香港中文大學（深圳）
The Chinese University of Hong Kong, Shenzhen

Introduction to Computer Science: Programming Methodology

Lecture 5 List

Prof. Junhua Zhao

School of Science and Engineering

List is kind of a collection

- A collection allows us to put many values in a single "variable"

- A collection is nice because we can carry all many variables around in one convenient package

What is not a collection

- Most of our variables have only one value in them – when we put a new value in the variable, the old value will be over-written

```
>>> x=2
>>> x=4
>>> print(x)
4
```

List constants

- List constants are surrounded by square brackets and the elements in the list are separated by commas

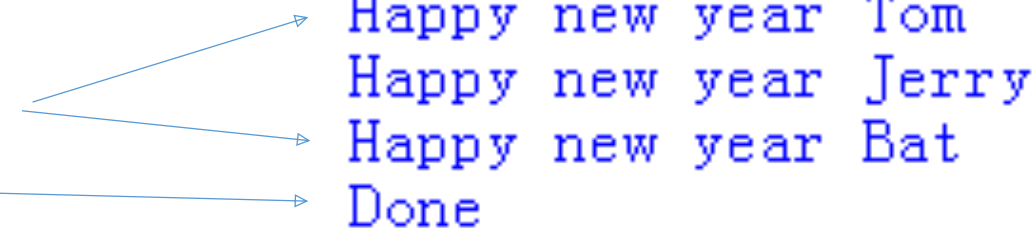
- A list element can be any Python object – even another list

- A list can be empty

```
>>> print([1, 24, 76])
[1, 24, 76]
>>> print(['red', 'yellow', 'blue'])
['red', 'yellow', 'blue']
>>> print(['red', 24, 98.6])
['red', 24, 98.6]
>>> print(1, [5, 6], 7)
1 [5, 6] 7
>>> print([])
[]
```

List and definite loop – best pal

```
friends = ['Tom','Jerry','Bat']
for friend in friends:
    print('Happy new year',friend)
print('Done')
```



```
Happy new year Tom
Happy new year Jerry
Happy new year Bat
Done
```

Looking inside lists

- Just like strings, we can access any single element in a list using an index specified in square bracket


```
>>> friends = ['Joseph', 'Glenn', 'Sally']
>>> print(friends[1])
Glenn
```

Lists are mutable

- Strings are “immutable” – we cannot change the contents of a string unless we make a new string

- Lists are “mutable” – we can change an element of a list using index operator

```
>>> fruit = 'Banana'
>>> fruit[0] = 'b'
Traceback (most recent call last):
  File "<pyshell#3>", line 1, in <module>
    fruit[0] = 'b'
TypeError: 'str' object does not support item assignment
>>>
>>> x=fruit.lower()
>>> print(x)
banana
>>>
>>> lotto = [2, 14, 26, 41, 63]
>>> print(lotto)
[2, 14, 26, 41, 63]
>>> lotto[2]=28
>>> print(lotto)
[2, 14, 28, 41, 63]
```

How long is a list?

- The len() function takes a list as input and returns the number of elements in that list

- Actually len() tells us the number of elements in any sequence (e.g. strings)

```
>>> greet = 'Hello Bob'
>>> print(len(greet))
9
>>> x=[1, 2, 'joe', 99]
>>> print(len(x))
4
```

Range() function

- The range() function returns a list of numbers

- We can construct an index loop using for and an integer iterator

```
>>> x=range(4)
>>> x
range(0, 4)
>>> x[0]
0
>>> x[1]
1
>>> x[2]
2
>>> x[3]
3

>>> x=range(2,10,2)
>>> x[0]
2
>>> x[3]
8
>>> x[4]
Traceback (most recent call last):
  File "<pyshell#31>", line 1, in <module>
    x[4]
IndexError: range object index out of range
```

A tale of two loops

Example

```
friends = ['Tom','Jerry','Bat']

for friend in friends:
    print('Happy new year,', friend)

for i in range(len(friends)):
    friend = friends[i]
    print('Happy new year,', friend)
```

Output

```
Happy new year, Tom
Happy new year, Jerry
Happy new year, Bat
Happy new year, Tom
Happy new year, Jerry
Happy new year, Bat
>>>
```

Concatenating lists using +

- Similar to strings, we can add two existing lists together to create a new list

```
>>> a=[1,2,3]
>>> b=[4,5,6]
>>> c=a+b
>>> print(c)
[1, 2, 3, 4, 5, 6]
>>> print(a)
[1, 2, 3]
```

Lists can be sliced using :

- Remember: similar to strings, the second number is "up to but no including"

```
>>> t=[9, 41, 12, 3, 74, 15]
>>> t[1:3]
[41, 12]
>>> t[:4]
[9, 41, 12, 3]
>>> t[3:]
[3, 74, 15]
>>> t[:]
[9, 41, 12, 3, 74, 15]
```

List methods

```
>>> x=list()
>>> type(x)
<class 'list'>
>>> dir(x)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__'
, '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__',
, '__gt__', '__hash__', '__iadd__', '__imul__', '__init__', '__iter__', '__le__'
, '__len__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_e
x__', '__repr__', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__s
izeof__', '__str__', '__subclasshook__', 'append', 'clear', 'copy', 'count', 'ex
tend', 'index', 'insert', 'pop', 'remove', 'reverse', 'sort']
```

https://docs.python.org/3/tutorial/datastructures.html#more-on-lists

Building a list from scratch

- We can create an empty list using list(), and then add elements using append() method

- The list stays in order, and new elements are added at the end of the list

```
>>> stuff = list()
>>> stuff.append('book')
>>> stuff.append(99)
>>> print(stuff)
['book', 99]
>>> stuff.append('cookie')
>>> print(stuff)
['book', 99, 'cookie']
```

Is something in a list

- Python provides two operators to check whether an item is in a list
- These are logical operators that return True or False
- They do not modify the list

```
>>> some = [1, 9, 21, 10, 16]
>>> 9 in some
True
>>> 15 in some
False
>>> 20 not in some
True
```

A list is an ordered sequence

- A list can hold many items and keeps them in the order until we do something to change the order

- A list can be sorted (i.e. change the order)

- The sort() method means "sort yourself"

```
>>> friend = ['Tom','Jerry','Bat']
>>> friends.sort()
>>> print(friends)
['Bat', 'Jerry', 'Tom']
>>> print(friends[1])
Jerry
>>>
>>> numbers = [1,2,5,100,32,7,97,1001]
>>> numbers.sort()
>>> print(numbers)
[1, 2, 5, 7, 32, 97, 100, 1001]
```

Built-in functions and lists

- There are a number of functions built into Python that take lists as inputs

- Remember the loops we built? These are much simpler

```
>>> numbers = [3, 41, 12, 9, 74, 15]
>>> print(len(numbers))
6
>>> print(max(numbers))
74
>>> print(min(numbers))
3
>>> print(sum(numbers))
154
>>> print(sum(numbers)/len(numbers))
25.666666666666668
```

Averaging with a list

```
total = 0
count = 0
while True:
    inp = input('Enter a number:')
    if inp == 'done': break
    value = float(inp)
    total = total + value
    count = count + 1

average = total/count
print('The average is:', average)
```

Practice

- Write a program to instruct the user to input several numbers and calculate their average using list methods

Best friends: strings and lists

- Use the split() method to break up a string into a list of strings
- We think of these as words
- We can access a particular word or loop through all the words

```
>>> myStr = 'Catch me if you can'
>>> words = myStr.split()
>>> print(words)
['Catch', 'me', 'if', 'you', 'can']
>>> print(len(words))
5
>>> print(words[0])
Catch
>>> for w in words: print(w)

Catch
me
if
you
can
```

- When you do not specify a delimiter, multiple spaces are treated like “one” delimiter

- You can specify what delimiter character to use in splitting

```
>>> line = 'A lot                    of spaces'
>>> etc = line.split()
>>> print(etc)
['A', 'lot', 'of', 'spaces']
>>>
>>> line = 'first;second;third'
>>> thing = line.split()
>>> print(thing)
['first;second;third']
>>> len(thing)
1
>>>
>>> thing = line.split(';')
>>> print(thing)
['first', 'second', 'third']
>>> print(len(thing))
3
```

Practice

- The header of an email takes the following format:

From professor.xman@uct.edu Sat Jan 5 09:14:16 2008

For a given email header, write a program to find out the domain of email address, and the month in which this email is sent

A story of two collections

- List: a linear collection of values that stay in order

- Dictionary: a “bag” of values, each with its own label

Dictionary

https://en.wikipedia.org/wiki/Associative_array

Dictionary

- Dictionaries are Python's most powerful data collection
- Dictionaries allow us to do fast database-like operations in Python
- Dictionaries have different names in different languages
- Associative arrays – Perl/PHP
- Properties or Map or HashMap – Java
- Property Bag – C#/.Net

Dictionary

- Lists index their entries based on the position in the list
- Dictionaries are like bags – no order
- We index the elements we put in the dictionary with a "lookup tag"

```
>>> purse = dict()
>>> purse['money'] = 12
>>> purse['candy'] = 3
>>> purse['tissues'] = 75
>>> print(purse)
{'money': 12, 'tissues': 75, 'candy': 3}
>>> print(purse['candy'])
3
>>> purse['candy']=purse['candy']+2
>>> print(purse)
{'money': 12, 'tissues': 75, 'candy': 5}
>>> purse[3] = 77
>>> print(purse)
{3: 77, 'money': 12, 'tissues': 75, 'candy': 5}
```

Dictionary

```
>>> purse = dict()
>>> purse['money'] = 12
>>> purse['candy'] = 3
>>> purse['tissues'] = 75
>>> print(purse)
{'money': 12, 'tissues': 75, 'candy': 3}
>>> print(purse['candy'])
3
>>> purse['candy']=purse['candy']+2
>>> print(purse)
{'money': 12, 'tissues': 75, 'candy': 5}
```

List v.s. dictionary

- Dictionaries are similar to lists, except that they use keys instead of numbers to look up values

```
>>> lst = list()
>>> lst.append(21)
>>> lst.append(183)
>>> print(lst)
[21, 183]
>>> lst[0] = 23
>>> print(lst)
[23, 183]
```

```
>>> ddd = dict()
>>> ddd['age']=21
>>> ddd['course']=182
>>> print(ddd)
{'age': 21, 'course': 182}
>>> ddd['age']=23
>>> print(ddd)
{'age': 23, 'course': 182}
```

```
>>> lst = list()
>>> lst.append(21)
>>> lst.append(183)
>>> print(lst)
[21, 183]
>>> lst[0] = 23
>>> print(lst)
[23, 183]
```

```
>>> ddd = dict()
>>> ddd['age']=21
>>> ddd['course']=182
>>> print(ddd)
{'age': 21, 'course': 182}
>>> ddd['age']=23
>>> print(ddd)
{'age': 23, 'course': 182}
```

Dictionary literals (constants)

- Dictionary literals use curly braces and have list of key:value pairs
- You can make an empty dictionary using empty curly braces

```
>>> jjj = {'chuck':1,'fred':42, 'jan':100}
>>> print(jjj)
{'fred': 42, 'chuck': 1, 'jan': 100}
>>> ooo={}
>>> print(ooo)
{}
```

Most common names

Counting with a dictionary

- A common use of dictionary is counting how often we “see” something

```
>>> ccc=dict()
>>> ccc['csev']=1
>>> ccc['cwen']=1
>>> print(ccc)
{'csev': 1, 'cwen': 1}
>>> ccc['cwen']=ccc['cwen']+1
>>> print(ccc['cwen'])
2
```

Dictionary tracebacks

- It is an error to reference a key which is not in the dictionary
- We can use the in operator to see if a key is in the dictionary

```
>>> ccc=dict()
>>> print(ccc['csev'])
Traceback (most recent call last):
  File "<pyshell#46>", line 1, in <module>
    print(ccc['csev'])
KeyError: 'csev'
>>> 'csev' in ccc
False
```

Practice

- Write a program to instruct the user to continuously input some words, and use dictionary to count how many times a word has been inputted before.

The get() method

- This pattern of checking to see if a key is already in a dictionary, and assuming a default value if the key is not there is so common, that there is a method called get() that does this for us

```
>>> counts = {'aaa':1,'bbb':2,'ccc':5}
>>> print(counts.get('eee',0))
0
```

Practice

- Write a program to instruct the user to input a line of texts, and use dictionary to count how many times a word has been seen in this line. You should use the get() method in this program.

Definite loops and dictionaries

- Even though dictionaries are not stored in order, we can write a for loop that goes through all elements in a dictionary – actually it goes through all the keys in that dictionary and looks up the values

```
counts = {'chuck':1,'fred':42,'jan':100}

for key in counts:
    print(key,counts[key])
```

```
jan 100
fred 42
chuck 1
```

Retrieving lists of keys and values

- You can get a list of keys, values or items (both) from a dictionary

```
>>> jjj = {'chuck':1,'fred':42,'jan':100}
>>> print(list(jjj))
['jan', 'fred', 'chuck']

>>> print(list(jjj.keys()))
['jan', 'fred', 'chuck']


>>> print(list(jjj.values()))
[100, 42, 1]
>>> print(list(jjj.items()))
[('jan', 100), ('fred', 42), ('chuck', 1)]
```

Bonus: two iteration variables

- We loop through the key-value pairs in a dictionary using two iteration variables

- Each iteration, the first variable is the key, and the second variable is the corresponding value for the key

```
counts = {'chuck':1,'fred':42,'jan':100}
for key,value in counts.items():
    print(key,value)
```

```
chuck 1
fred 42
jan 100
```

Tuples

- Tuples are another type of sequence that function more like a list – they have elements which are indexed starting from 0

```
>>> x=('Glenn','Sally','Joseph')
>>> print(x)
('Glenn', 'Sally', 'Joseph')
>>> y=(1,9,2)
>>> print(y)
(1, 9, 2)
>>> print(max(y))
9
```

```
>>> for i in y:
        print(i)


1
9
2
```

But, tuples are “immutable”

- Unlike a list, once you create a tuple, you cannot change its contents – similar to a string

```
>>> x=[9, 8, 7]
>>> x[2]=6
>>> print(x)
[9, 8, 6]
```

```
>>> y='abc'
>>> y[2]='e'
Traceback (most recent call last)
:
  File "<pyshell#23>", line 1, in
<module>
    y[2]='e'
TypeError: 'str' object does not
support item assignment
```

```
>>> z=(5, 4, 3)
>>> z[2]
3
>>> z[2]=0
Traceback (most recent call last)
:
  File "<pyshell#28>", line 1, in
<module>
    z[2]=0
TypeError: 'tuple' object does no
t support item assignment
```

Some things that you cannot do with tuples

```
>>> x=(1,2,3)
>>> x.sort()
Traceback (most recent call last):
  File "<pyshell#32>", line 1, in <module>
    x.sort()
AttributeError: 'tuple' object has no attribute 'sort'
>>> x.append(5)
Traceback (most recent call last):
  File "<pyshell#33>", line 1, in <module>
    x.append(5)
AttributeError: 'tuple' object has no attribute 'append'
>>> x.reverse()
Traceback (most recent call last):
  File "<pyshell#34>", line 1, in <module>
    x.reverse()
AttributeError: 'tuple' object has no attribute 'reverse'
```

A tale of two sequences

```
>>> l = list()
>>> dir(l)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__', '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__', '__gt__', '__hash__', '__iadd__', '__imul__', '__init__', '__iter__', '__le__', '__len__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__repr__', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__sizeof__', '__str__', '__subclasshook__', 'append', 'clear', 'copy', 'count', 'extend', 'index', 'insert', 'pop', 'remove', 'reverse', 'sort']
>>> t = tuple()
>>> dir(t)
['__add__', '__class__', '__contains__', '__delattr__', '__dir__', '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__', '__getnewargs__', '__gt__', '__hash__', '__init__', '__iter__', '__le__', '__len__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__repr__', '__rmul__', '__setattr__', '__sizeof__', '__str__', '__subclasshook__', 'count', 'index']
```

Tuples are more efficient

- Since Python doe not have to build tuple structures to be modifiable, they are simpler and more efficient in terms of memory use and performance than lists

- In our program when we are making “temporary variables” we prefer tuples over lists

Tuples and dictionaries

- The item() method in dictionaries returns a list of (key, value) tuples

```
>>> d=dict()
>>> d['csev']=2
>>> d['cwen']=4
>>> for (k,v) in d.items():
        print(k,v)


csev 2
cwen 4
>>> tups = d.items()
>>> print(tups)
dict_items([('csev', 2), ('cwen', 4)])
>>> print(list(tups))
[('csev', 2), ('cwen', 4)]

>>> tups = list(tups)
>>> tups[1]
('cwen', 4)
```

字典：d.sort

Tuples are comparable

- The comparison operators work with tuples and other sequences if the first item is equal. Python goes on to the next element, until it finds the elements which are different

```
>>> (0, 1, 2)<(5, 1, 2)
True
>>> (0, 1, 200000)<(0, 3, 4)
True
>>> ('Jones','Sally')<('Jones','Fred')
False
>>> ('Jones','Sally')>('Adams','Sam')
True
```

Sorting lists of tuples

- We can take advantage of the ability to sort a list of tuples to get a sorted version of a dictionary

- First we sort the dictionary by the key using the items() method

```
>>> d={'a':10,'b':1,'c':22}
>>> t=d.items()
>>> t=list(t)
>>> t
[('c', 22), ('b', 1), ('a', 10)]
>>> t.sort()
>>> t
[('a', 10), ('b', 1), ('c', 22)]
```

built-in function ⟷ list function

Using sorted()

sort

list is unchange

list is changed

- We can do this even more efficiently using a built-in function sorted() which takes a sequence as a parameter and returns a sorted sequence

```
>>> d={'a':10,'b':1,'c':22}
>>> d.items()
dict_items([('c', 22), ('b', 1), ('a', 10)])
>>> t=sorted(list(d.items()))
>>> t
[('a', 10), ('b', 1), ('c', 22)]


>>> for k,v in t:
        print(k,v)


a 10
b 1
c 22
```

Practice

- Write a program, which sorts the elements of a dictionary by the value of each element

Answer

```
myDict = {'a':100,'b':10,'c':11,'d':21}
myList = myDict.items()

newList = list()
for e in myList:
    newTuple = (e[1],e[0])
    newList.append(newTuple)

print('The list before sorting:')
print(newList)
print('The list after sorting:')
print(sorted(newList))
```

Sort by values instead of key

- If we could construct a list of tuples of the form (key, value) we could sort by value

- We do this with a for loop that creates a list of tuples

```
>>> d={'a':10,'b':1,'c':22}
>>> tmp = list()
>>> for k,v in d.items():
        tmp.append((v,k))
```

```
>>> print(tmp)
[(22, 'c'), (1, 'b'), (10, 'a')]
>>> tmp.sort(reverse=True)
>>> print(tmp)
[(22, 'c'), (10, 'a'), (1, 'b')]
```

Example: Finding the 10 most common words in a file

```
fhand = open('myhost.txt','r')
counts = dict()
for line in fhand:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0)+1

lst = list()
for key,val in counts.items():
    lst.append((val,key))

lst.sort(reverse = True)

for val,key in lst[:10]:
    print(key,val)
```