

Topic 7: Lists, Dictionaries and Strings

The human animal differs from the lesser
primates in his passion for lists of “Ten Best”

– H. Allen Smith

Recommended Readings

- Chapter 8

STARTING OUT WITH PYTHON®



Lists

- Consider the following problem
 - Write a program that reads the high temperature of each day for the past year
 - Once the data is read, compute
 - Hottest day, Coldest day
 - Identify heat waves, extended cold periods
 - Determine last day of frost in spring, first day of frost in fall
 - Compute average and median temperature
 - Graph the data

What is a List?

- A collection of values
 - All values may have the same type, or
 - Values may have different types
 - Each item is referred to as an element
 - Each element has an index
 - Unique integer identifying its position in the list
 - A list is one type of data structure
 - A mechanism for organizing related data

Creating a List

- Created like other variables
 - Values are comma separated inside square brackets
 - Examples:

```
low_temps = [1.4, -1.8, 0.7, 0.9, 1.2, -2.2, -0.3]
names = ["Ben"]
stuff = [1, "ICT", 3.14]
empty = []
```

Accessing Elements

- Each list element has a unique index
 - Values range from 0 to length of the list - 1
- To access one element, use the name of the list, followed by the index of that element in square brackets
 - Use this one element just like any other variable

Changing Elements

- Individual elements in a list can be changed without impacting the rest of the list

```
aList = [1, "ICT", 3.14]
aList[1] = "Hello"
print aList
aList[2] = "World"
print aList
```

Loops and Lists

- A for loop iterates over the values in a list
 - List can be created by the range function
 - List can be created by any other means
- Consider the following loop:

```
for item in [1, "ICT", 3.14]:  
    print item
```


Length of a List

- When a list is initially created, we know its length
 - Adding / removing elements from the list will change its length
 - New length can be determined using the `len` function in the standard library
 - Examples:
 - `len([0.69, 3.14, -16.0])` returns 3
 - `len([])` returns 0

Loops and Lists

- Sometimes we need a loop where the control variable varies over the indices rather than the values

```
list = [1, "ICT", 3.14]
for i in range(0, len(list))
    print list[i]
```

Adding Elements

- Several methods are defined on lists
 - Use the name of the list you want to work with
 - Follow it by a dot
 - Use the name of the method
 - Provide any required parameters
- Elements are added with `append`

```
aList = [1, "ICT"]  
aList.append(3.14)  
print aList
```

Inserting New Elements

- Append allowed us to add an element to the end of a list
 - What if we want to insert an item in the middle of the list?

Searching

- Use `in` to check if an item is present in a list
 - `2 in [1,2,3,4,5]` evaluates to `True`
 - `8 in [1,2,3,4,5]` evaluates to `False`
- Use `index` to determine where it is in the list
 - `[11,12,13,14].index(12)` evaluates to `1`
 - `[11,12,13,14].index(8)` results in a `Value Error`

Removing

- How can we remove an item from a list?
 - Use the remove method
 - Removes the first occurrence of the item
 - Subsequent identical items remain in the list
 - Item must exist or a Value Error will occur

```
x = [1,2,1,3,4,2,1]
x.remove(1)
print x
```

Removing

- What if we want to remove all occurrences of an item from a list?

Removing

- What if we know the index of the item we want to remove?
 - Use pop
 - With no parameters: Removes last item
 - With one parameter: Removes item at the index specified
 - Returns the item that is removed

Example

- Compute the median of a list of values entered by the user
 - User will enter an unknown number of values
 - A negative number will be used to indicate that no additional values will be entered
 - If the list has an odd number of elements
 - Median is the middle value
 - If the list has an even number of elements
 - Median is average of the two middle values

Design

Sorting

- How do we put things into order?

Selection Sort

Insertion Sort

Bubble Sort

Sorting

- Sorting is an important task
 - Needed when working with large data sets
 - Frequently occurs as part of other algorithms
- Sorting has been studied extensively
 - Many algorithms, some of which are quite complex
 - Selection Sort, Insertion Sort and Bubble Sort
 - Relatively easy algorithms
 - Poor performance for large data sets

Sorting in Python

- Python makes sorting a list easy
 - Use the sorted function
 - Takes one parameter which is an unsorted list
 - Returns a new list sorted into increasing order
 - Use the sort method
 - Invoked on a list using dot notation
 - Does not require any parameters
 - Modifies the list, sorting it into ascending order

Example

- Compute the median of a list of values entered by the user

Other List Operations

- Concatenation
 - Joins two lists
 - Performed using the + operator
- Slicing
 - Extracts a portion of a list
 - Performed using : operator
 - Forms
 - `ListName[first:last]`
 - `ListName[first:last:increment]`

More Dimensions

- All of the lists we have used so far have been one-dimensional
- We can add a second dimension by making each element in a list another list

```
myList = []  
myList.append([1,2])  
myList.append([3,4])
```

Images

- Lists provide a natural representation for images
 - Two dimensional list
 - Outer list is a list of columns (x coordinate)
 - Each column is a list of colors (one for each y coordinate)
 - Each color must be represented
 - Could be packed into a integer
 - Could be a list of the red, green and blue components

Create a New Image

- Create a new image that is 600 pixels wide by 400 pixels high
- Fill the image so that it is a smooth gradient from solid black at the top, to color 255 192 64 at the bottom
- Write a function that displays an image in this format using QuickDraw

Create a New Image

Image Processing

- Common to use loops to process images
 - Nested for loops over indices
 - Apply a transformation to each pixel, possibly using values from nearby pixels as well
 - Examples:
 - Blur / low pass filter
 - Edge detection
 - Grayscale
 - Rotation
 - ...

Image Processing Example

Tuples

- Similar to lists, but
 - length cannot be changed
 - Items cannot be assigned individually
 - () empty tuple, (3,) length one

```
aTuple = (1, "ICT", 3.14)
aList.append(3.14)
print aList
```

From Lists to Dictionaries

- Consider the following problem
 - Many cities in Alberta
 - Want to have a list that contains the populations
 - Need to be able to look up population by city

Dictionaries

- Dictionary: A collection of values
 - Each element in a list has an index
 - A unique integer, starting from 0
 - Dictionaries allow us to extend this idea
 - Each value in the dictionary has a unique identifier associated to it
 - Referred to as a key
 - Can be a string or a number
 - Items in the dictionary are unordered

Dictionary Example

- Create a dictionary that describes the population of several Alberta cities

Adding to a Dictionary

- What if we want to add more cities to our dictionary later in the program?

Removing Items

- Remove one item
 - Use a del statement
 - Example: `del cities["calgary"]`
 - Also works on lists
 - `del some_list[3]`
- Remove all items
 - Use clear method
 - Example: `cities.clear()`

Dictionary Methods

- Want a list of the keys in a dictionary?
 - Use `dictionary_name.keys()`
 - Example:

```
for i in cities.keys():  
    print cities[i], "people live in", i
```

Dictionary Methods

- Want a list of values in a dictionary?
 - Use `dictionary_name.values()`

Dictionary Example

- Consider the following problem
 - We have a list of values
 - Want to determine the mode for the list
 - Mode is defined to be the most frequently occurring value
 - A list may have more than one mode

Dictionaries Example

Dictionaries Summary

- Dictionaries
 - Hold a collection of values
 - Unordered
 - Each element is a key value pair
 - Easy to lookup the value associated with each key

Strings

- Strings
 - A collection of characters
 - Numerous methods available to manipulating strings
 - upper
 - lower
 - swapcase
 - rjust
 - ...

Strings

- Strings provide additional methods for searching, separating, etc.
 - Processing input from the user is challenging
 - Anything could be entered
 - Generally want our program to handle this nicely
 - Common to expend significant effort processing input before it is passed to the rest of the program

String Example: Validating a Password

- Write a function that determines if a password is (somewhat!) secure
 - Has at least 7 characters
 - Contains at least one upper case letter
 - Contains at least one lower case letter
 - Contains at least one numeric digit

Searching

- The find method searches a string for a substring

```
s = "Hello World!"  
print s.find("ll")  
print s.find("o")  
print s.find("o",5)  
print s.find("Wor",0,6)
```

Separating

- Use split
 - Returns a list of strings
 - Splits the string at each separator character that is encountered

```
s = "This is a test string"  
list = s.split(" ")  
for i in list:  
    print i
```


Extracting Characters

- Characters in a string can be accessed by index
 - Enclose index of single character in square brackets
 - Use : to form a slice

```
s = "Hello World!"  
print s[3]  
print s[6:]
```

String Example: Validating a Password

Functions Involving Strings, Lists and Dictionaries

- Lists, Dictionaries & Strings
 - Can be passed as parameters
 - Can be returned as results
- Care must be taken to avoid inadvertently modifying a list or dictionary inside a function

Functions Involving Lists and Dictionaries

Mutable vs. Immutable Types

- In python, every variable is an object
 - Consists of
 - a pointer to some memory
 - value(s) stored in that memory
 - The location that the pointer points to can change
 - For mutable types, the values stored in memory can also change
 - Values stored in memory can not change for immutable types

Mutable vs. Immutable Types

- What happens when a new value is assigned to a variable storing an immutable type?

Mutable vs. Immutable Types

- What happens when we change a value in a list (a mutable data type)?

Mutable vs. Immutable Types

- Examples of Immutable Types
 - Integer, Float
 - String
 - Boolean
 - ...
- Examples of Mutable Types
 - Lists
 - Dictionaries
 - ...

Mutable vs. Immutable Types Review

- Which types are immutable?
- Which types are mutable?
- What happens when you change the value of a variable with immutable type?

Mutable vs. Immutable Types Review

- What happens when you change a variable with mutable type?

- Why are some types immutable and other types mutable?

Organization of Memory

- The memory for a program is organized into four regions
 - Text
 - Data
 - Heap
 - Stack

Key Points

- **Mutable vs. Immutable Types**
 - Memory in the heap doesn't change for immutable types
 - Changing the value of a variable with immutable type causes it to point to a different piece of memory
 - Changing a variable with immutable type in the called scope will not change the value of the variable in the calling scope

Wrapping Up

- Data structures allow us to organize larger amounts of information
 - Lists hold many values (ordered)
 - May have same type or may have different types
 - Each element has a unique integer index, starting from zero
 - Dictionaries hold many values
 - Each element consists of a key-value pair
 - Items can be looked up by key
 - Unordered data structure

Wrapping Up

- Strings help us organize character data
 - Provide mechanisms for searching and splitting strings
 - Can be used to validate user input
- Lists, dictionaries and strings can be passed to and returned from functions
 - Strings are immutable
 - Lists and dictionaries are mutable

Where Are We Going?

- Data structures allow us to manage larger amounts of data in a reasonable way
 - Larger amounts of data typically come from disk
 - Too much to enter by hand
 - How do we load data from files?
 - How do we save data in files?
 - How do we handle errors?