Introduction to Programming
CS101

Fall 2011

Lecture #6

Roadmap

Last week we learned

- Local and global variables
- Modules
- Graphics

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- Local and global variables
- Modules
- Graphics

This week we will learn

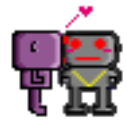
- Lists
  - Aliasing
  - Built-in functions
  - Traversing
  - Sorting
  - Reversing
  - Slicing
  - Ranking
  - Indexing

Lots of data

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



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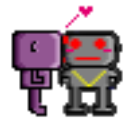
How can we store this much data in Python? We would need 4×26 variables...



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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.

Lists

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]
```

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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:

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

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'Korea'
>>> gold[15]
6
```

Negative indices start at the end of the list:

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

Lists

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

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>>> len(countries)
26
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'KR'
>>> korea[2]
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>>> korea[1]
'KR'
>>> korea[2]
6
```

Or even:

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

Lists are mutable

A list of noble gases:

```
>>> nobles = [ 'helium', 'none', 'argon', 'krypton',
               'xenon' ]
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Oops. Correct the typo:

```
>>> nobles[1] = "neon"
>>> nobles
['helium', 'neon', 'argon', 'krypton', 'xenon']
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>>> nobles[1] = "neon"
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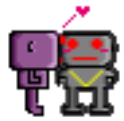
['helium', 'neon', 'argon', 'krypton', 'xenon']
```

Oops oops. I forgot radon!

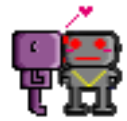
```
>>> nobles.append('radon')
>>> nobles
['helium', 'neon', 'argon', 'krypton', 'xenon', 'radon']
```



Aliasing

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']
```



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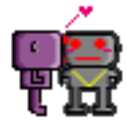

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>>> list1 is list2
True
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>>> list1 is list2
False
```

Built-in functions on lists

`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)
```

Traversing a list

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

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for country in countries:
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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]
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>>> 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]
```

Traversing several lists

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

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for i in range(len(countries)):
  print countries[i], gold[i]+silver[i]+bronze[i]
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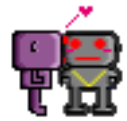
We can create a new list:

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



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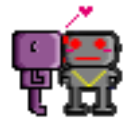
The list `totals` is now a list of tuples (medals, country).

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

Sorting

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

```
>>> ta = [ "Minsu", "Hyunik", "Hyo-Sil",
...         "Junghwan", "YeongJae", "Jinki" ]
>>> ta.sort()
>>> ta
['Hyo-Sil', 'Hyunik', 'Jinki', 'Junghwan',
'Minsu', 'YeongJae']
```



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>>> ta
['Hyo-Sil', 'Hyunik', 'Jinki', 'Junghwan',
'Minsu', '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')]
```

Reversing

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')]
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Actually we only care about the top 10:

```
top_ten = totals[:10]
for p in top_ten:
  medals, country = p
  print medals, country
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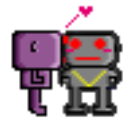

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Slicing

Unpack immediately

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

Slicing

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

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

Then `sublist` contains elements i, $i+1$, ..., $j-1$ of `mylist`.

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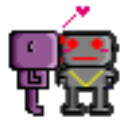
Special case: We can create a copy of a list with

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

Ranking

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
```



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for g,s,b,country in top_ten:
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```

```
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
```

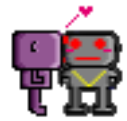
Selecting elements

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

```
def no_medals(countries, al, bl):
  result = []
  for i in range(len(countries)):
    if al[i] == 0 and bl[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
```



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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 methods

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`
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- `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 ]
```

Sequences

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

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Strings:

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

Sequences

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'C'
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>>> for i in a:
...   print i,
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```

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, tuples, strings

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
```

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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']
```

Back to medals

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 ) ]
```

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```

Print total number of medals for each country:

```
def print_totals1():
  for country, g, s, b in medals:
    print country + ":", g + s + b
```

Back to medals

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           ...
           ( '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:])
```

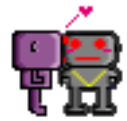
Top ten again

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
```



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

Histogram

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: *
```

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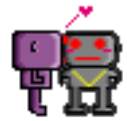
3~5:    ********
6~8:    ***
9~11:   ****
12~14:  *
15~17:  **
18~20:
21~23:  *
24~26:  *
27~29:
30~32:  *
33~35:
36~38:  *
```

```
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])
```

Computing prime numbers

Sieve of Eratosthenes

```
def sieve(n):
  t = range(3, n, 2)
  sqrtn = int(math.sqrt(n))
  i = 0
  while t[i] <= sqrtn:
    # 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
```



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```

```
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
```