

Introduction to Python

Object-Oriented Programming

Topics

- 1) Classes
- 2) Class vs Object
- 3) `__init__`(dunder init)
- 4) Functions vs Methods
- 5) `self`
- 6) Importing modules

An Example

So far, our data has been one piece of information: an int, a float, a string. If we have several pieces of information, we can use tuples to store all of the data:

```
student = ("Mike Smith", 3.5)
```

Tuples are often used to store static data: data that doesn't change in the course of the program. In a more complex setting, we might need to store data that does change throughout the program.

We need a data type that: 1) store several pieces of data and 2) have the ability to manipulate or change that data.

An Example

Suppose we are writing a program that manages a database of students.

We need a data type that contains information about a student. A student has more than just one piece of information: name, age, id, address, list of courses, grades etc... These collectively are the **data** of a student.

A student might have some **functionalities**: ability to print personal information, add a course, update a grade., change their address, update school information,

We like a data type that can bundle **data** and **functionality** into one variable.

A **class** bundles together *data* (instance variables or attributes) and *functionality* (functions). From that class, we can create many **objects** of that class.

An Example of a class

We'll discuss "self" later in the slides.

```
class Student:
    def __init__(self, name, id):
        self.name = name
        self.id = id
    def print_info(self):
        print(self.name, self.id)
```

Class definition.

This class Student can then be used to create multiple Student objects.

```
s1 = Student("Mike Smith", 34323)
s2 = Student("Sarah Jones", 67432)
print(s1.name)      # Mike Smith
print(s2.name)      # Sarah Jones
print(s1.id)        # 34323
s1.print_info()     # Mike Smith 34323
s2.print_info()     # Sarah Jones 67432
```

Each Student object has data(name, id) and functionality(print_info).

To access data/functionality, the dot notation is used.

Class vs Objects

A **class** bundles together *data* (instance variables or attributes) and *functionality* (methods).

Thus, in the previous example, Student is a **class** and s1 and s2 are two of its **objects**.

OOP/OOD

Object-Oriented Programming(OOP) is a programming paradigm based on the concepts of **objects** which bundles together **data**(in the form of instance variables) and **functionality or behavior**(in the form of functions or methods).

Many popular languages are object-oriented(C++, Java, Javascript, Python).

In OOP, programs are made up of many objects and a program run is the interaction of these objects.

Custom Classes

A **class** bundles together **data** (instance variables or attributes) and **functionality** (methods).

A list has data(the elements of the list). It also has methods that manipulate those data(append, insert, pop, remove, etc...).

The classes int, bool, str, list, tuple, etc... are built-in classes.

Python provides the ability for programmers to design their own classes(**custom classes**).

Class

We like to be able to build our own classes to represent objects relevant to our game or application.

A game might have a Character class, from which we may create several Character **instances** or **objects**.

This **reusability** feature is important especially when we need to create many objects(for example enemies) with similar data and behaviors.

Examples

Suppose you are writing an arcade game. What are some useful classes and their corresponding objects?

Example:

The **Character** Class represents characters in the game.

Variables/Attributes/Data: name, position, speed.

Behavior/Methods: shoot(), runLeft(), runRight(), jump().

Objects: From the same blueprint, the Character class, we can create multiple Character objects.

Examples

Your game might have more than one classes. Each class can have many objects of that class or type.

Classes: Character, Boss, Tile, Bullet.

Objects:

- 1) You may have one player object from the Character class.
- 2) Several Boss objects, one for each level.
- 3) A set of Tile objects for the the platforms on which the game objects walk.
- 4) Many Bullet objects are created as Character or Boss objects shoot.

Class Declaration

A class is declared with the keyword `class` followed by the class name.

```
class ClassName:
```

To create and initialize our instance variables, we need to define a **special method** called `__init__` (double underscore init or "dunder init"). This method is sometimes called the **constructor**.

The Character Class

An example of a class.

```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        self.name = i_name
        self.x = i_x
        self.speed = i_speed
```

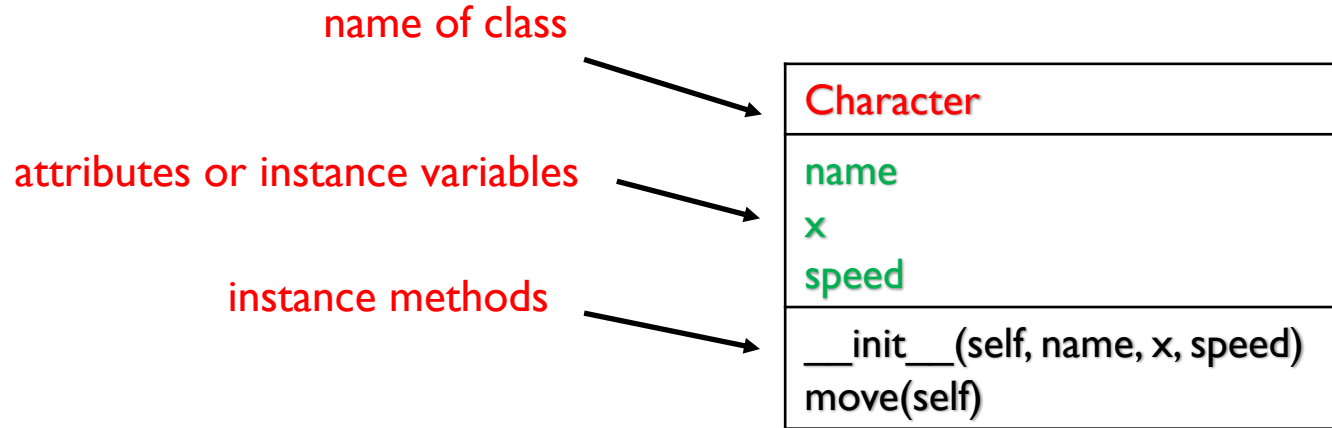
Constructor: **init** is a **special method** that creates and initializes the instance variables(or attributes) (pronounced "dunder init" (double underscore init))

instance variables or instance attributes (use **self** with dot notation)

The **self** parameter is automatically set to reference the newly created object. It can use another name but "**self**" is the convention.

A Class Diagram

Here's a class diagram that can help you visualize a class.



Class

2) The self parameter is now pointing to the newly created Character object or instance

```
class Character:
```

```
    def __init__(self, i_name, i_x, i_speed):
```

```
        self.name = i_name
```

```
        self.x = i_x
```

```
        self.speed = i_speed
```

```
p = Character("John", 10, 4)
```

1) An object is first created in memory. Then `__init__` is called and the address of this object is sent to `self`.

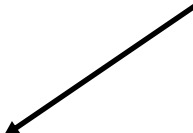
3) The self reference is then used to create and initialize the other attributes or variables of the object.

In this case: name, x and speed are the three attributes of the Character object.

Class

```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        self.name = i_name
        self.x = i_x
        self.speed = i_speed
```

4) After all instance variables are initialized, the address or reference of the object is returned(to p).



```
p = Character("John", 10, 4)
print(p.x, p.speed) # accessing attributes: 10 4
p.speed = 15 # modifying an instance attribute
print(p.speed) # 15
```

game.py

```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        self.name = i_name
        self.x = i_x
        self.speed = i_speed
```

- 1) Character is a **class** or **type**.
- 2) p is an **instance** of the Character class.
- 3) p is an **object** of the Character class.
- 4) name, x and speed are **attributes** of the object.

```
p = Character("John", 10, 4)
print(p.x, p.speed) # accessing attributes, 10 4
p.speed = 15 # modifying an instance attribute
print(p.speed) # 15
```

Function vs Methods

A function defined inside of a class is called a **method(instance method)**.

We saw that `__init__` is one example of a method.

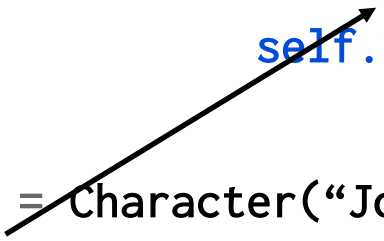
The first parameter of an instance method refers to the instance or object being manipulated. By convention, we use "self" for this first parameter.

Note: In addition to instance methods, Python supports **class methods** and **static methods**. We won't discuss these in this class.

game.py

```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        ...
    def move(self):
        self.x += self.speed

p = Character("John", 10, 4)
p.move()
print(p.x) # 14
e = Character("Sarah", 100, -5)
e.move()
print(e.x) # 95
main()
```



`move()` is an **instance method**. The first parameter of a method(`self`) refers to the instance being manipulated.

In this case, `p` is being moved.

We have seen this notation before. For example:

```
a = [1, 2, 3]
a.pop()
```

game.py

```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        ...
    def move(self):
        self.x += self.speed
```

```
p = Character("John", 10, 4)
```

```
p.move()
```

```
print(p.x) # 14
```

```
e = Character("Sarah", 100, -5)
```

```
e.move()
```

```
print(e.x) # 95
```

In this case, e is being moved.

game2.py

```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        self.name = i_name
        self.x = i_x
        self.speed = i_speed
    def move(self):
        self.x += self.speed
```

```
p1 = Character("Jack", 10, 4)
p2 = Character("Jill", 20, -3)
p1.move() # p1.x = 14
p2.move() # p2.x = 17
```

The utility of writing a class is that we can create many objects or instances of that class. This code for this example creates 2 Character objects.

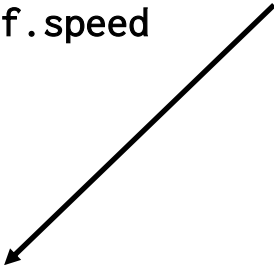
game3.py

```
import random

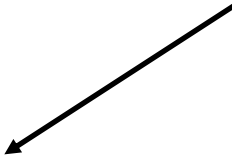
class Character:
    def __init__(self, i_name, i_x, i_speed):
        self.name = i_name
        self.x = i_x
        self.speed = i_speed
    def move(self):
        self.x += self.speed
```

```
enemies = []
for i in range(10):
    x = random.randrange(0, 800)
    enemies.append(Character("Goomba", x, 5))
```

randrange(a, b) generates a random integer from a(included) to b(not included).



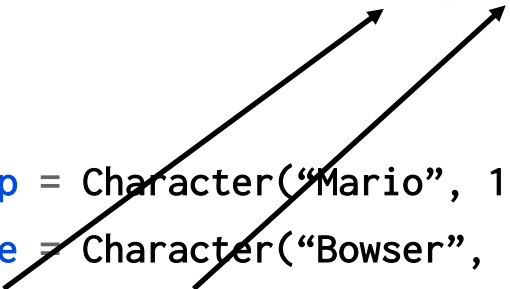
We can even create any number of randomized objects.



game3.py

```
class Character:
    def __init__(self, i_name, i_x, i_speed): ...
    def move(self): ...
    def shoot(self, target): ...
```

```
p = Character("Mario", 10, 4)
e = Character("Bowser", 20, -3)
e.shoot(p) # p1.x = 14
```



The object `e` is shooting the object `p` in this example.

Thus, `e`'s address is sent to `self` and `p`'s address is sent to `target`.

Python Program Template

`main.py`

`# declare and initialize global variables with file scope`

`...`

`# function definitions`

`def func1(...):`

`...`

`def func2(...):`

`...`

`# class definitions`

`class MyClass1:`

`...`

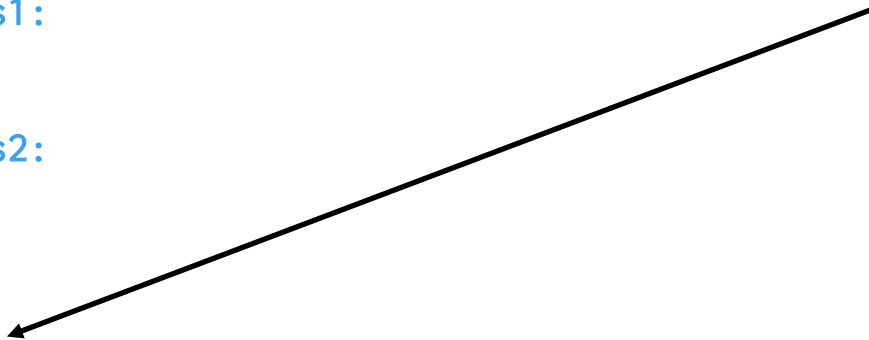
`class MyClass2:`

`...`

`func1()`

`a = MyClass1()`

If our program has a small number of functions and classes, we can define all of them in the same file and use them right below their definitions.



A Program with Multiple Modules

A more complex program may require many functions, classes. We may wish to organize them into different **modules**.

A **module** is a .py file that contains code, including variable, function and class definitions.

Importing a module will execute all of its statements. The objects defined in the imported module is now available in the current module. Let's see how this is done.

A Program with Multiple Modules

The statement **import** can be used to import the entire module. All of the code from `helper.py` is executed. The dot(".") notation is needed to access imported code.

main.py

```
import helper

print(helper.a)
helper.lst.append("hello")
print(helper.lst)
print(helper.add(3, 5))
```

helper.py

```
print("in helper.py!")

a = 5

lst = [1, "hi"]

def add(x, y):
    return x + y
```

Output:

in helper.py!

5

[1, "hi", "hello"]

8

You can see the code for this example on repl.it at:

<https://repl.it/@LongNguyen18/ImportModulesPython>

A Program with Multiple Modules

You can specify an **alias** for the imported module.

main.py

```
import helper as hp

print(helper.a)
print(helper.lst)
print(helper.add(3, 5))
```

helper.py

```
print("in helper.py!")

a = 5

lst = [1, "hi"]

def add(x, y):
    return x + y
```

Output:

in helper.py!

5

[1,"hi"]

8

A Program with Multiple Modules

You can import all objects by using *. No dot notation is needed to access the imported code in this case.

main.py

```
from helper import *  
  
print(a)  
print(lst)  
print(add(3, 5))
```

helper.py

```
print("in helper.py!")  
  
a = 5  
  
lst = [1, "hi"]  
  
def add(x, y):  
    return x + y
```

Output:
in helper.py!
5
[1,"hi"]
8

Lab I

Write the Student class which has two instance variables: name(str) and gpa(float).

Write the average_gpa function which accepts a list of Student objects and returns the average gpa.

Write the main method and:

- 1) Create a Student object and store it in a variable. Print out name and gpa of the Student object using the dot notation.
- 2) Create a list of three Student objects. Use a for loop to print out the names.
- 3) Call average_gpa and make sure it works by printing out the average gpa.

Lab I

Modify the previous lab by putting Student class and the average gpa function in a different module(.py).

Make the necessary import statement to make your code runs correctly.

References

- I) Halterman, Richard. Fundamentals of Python Programming. Southern Adventist University.