

Object-oriented Programming and Workflows

A. Richards

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Objectives

Morning

- Compare and contrast functional and object oriented programming
- Given the code for a python class be able to: instantiate, call methods and access the attributes
- Write the python code for a simple class
- Design a program or algorithm in object oriented fashion
- Be able to implement several **magic methods**

Afternoon

- Intro to design patterns – thinking in an object oriented fashion
- Intro to functional programming – be able to compare and contrast functional and object oriented programming
- Intro to workflows

Programming Paradigms

Paradigm	Notable languages	Description
imperative	Fortran, Pascal, BASIC, C	<i>how to do this and how to do that</i>
declarative	SQL, Wolfram Language	<i>the how being left up to the language</i>
functional	Haskell, Erlang, Lisp	<i>evaluate an expression and use the result</i>
logic	Prolog, ALF, Leda	<i>answer a question via search for a solution</i>
object-oriented	Python, Java, Smalltalk	<i>pass messages between meaningful objects</i>

- **imperative** programming languages make use of **procedural programming** (functions)
- A heavy lean on procedural and we move towards **structured** and **modular** programming– fundamental concepts in OOP
- all (pure) functional and logic-based programming languages are also declarative.
- **functional** and **logical** constitute subcategories of the **declarative** category
- Here is [a link to the more comprehensive wiki comparison](#)

What is Python then?

Python

Is an **imperative** programming language that has both **functional** and **object-oriented** aspects. It is also **interpreted**, **interactive**, **iterative**, and more.

Like many popular languages today it is **multiparadigm**.

- Interpreted languages are programming languages in which programs may be executed from source code form, by an interpreter
- This is in contrast to compiled languages
- In theory any language can be compiled or interpreted—it is just that one is generally done more often than the other
- Iterative languages are built around or offering generators

Object-oriented programming

- Object-oriented programming (OOP) is a programming paradigm based on the concept of objects
- In Python, objects are data structures that contain
 - 1 data → attributes
 - 2 procedures → methods

Important

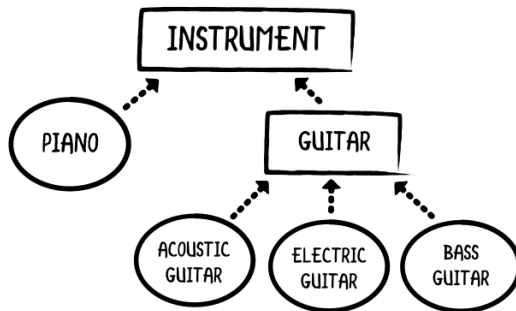
Languages are not object-oriented as much as the language environment supports OOP. Scala is another great example of a language that supports both functional and object-oriented scripting.

Message passing, Polymorphism, Encapsulation, and Inheritance

- ① **Message passing** - objects communicate by sending and receiving messages (methods)
- ② **Polymorphism** - also called subtype polymorphism (can create instances of classes)
- ③ **Encapsulation** - A language construct that facilitates the bundling of data with the methods operating on that data
- ④ **Inheritance** - reuse of base classes to form derived classes

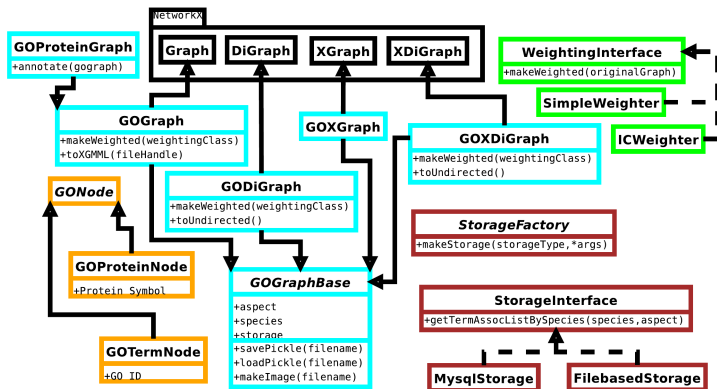
Python does not support **full encapsulation**

A paradigm for the real world



<https://www.raywenderlich.com/160728/object-oriented-programming-swift>

A library to model functional annotation in Biology



This figure is a UML class diagram in which classes are grouped according to their functionalities....

You have been working with objects all along

```
print(type([1,2,3]))
<class 'list'>

print(type(1))
<class 'int'>

print(type(lambda x: x**2))
<class 'function'>
```

In Ipython or Jupyter [tab-completion](#) shows the methods and attributes, but with `dir` you can filter

```
print([t for t in dir(np.array([1,2,3])) if 'set' in t.lower()])
['__setattr__', '__setitem__', '__setstate__', 'itemset', 'setfield', 'setflags']
```

A class is a blueprint that describes the format of an object. How many classes? How many objects?



*args and **kwargs

Convention and shorthand to refer to a variable number of arguments:

For regular arguments, use `*args`:

`*args` is a list

`def a_func(*args):` takes multiple arguments

Can also call function using a list

For keyword arguments, use `**kwargs`:

`**kwargs` is a dict

`def a_func(**kwargs):` takes multiple keyword arguments

Can also call function using a dict

```
def print_all(*args):  
    for count,item in enumerate(args):  
        print('{0}. {1}'.format(count, item))  
  
print(print_all('earth', 'air', 'water', 'fire'))
```

```
0. earth  
1. air  
2. water  
3. fire
```

```
def list_all(**kwargs):  
    for name, item in kwargs.items():  
        print('{0} = {1}'.format(name, item))  
  
list_all(blue_whale = 'Mammalia', lady_bug = 'Insecta')
```

```
blue_whale = Mammalia  
lady_bug = Insecta
```

Magic Methods

Special methods, indicated by double underscore, that you can use to give ubiquitous functionality of some operators to objects defined by your class.

Magic method	Purpose
<code>__init__(self, ...)</code>	Constructor, initializes the class
<code>__repr__(self)</code>	Defines format for how object should be represented
<code>__len__(self)</code>	Returns number of elements in an object
<code>__gt__(self, other)</code>	Provides functionality for the <code>></code> operator
<code>__add__(self, other)</code>	Provides functionality for the <code>+</code> operator
<code>__iadd__(self, other)</code>	Provides functionality for the <code>+=</code> operator

https://www.python-course.eu/python3_magic_methods.php

Morning Breakout

Write a class to make an n-sided die

After a die is instantiated let the user be able to query:

- 1 How many sides it has
- 2 What number is face up (its value)

Also, let the user be able to:

- 1 Roll the die
- 2 Check compare the values of two die ($>$, $<$, $=$, \geq , \leq)



You may use the `Simple.py` or the `Fruit.py` template. Also, before you write any code **Write out the pseudocode.**

Check-in questions

Core questions

- 1 What is the difference between an object and a class?
- 2 What is the difference between an attribute and a method?
- 3 What is the role of `self` in defining a class?
- 4 What can be used to give a custom class functionality similar to other classes?
- 5 How can we see the attributes and methods available on an object?

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Functions, classes, modules and packages

- **function** - A block of organized, reusable code that is used to perform a single related action
- **class** - A template of reusable code that creates objects containing attributes and methods
- **module** - A file containing Python definitions and statements (e.g `mylib.py`)
- **package** - Packages are a way of structuring Python's module namespace
- **library** - A generic term for code designed to be usable by many applications
- **script** - a executable module

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- All packages are modules, but not all modules are packages
 - Any module that contains a `__path__` attribute is considered a package.
 - Packages may be installable via `run.py` and registered in PyPI

The [Python Package index](#) is where many packages live,

OOP design

Build classes via:

- Composition/aggregation:
 - Class contains an object of another class with the desired functionality
 - Often, just basic types: `str`, `float`, `list`, `dict`, etc.
 - *HasA* \Rightarrow use members, aggregation
- Inheritance
 - Class specializes behavior of a base class
 - *IsA* \Rightarrow use inheritance
 - In some cases, derived class uses a *mix-in* base class only to provide functionality, not polymorphism

Interfaces

An interface is a contract between the client and the service provider:

- Isolates client from details of implementation
- Client must satisfy preconditions to call method/function
- Respect boundary of interface:
- Library/module provides a service
- Clients only access resource/service via library
- Then bugs arise from arise incorrect access or defect in library

Test Driven Development (TDD)

Make sure your interface is intuitive and friction-free:

- Use unit tests or specification test
 - To verify interface is good before implementation
 - To exercise individual functions or objects before application is complete
 - Framework can setup and tear-down necessary test fixture
- Stub out methods using pass
- Test Driven Development (TDD):
 - Red/Green/refactor
 - 1 Write unit tests
 - 2 Verify that they fail (red)
 - 3 Implement code (green)
 - 4 Refactor code (green)
- Use a **unit test** framework – unittest (best), doctest, or nose

Verification and Validation in [Scientific Computing](#) discusses rigorous framework to ensure correctness

Afternoon Breakout

Write a unit test to test for object equality

- 1 `run-tests.py` - controls all tests
 - 2 `unittests` - is a folder where the test scripts live
 - 3 `unittests/__init__.py` - controls what is run by `run-tests.py`
 - 4 `unittests/DieTest.py` - contains the actual tests for the `Dice` class
-
- 1 Fill in the `testEquality` function
 - 2 Using the red/green/refactor procedure to write a new test for the `__lt__` magic method in `BaseDie`

In part II, Just test something simple—exposure to this framework is what is important not the [coverage](#)

Design Patterns

Many design patterns exist to standardize best practice and they are worth learning if you regularly develop software

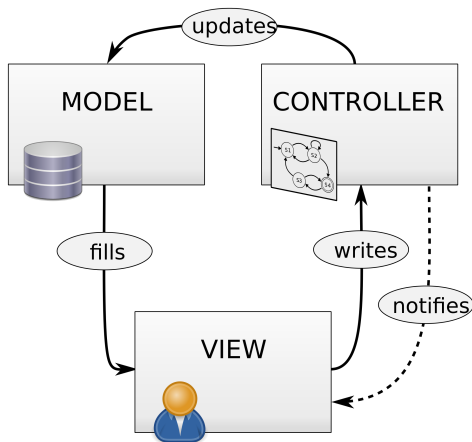
Examples

- **MVC** (Separate out Model, View, Controller)
- **Abstract Factory** - Provide an interface for creating families of related or dependent objects without specifying their concrete classes
- **Decorator** - Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality
- **Observer** - Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically
- **Builder** - Separate the construction of a complex object from its representation so that the same construction process can create different representations

Check out the book:

Design Patterns: Elements of reusable Object-Oriented Software

Design Patterns



[https://commons.wikimedia.org/wiki/File:MVC_Diagram_\(Model-View-Controller\).svg](https://commons.wikimedia.org/wiki/File:MVC_Diagram_(Model-View-Controller).svg)

Check-in questions

Core questions

- 1 How do we know if we need functions, modules, or packages?
- 2 What are the three key components of OOP? How do they lead to better code?
- 3 How should I implement my code if the relationship is *Is A*?
What if the relationship is *Has A*?
- 4 What should you do ensure an object is initialized correctly?
- 5 What are the benefits of TDD? What does Red/Green/Refactor mean?