Recap from last Python lecture

Interpreted, imperative, OO Language

- Everything is an object
- Dynamic Typing

Programs are made up of:

- Expressions
- Statements
  - Assignment
  - if/elif/else
  - while-loops
  - Functions
- Classes (still to come)

Today: Revisit some objects

- Exploit features and build powerful expressions

Base: *int*, *float*, *complex*

Sequence: *string*, *tuple*, *list*

What can sequences do ?

Select

- i-th element: `s[i]`
- subsequence ("slice"): `s[i:j]`

Update -- For mutable sequences (e.g. Lists)

- Update i-th element: `s[i] = e`
- Update subsequence: `s[i:j] = e`

Update subsequence `s[i:j]=e`

Update subsequence: `s[i:j] = e`

- Changes the “object” referred to by s
- May change the length of the sequence
  - Increase: if RHS length > `j-i`
  - Decrease: if RHS length < `j-i`

Update subsequence `s[i:j]=e`

```
>>> z = [1,2,3,4,5,6,7,8,9,10]
>>> z[3:6] = [“a”,“b”,“c”]
>>> z
[1,2,3,”a”,”b”,”c”,7,8,9,10]
>>> z[3:6] = [“a”, “b”] * 2
>>> z
[1,2,3,”a”,”b”,”a”,”b”,7,8,9,10]
>>> z[4:]=[]
>>> z
[1,2,3,”a”]
>>> z[:0] = [“al”, “be”]
>>> z
[“al”,”be”,1,2,3,”a”,”b”,”a”,”b”,7,8,9,10]
```

What else can sequences do ?

Q: Suppose you are given a sequence `s`

How to find if the element `x` appears in `s` ?

```
x in s
```

Works for any sequence type …

Sequence "contains"

`x in s`

```
>>> "a" in "cat"
True
>>> "a" in "entebbe"
False
>>> "a" in ("c", "a", "t")
True
>>> 2 in [1,2,3,4,5]
True
>>> 2 in [1,4,"92",2.4]
False
```

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Member

- Is an element in a sequence: `x in s`

Doesn't Python have For-Loops ?

Why haven't we seen For-loops yet ?

- Because they are connected to sequences

For-loops are used to iterate over sequences

- Unlike in C, but similar to new Java foreach
- Elegant, powerful mechanism - use it!

```
for x in s:
    <BODY>
```

```
x=s[0]
<BODY>
x=s[1]
<BODY>
...
x=s[len(s)-1]
<BODY>
```

Iteration

`for x in s:`

```
>>> for x in [“Midterms”, “ain’t”, “cool”]:
            print x,len(x)

Midterms 5
ain’t 5
cool 4
```

Works for any sequence …

```
>>> for c in “chimichanga”:
            print c*3
ccc
hhh
iii
mmm …
```

Iteration

`for x in s:`

```
>>> s=0
>>> z=(1,2,3,4.0,"5")      #tuple
>>> for i in z:
        s = s + i
ERROR
>>> s
10
```

Can't add string to float

- Note that first 4 elts added!
- Dynamic Types!
- Run-time Type Error

```
>>> s=0
>>> for i in z:
        s=s+float(i)
>>> s
15
```

Iteration + binding `for x,… in s:`

If s is a sequence of tuples/sequences, then we can

Bind to individual elements of “subsequences”

```
>>>craigslist = [("alien",3.50),
   ("dinosaur",1.90), ("quiz",100.50),
   ("quesadilla",3.00), ("good grade in
   130","priceless")]
>>>for i,p in craislist:
            print “One”,i,“costs”,p
One alien costs 3.5
One dinosaur costs 1.9
One quiz costs 100.5
One quesadilla costs 3.0
One good grade in 130 costs priceless
```

Old school For-loops

There's a simple way to write good-old for-loops

```
for(i=0,i<10,i++){
   print i;
}
```

Built-in function: `range`

```
>>> range(10)
[0,1,2,3,4,5,6,7,8,9]
>> for i in range(10):
        print i
```

```
>>> range(5,15)        #fixed upper bound
[5,6,7,8,9,10,11,12,13,14]
>>> range(15,5,-1)     #step
[15, 14, 13, 12, 11, 10, 9, 8, 7, 6]
```

But lookout!

For-loops are used to iterate over sequences

```
for x in s:
    <BODY>
```

What if object referred to by `s` is changed in `BODY`?

Unpleasantness ensues:

- Try to ensure this never happens
- Iterate over a “copy” of the object
  - `s[:]`

But lookout!

```
def funny_fun(s):
    for x in s:
        print x
        s[len(s):] = [x]
```

Adds `x` to end object being iterated over!

- Loops forever

```
def dup_by_k(s,k):
    for x in s:
        print x
        s = s + x*k
return s
```

Creates new object w/ `x*k` added at end

Iteration object is what s "originally" referred to, which is unchanged

But lookout!

```
def funny_fun(s):
    for x in s:
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```

Adds `x` to end object being iterated over!

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def dup_by_k(s,k):
    for x in s[:] :
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        s = s + x*k
return s
```

Creates new object w/ `x*k` added at end

To make it more readable

Iteration object is what s "originally" referred to, which is unchanged

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Update -- For mutable sequences (e.g. Lists)

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- Update subsequence: `s[i:j] = e`

Member: `x in s`

Iteration: `for x in s: <body>`

What else ?

Three useful functions for lists from ML ?

- map
- filter
- fold (a.k.a. reduce)

Built-in in Python:

map

```
def dup(x):
  return 2*x
```

```
>>> z = range(10)
>>> z
[0,1,2,3,4,5,6,7,8,9]
>>> map(dup,z)
[0,2,4,6,8,10,12,14,16,18]
>>>map(dup,"chimichanga")
["cc","hh","ii","mm","ii","cc","hh","
  aa","nn","gg","aa]
```

- Works for all sequences, returns a list
- More flexible ways to call it, see documentation

filter

- Works for all sequences, returns same kind of sequence

```
>>> def even(x): return int(x)%2==0
>>> filter(even,range(10))
[0,2,4,6,8]
>>> filter(even,"1234096001234125")
"240600242"
>>> filter(even,(1,2.0,3.2,4))
(2,4)
```

- Again, note the polymorphism that we get from dynamic types and conversion

reduce

- i.e. `fold`

```
>>> def add(x,y): x+y
>>> reduce(add,range(10),0)
45
>>> def fac(x):
      def mul(x,y): return x*y
      return reduce(mul,range(1, x+1),1)
>>> fac(5)
120
```

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- subsequence ("slice"): `s[i:j]`

Update -- For mutable sequences (e.g. Lists)

- Update i-th element: `s[i] = e`
- Update subsequence: `s[i:j] = e`

Member: `x in s`

Iteration: `for x in s: <body>`

`map,filter,reduce`

List Comprehensions

A cleaner, nicer way to do map-like operations

```
>>> [ x*x for x in range(10)]
[0,1,4,9,16,25,36,49,64,81]
>>> [2*x for x in "yogurt cheese"]
["yy","oo","gg","uu","rr","tt",…]
```

List Comprehensions

Syntax: `>>> [e_x for x in s]`

Equivalent to:

List Comprehensions

Syntax:

```
>>> [e_x for x in s]
```

Equivalent to:

```
>>> def map_fn(x): return e_x
>>> map(map_fn, s)
```

List Comprehensions

A cleaner, nicer way to do **map+filter**-like operations

```
>>> [ x*x for x in range(10) if even(x)]
[0,4,16,36,64]
>>> [ 2*x for x in "0123456" if even(x)]
["00","22","44","66"]
>>> [z[0] for z in craigslist if z[1]<3.0]
["dinosaur"]
```

List Comprehensions

Syntax: `>>> [e_x for x in s if c_x ]`

Equivalent to:

List Comprehensions

Syntax: `>>> [e_x for x in s if c_x ]`

Equivalent to:

```
>>> def map_fn(x): return e_x
>>> def filter_fn(x): return c_x
>>> map(map_fn, filter(filter_fn, s))
```

List Comprehensions

Can “nest” the for to iterate over multiple sequences

```
>>>[(x,y) for x in range(3) for y range(3)]
[(0,0),(0,1),(0,2),(1,0),(1,1),(1,2),(2,0),(2,
  1),(2,2)]
>>>[(x,y) for x in range(3) for y in range(3)
  if x > y]
[(1,0),(2,0),(2,1)]
```

What can sequences do ?

Select

- i-th element: `s[i]`
- subsequence ("slice"): `s[i:j]`

Update -- For mutable sequences (e.g. Lists)

- Update i-th element: `s[i] = e`
- Update subsequence: `s[i:j] = e`

Member: `x in s`

Iteration: `for x in s: <body>`

`map,filter,reduce`

Comprehensions: $[e_x$ `for x in s if` $c_x]$

Quicksort in Python

```
def sort(L):
  if L==[]: return L
  else:
    l=sort(...)
    r=sort(...)
    return(l+L[0:1]+r)
```

Quicksort in Python

```
def sort(L):
  if L==[]: return L
  else:
    l=sort([x for x in L[1:] if x < L[0]])
    r=sort([x for x in L[1:] if x >= L[0]])
    return(l+L[0:1]+r)
```

Today: Revisit some objects

- Exploit features and build powerful expressions

Base: *int*, *float*, *complex*

Sequence: *string*, *tuple*, *list*

Maps (Dictionary): *key* → *value*

Key data structure: Dictionaries

Associative arrays, Hash tables …

A table storing a set of “keys”,
And a “value” for each key.

Any (immutable) object can be a key!

- int,float,string,tuples…

Very useful!

Using Dictionaries

Unsorted list of key,value pairs

Empty Dictionary: `{}`

Non-empty Dictionary: `{k1:v1,k2:v2,…}`

Membership: is k in dict: `k in d`

Lookup value of key: `d[k]`

Set value of key: `d[k]=v`

Dictionaries

```
>>> d={}
>>> d=dict(mexmenu)
>>> d[“ceviche”] = 3.95
>>> d
{…}
>>> d[“burrito”]
3.50
>>> d.keys()
…
>>> d.values()
```

Dictionaries

```
def freq(s):
   d={}
   for c in s:
     if c in d: d[c]+=1
     else: d[c]=1
   return d
```

```
def plotfreq(s):
   d=freq(s)
   for k in d.keys():
       print k, "*"*d[k]
```

```
>>> d=plotfreq([1,1,3.0,"A",3.0,"A","A",1,2,3.0,1,"A"])
>>> d
…
>>> d = plotfreq("avrakedavra")
>>> d.keys()
>>> d
…
```

```
>>> f = open("foo.txt","read")
>>> f.readlines()
…
>>> for l in f.readlines():
            <BODY>

>>> f.close
```

You now know enough to do PA5

- Python Tutorial: How to open files, read lines
- Use the `help` command
- Document every function: What does it do ?