Introduction to programming for Geoscientists

Revision Lecture 2

Christian Jacobs

c.jacobs10@imperial.ac.uk

NumPy Arrays

Definition

- Arrays: data structures which comprise a finite number of elements/items/values.
- Similar to lists (or lists of lists), but are of a fixed size.
- The flexibility of adding/removing elements from a list comes with a cost. List elements may not be stored in contiguous areas of memory and Python therefore has to look up where the elements are stored. This is called indirect addressing.
- In contrast, arrays are generally faster than lists because the elements are stored in contiguous areas of memory.

NumPy Arrays

linspace and zeros

- Two useful functions for creating arrays:
  - linspace(start, end, n): creates an array of n uniformly distributed points in the interval [start, end].
  - zeros(n): creates an array of n elements that are all initialised to zero.
- Or...simply define as a list of lists and cast/convert to an array:

$$\begin{bmatrix} 0 & 12 & -1 \\ -1 & -1 & -1 \\ 11 & 5 & 5 \end{bmatrix}$$

```
a = [ [0, 12, -1],
[-1, -1, -1],
[11, 5, 5] ]
a = array(a)
```

- Remember to include `from numpy import *` in your program.

NumPy Arrays

Referencing/accessing elements

- Referencing/accessing elements in an array is the same as referencing list elements.
- `a[i][j]` accesses the element at row `i` and column `j`.
- Row fiRst, Column seCond.

NumPy Arrays

Vectorised functions

- A vectorised function can accept an array as its input...
- ...and for each element of that array, compute the result...
- ...and output all results in a new array.

```
from numpy import *
a = linspace(0, 1, 10)
result = sin(a) # Result is an array here.
```

- This is like doing:

```
from numpy import *
a = linspace(0, 1, 10)
result = zeros(10)
for i in range(0, 10):
    result[i] = sin(a[i])
```

- But with vectorised functions, this `for` loop is implicit.

Files

Reading

- Open a file (for reading) using `f = open("file_name_here.txt", "r")`.
- A file can be thought of as a list of strings, with each string being a single line of the file.
- We can select one line at a time using `f.readline()`, ...
- ...or select all the lines in the file using `f.readlines()`.
- It is good practice to close the file (once it is no longer needed) with `f.close()`

Files

Writing

- Open a file (for writing) using `f = open("file_name_here.txt", "w")`.
- Write a string to the file using `f.write(string_to_write_here)`.
- Once again, remember to close the file after use.

Dictionaries

Definition

- Dictionary: a data structure whose elements are key-value pairs.
- The key does not have to be an integer.
- Example: `d = {"Barcelona":11.0, "Lleida":6.0, "Tarragona":8.0 }`
- `d.keys()` $\rightarrow$ [“Barcelona”, “Lleida”, “Tarragona”]
- `d.values()` $\rightarrow$ [11.0, 6.0, 8.0]
- Items can be added using `b[new_key_here] = value_here`.
- ...or existing items can be accessed using the key: `print b["Barcelona"]`.

Strings
Definition

- String: a sequence of characters, terminated by an end-of-line marker.
- Each character
  in a string can be accessed in the same way as elements of a list or array:
  `s = "hello"`
  `print s[0]` → "h"
  `print s[2]` → "l"
- `split` breaks up strings wherever a user-defined delimiter is encountered.
- For example, if the delimiter is a comma:
  `s = "hello world, Python is really awesome."`
  `print s.split(",")` → ["hello world", " Python is really awesome"]
- Remember: Strings are immutable/constant data structures. They cannot be modified once defined.

Classes and Objects

Definitions

- Class: a programming construct used to encapsulate data (attributes) and functions (behaviour) in a single package.
  - They make programs more managable.
  - They allow information hiding.
- Object: a specific instance of a class.
- Instantiation: the process of creating an object from a class.
- A class is like a blueprint/template from which objects can be created/instantiated.
- Cake analogy: A cake (object) is created using a recipe (class).

Classes and Objects

Terminology

- Variables belonging to a class are known as attributes.
- Functions belonging to a class are known as methods.
- It is good practice to change attributes via get/set methods, not directly.

Classes and Objects

Example

- General example of a class definition in Python:

```
class ClassName:
    def __init__(self, input1, input2):
        self.a = input1
        self.b = input2
    def method1(self, input1):
        print "Hello %s!" % input1
    def method2(self):
        print "a = %d, b = %d" % (self.a, self.b)

A = ClassName(5, 10)
```

`A.method1("world")` $\rightarrow$ "Hello world!"

`A.method2()` $\rightarrow$ 5, 10

- `self` helps to distinguish class attributes from other variables.
- `__init__` is a special method used to initialise/setup objects.

Classes and Objects

Cake

- The following example describes cake:

```
class Cake:
    def __init__(self, cake_type):
        self.type = cake_type
        self.number_of_slices = 10
    def eat_slice(self):
        self.number_of_slices = self.number_of_slices - 1
        print "%d slices remaining." % self.number_of_slices

A = Cake("Chocolate")
B = Cake("Lemon")
```

`print A.type` → "Chocolate"
`print B.type` → "Lemon"
`B.eat_slice()` → "9 slices remaining."