1, 2, 3, 4], 2)`

(Demo)

Typical Names for Higher-Order Sequence Functions

`apply_to_all` is usually called `map`

`keep_if` is usually called `filter`

`reduce` is usually called `reduce` (but sometimes `fold` or `accumulate`)

`map` and `filter` are built into Python, but they don't return lists

`reduce` is in the standard library in a module called `functools`

Most Python programmers just use list comprehensions