



CS101, Spring 2015

Sequences: Lists, Strings, and Tuples

Lecture #6



Last week we learned

- Local and global variables
- Modules
- Graphics

This week we will learn

- Sequences
 - Lists
 - Strings
 - Tuples



Here is a table of olympic medals from the 2010 Vancouver winter games:

Source: www.vancouver2010.com

| | | | |
|--------------------|----|----|----|
| Australia | 2 | 1 | 0 |
| Austria | 4 | 6 | 6 |
| Belarus | 1 | 1 | 1 |
| Canada | 14 | 7 | 5 |
| China | 5 | 2 | 4 |
| Croatia | 0 | 2 | 1 |
| Czech Republic | 2 | 0 | 4 |
| Estonia | 0 | 1 | 0 |
| Finland | 0 | 1 | 4 |
| France | 2 | 3 | 6 |
| Germany | 10 | 13 | 7 |
| Great Britain | 1 | 0 | 0 |
| Italy | 1 | 1 | 3 |
| Japan | 0 | 3 | 2 |
| Kazakhstan | 0 | 1 | 0 |
| Korea | 6 | 6 | 2 |
| Latvia | 0 | 2 | 0 |
| Netherlands | 4 | 1 | 3 |
| Norway | 9 | 8 | 6 |
| Poland | 1 | 3 | 2 |
| Russian Federation | 3 | 5 | 7 |
| Slovakia | 1 | 1 | 1 |
| Slovenia | 0 | 2 | 1 |
| Sweden | 5 | 2 | 4 |
| Switzerland | 6 | 0 | 3 |
| United States | 9 | 15 | 13 |

How can we store this much data in Python? We would need 4×26 variables...

The solution is to store all values together in a **list**.



To create a list, enclose the values in square brackets:

```
countries = [ "Australia", ... , "United States" ]  
gold = [2, 4, 1, 14, 5, 0, 2, 0, 0, 2, 10, 1, 1, 0,  
        0, 6, 0, 4, 9, 1, 3, 1, 0, 5, 6, 9]
```

A list is an object of type `list`.

We can access the elements of a list using an integer index.
The first element is at index `0`, the second at index `1`, and so on:

```
>>> countries[0]  
'Australia'  
>>> countries[15]  
'Korea'  
>>> gold[15]  
6
```

Negative indices start at the end of the list:

```
>>> countries[-1]  
'United States'  
>>> countries[-11]  
'Korea'
```



The length of a list is given by `len`:

```
>>> len(countries)
26
```

The empty list is written `[]` and has length zero.

Lists can contain a mixture of objects of any type:

```
>>> korea = [ 'Korea', 'KR', 6, 6, 2 ]
>>> korea[1]
'KR'
>>> korea[2]
6
```

Or even:

```
>>> korea = [ "Korea", 'KR', (6, 6, 2) ]
```



A list of noble gases:

```
>>> nobles = [ 'helium', 'none', 'argon', 'krypton',  
                'xenon' ]
```

Oops. Correct the typo:

```
>>> nobles[1] = "neon"
```

```
>>> nobles
```

```
['helium', 'neon', 'argon', 'krypton', 'xenon']
```

Oops oops. I forgot radon!

```
>>> nobles.append('radon')
```

```
>>> nobles
```

```
['helium', 'neon', 'argon', 'krypton', 'xenon', 'radon']
```



Reminder: An object can have more than one name. This is called **aliasing**. We have to be careful when working with mutable objects:

```
>>> list1 = ["A","B","C"]
>>> list2 = list1
>>> len(list1)
3
>>> list2.append("D")
>>> len(list1)
4
>>> list1[1] = "X"
>>> list2
['A', 'X', 'C', 'D']
>>> list1 is list2
True
```

```
>>> list1 = ["A","B","C"]
>>> list2 = ["A","B","C"]
>>> len(list1)
3
>>> list2.append("D")
>>> len(list1)
3
>>> list1[1] = "X"
>>> list2
['A', 'B', 'C', 'D']
>>> list1 is list2
False
```



`len` returns length of a list, `sum` the sum of the elements, `max` the largest element, `min` the smallest element:

```
>>> len(gold), sum(gold), max(gold), min(gold)
(26, 86, 14, 0)
```

```
>>> len(silver), sum(silver), max(silver)
(26, 87, 15)
```

```
>>> len(bronze), sum(bronze), max(bronze)
(26, 85, 13)
```




A **for** loop looks at every element of a list:

```
for country in countries:  
    print country
```

The **range** function returns a list:

```
>>> range(10)  
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]  
>>> range(10, 15)  
[10, 11, 12, 13, 14]
```

If we want to modify elements, we need the index:

```
>>> l = range(1, 11)  
>>> for i in range(len(l)):  
...     l[i] = l[i] ** 2  
>>> l  
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
```



Let's print out the total number of medals for each country:

```
for i in range(len(countries)):
    print countries[i], gold[i]+silver[i]+bronze[i]
```

We can create a new list:

```
totals = []
for i in range(len(countries)):
    medals = gold[i]+silver[i]+bronze[i]
    totals.append( (medals, countries[i]) )
```

The list **totals** is now a list of tuples (**medals, country**).

```
[(3, 'Australia'), (16, 'Austria'), (3, 'Belarus'), ...,
(14, 'Korea'), (2, 'Latvia'), (8, 'Netherlands'), ...,
(11, 'Sweden'), (9, 'Switzerland'), (37, 'United States')]
```



We can sort a list using its `sort` method:

```
>>> ta = [ "Jongbin", "Sungeun", "Dongyoung",  
...       "Suwon", "YeongJae", "Jinki" ]  
>>> ta.sort()  
>>> ta  
['Dongyoung', 'Jinki', 'Jongbin', 'Sungeun',  
'Suwon', 'YeongJae']
```

Let's sort the medal totals: `totals.sort()`.

```
[(1, 'Estonia'), (1, 'Great Britain'), (1, 'Kazakhstan'),  
 (2, 'Latvia'), (3, 'Australia'), (3, 'Belarus'), ...,  
 (14, 'Korea'), ..., (26, 'Canada'), (30, 'Germany'),  
 (37, 'United States')]
```

We rather want the countries with the largest number of medals at the top:

```
totals.reverse()
```

```
[(37, 'United States'), (30, 'Germany'), (26, 'Canada'),  
 (23, 'Norway'), (16, 'Austria'), ..., (14, 'Korea'),  
 (11, 'Sweden'), ... (1, 'Estonia')]
```

Actually we only care about the top 10:

```
top_ten = totals[:10]
```

```
for p in top_ten:
```

```
    medals, country = p
```

```
    print medals, country
```

Slicing

Unpack immediately

```
for medals, country in top_ten:
```

```
    print medals, country
```



Slicing creates a **new list** with elements of the given list:

```
sublist = mylist[i:j]
```

Then **sublist** contains elements $i, i + 1, \dots, j - 1$ of **mylist**.

If **i** is omitted, the sublist starts with the first element.

If **j** is omitted, then the sublist ends with the last element.

Special case: We can create a copy of a list with

```
list2 = list1[:]
```



Let's create the top-10 lexicographical ranking:

```
table = []
for i in range(len(countries)):
    table.append( (gold[i], silver[i],
                  bronze[i], countries[i]) )
table.sort()
top_ten = table[-10:]
top_ten.reverse()
for g,s,b,country in top_ten:
    print country, g, s, b
```

| | | | |
|---------------|----|----|----|
| Canada | 14 | 7 | 5 |
| Germany | 10 | 13 | 7 |
| United States | 9 | 15 | 13 |
| Norway | 9 | 8 | 6 |
| Korea | 6 | 6 | 2 |
| Switzerland | 6 | 0 | 3 |
| Sweden | 5 | 2 | 4 |
| China | 5 | 2 | 4 |
| Austria | 4 | 6 | 6 |
| Netherlands | 4 | 1 | 3 |



Let's find all countries that have only one kind of medal:

```
def no_medals(countries, a1, b1):  
    result = []  
    for i in range(len(countries)):  
        if a1[i] == 0 and b1[i] == 0:  
            result.append(countries[i])  
    return result
```

```
only_gold = no_medals(countries, silver, bronze)  
only_silver = no_medals(countries, gold, bronze)  
only_bronze = no_medals(countries, gold, silver)
```

```
only_one = only_gold ⊕ only_silver ⊕ only_bronze
```

list concatenation



List objects `L` have the following methods:

- `L.append(v)` add object `v` at the end
- `L.insert(i, v)` insert element at position `i`
- `L.pop()` remove and return last element
- `L.pop(i)` remove and return element at position `i`
- `L.remove(v)` remove first element equal to `v`
- `L.index(v)` return index of first element equal to `v`
- `L.count(v)` return number of elements equal to `v`
- `L.extend(K)` append all elements of sequence `K` to `L`
- `L.reverse()` reverse the list
- `L.sort()` sort the list

What is the difference?

```
L.append(13)
```

```
L + [ 13 ]
```




Lists are a kind of **sequence**. We already met other kinds of sequences: strings, and tuples:

Strings:

```
>>> a = "CS101"
>>> a[0]
'C'
>>> a[-1]
'1'
>>> a[2:]
'101'
>>> for i in a:
...     print i,
C S 1 0 1
```

Tuples:

```
>>> t = ("CS101", "A+", 13)
>>> t[0]
'CS101'
>>> t[-1]
13
>>> t[1:]
('A+', 13)
>>> for i in t:
...     print i,
CS101 A+ 13
```

Lists and tuples are very similar, but lists are **mutable**, while tuples (and strings) are **immutable**:

```
>>> t[0] = "CS206"
```

```
TypeError: 'tuple' object does not support  
item assignment
```

We can convert a sequence into a list or tuple using the **list** and **tuple** functions:

```
>>> list(t)
```

```
['CS101', 'A+', 13]
```

```
>>> tuple(gold)
```

```
(2, 4, 1, 14, 5, 0, 2, 0, 0, ..., 0, 5, 6, 9)
```

```
>>> list("CS101")
```

```
['C', 'S', '1', '0', '1']
```



Using four lists to store the medal information is not typical for Python. We would normally make a single list of tuples:

```
medals = [ ( 'Australia', 2, 1, 0 ),  
            ( 'Austria', 4, 6, 6 ),  
            ...  
            ( 'United States', 9, 15, 13 ) ]
```

Print total number of medals for each country:

```
def print_totals1():  
    for country, g, s, b in medals:  
        print country + ":", g + s + b  
  
def print_totals2():  
    for item in medals:  
        print item[0] + ":", sum(item[1:])
```



Instead of creating a new list, let's sort the original list by total number of medals:

```
def compare(item1, item2):  
    medals1 = sum(item1[1:])  
    medals2 = sum(item2[1:])  
    return cmp(medals2, medals1)
```

```
def top_ten():  
    medals.sort(compare)  
    top_ten = medals[:10]  
    for item in top_ten:  
        print item[0] + ":", sum(item[1:])
```

United States: 37
Germany: 30
Canada: 26
Norway: 23
Austria: 16
Russian Federation: 15
Korea: 14
China: 11
France: 11
Sweden: 11

`cmp(a,b)` returns `-1` if $a < b$, `0` if $a = b$, and `+1` if $a > b$.



We want to create a histogram of medals:

```
0~2:    ****
3~5:    ****
6~8:    ***
9~11:   ****
12~14:  *
15~17:  **
18~20:
21~23:  *
24~26:  *
27~29:
30~32:  *
33~35:
36~38:  *
```

```
def histogram():
    t = [0] * 13
    for item in medals:
        total = sum(item[1:])
        t[total / 3] += 1
    for i in range(13):
        print str(3*i) + "~" + str(3*i+2)
              + ":\t" + ("*" * t[i])
```



Sieve of Eratosthenes

```
def sieve(n):
    t = range(3, n, 2)
    sqrt_n = int(math.sqrt(n))
    i = 0
    while t[i] <= sqrt_n:
        # remove all multiples of t[i]
        p = t[i]
        for j in range(len(t)-1, i, -1):
            if t[j] % p == 0:
                t.pop(j)
        i += 1
    return t
```

3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61,
67, 71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137,
139, 149, 151, 157, 163, 167, 173, 179, 181, 191, 193, 197, 199,
211, 223, 227, 229, 233, 239, 241, 251, 257, 263, 269, 271, 277,
281, 283, 293, 307, 311, 313, 317, 331, 337, 347, 349, 353, 359,
367, 373, 379, 383, 389, 397, 401, 409, 419, 421, 431, 433, 439,
443, 449, 457, 461, 463, 467, 479, 487, 491, 499, 503, 509, 521,
523, 541, 547, 557, 563, 569, 571, 577, 587, 593, 599, 601, 607,
613, 617, 619, 631, 641, 643, 647, 653, 659, 661, 673, 677, 683,
691, 701, 709, 719, 727, 733, 739, 743, 751, 757, 761, 769, 773,
787, 797, 809, 811, 821, 823, 827, 829, 839, 853, 857, 859, 863,
877, 881, 883, 887, 907, 911, 919, 929, 937, 941, 947, 953, 967,
971, 977, 983, 991, 997