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.

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, etc…These collectively are the **data** of a student.

A student might have some **functionality**: ability to print personal information, 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). Another name for class is **type**.

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)

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
```

Class definition.

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

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). Another name for class is **type**.

Thus, in the previous example, Student is a **class**(or **type**) 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 **data(**in the form of instance variables) and **functionality or behavior(**in the form of 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 types or 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.

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

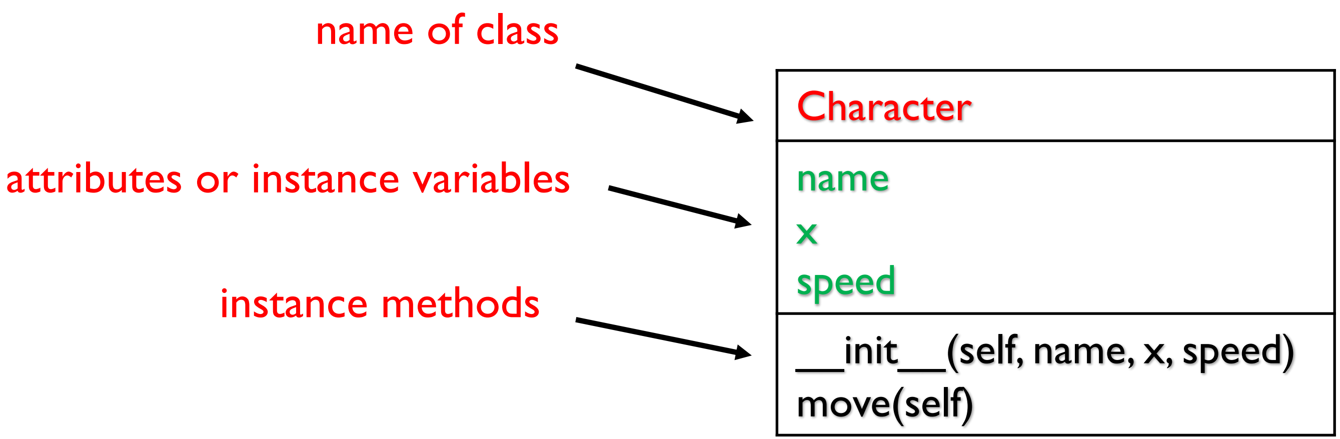
```
class Character:
    def __init__(self, i_name, i_x, i_speed):
        self.name = i_name
        self.x = i_x
        self.speed = i_speed
```

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

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

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

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
```

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.

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:
        …

funct1()
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.

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

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

helper.py

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

a = 5

lst = [1, "hi"]

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

A Program with Multiple Modules

You can selectively import certain objects.

main.py

```
from helper import lst, add

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

Output:

in helper.py!
[1,"hi", "hello"]
8

helper.py

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

a = 5

lst = [1, "hi"]

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

A Program with Multiple Modules

You can import all objects by using *.

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

import vs from

It is generally better to use the import statement than to use the from statement.

Even though using import is less concise, it is more explicit and readable. Other programmers can see from the syntax which module contains the imported attributes and functions. For example:

It is better to:

```
import math

print(math.pi)
```

than to:

```
from math import pi

print(pi)
```

isinstance

The built-in `isinstance(a, b)` function returns whether a is an instance of b.

```
a = [0, 5, 2]
print(isinstance(a, list))          # True
print(isinstance(a, str))           # False

b = ”hi”
print(isinstance(b, str))           # True

p = Character(”Mario”, 100, 5)
print(isinstance(p, Character))     # True
```

Another Example

```
# class definitions
class Employee:
      def __init__(self, name, salary)
            self.name = name
            self.salary = salary

emp1 = Employee("Mike Smith", 60000.0)
emp2 = Employee("Sarah Jones", 75000.0)
print(emp1.name)
print(emp2.salary)
```

A list of objects

main.py

```
class Employee:
	def __init__(self, name, salary)
		self.name = name
		self.salary = salary
def printEmployeesInfo(lst):
	for emp in lst:
		print("Name: ", emp.name)
		print("Salary: ", emp.salary)

emp1 = Employee("Mike Smith", 60000.0)
emp2 = Employee("Sarah Jones", 75000.0)
employees = [emp1]
employees.append(emp2)
printEmployeesInfo(employees)
```

Lab 1

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 1

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

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