

Object-Oriented Programming in Python

Videogames Technology
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Departamento de Automática

Objectives

1. Introduce basic programming concepts.
2. Understand the main characteristics of Object-Oriented Programming (OOP).
3. Use Python to implement class hierarchies
4. Use class libraries

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Understanding concepts

Differentiate between ...

Programming

Set of techniques that allow the development of programs using a programming language.

Programming language

Set of rules and instructions based on a familiar syntax and later translated into machine language which allow the elaboration of a program to solve a problem.

Paradigm

Set of rules, patterns and styles of programming that are used by programming languages.

Programming paradigms types (I)

Declarative programming

Describe **what** is used to calculate through conditions, propositions, statements, etc., but does not specify **how**.

- **Logic:** follows the first order predicate logic in order to formalize facts of the real world. (Prolog)
 - Example: Anne's father is Raul, Raul's mother is Agnes. Who is Ana's grandmother
- **Functional:** it is based on the evaluation of functions (like maths) recursively (Lisp y Haskell).
 - Example: the factorial from 0 and 1 is 1 and n is the factorial from $n * \text{factorial}(n-1)$. What is the factorial from 3?

Programming paradigms types (II)

Imperative programming

Describes, by a set of instructions that change the **program state**, **how** the task should be implemented.

- **Structural:** is based on nesting, loops, conditionals and subroutines. **GOTO** command is forbidden (C, Pascal, Python).
 - Example: reviewing products of a shopping list and add the item X to the shopping if it is available.
- **Object-Oriented Programming**

Programming paradigms types (III)

Object-Oriented Programming

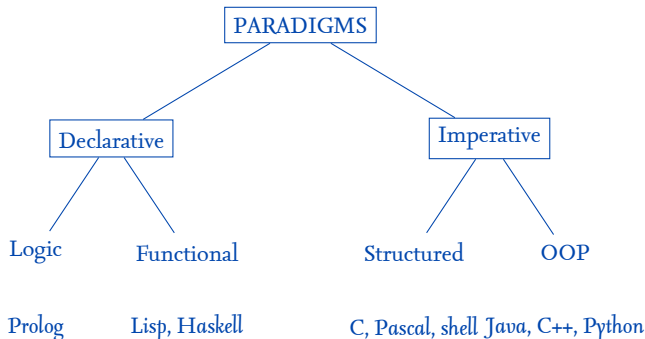
Evolves from imperative programming. It is based on **objects** that allow express the **characteristics** and **behavior** in a closer way to real life.

- **Main characteristics:** abstraction, encapsulation, polymorphism, inheritance, modularity, etc.
- Example: a car has a set of properties (color, fuel type, model) and a functionality (speed up, shift gears, braking).

There are many other paradigms such as Event-Driven programming, Concurrent, Reactive, Generic, etc.

Programming paradigms types (IV)

Classification



Python supports the three major paradigms, although it stands out for the OOP

Object-Oriented Programming

Objectives

- **Reusability:** Ability of software elements to serve for the construction of many different applications.
- **Extensibility:** Ease of adapting software products to specification changes.
- **Maintainability:** Amount of effort necessary for a product to maintain its normal functionality.
- **Usability:** Ease of using the tool.

Object-Oriented Programming

Concepts (I)

Class

Generic entity that groups attributes and functions

Attribute

Individual characteristics that determine the qualities of an object



Method

Function responsible for performing operations



Object-Oriented Programming

Concepts (IV)

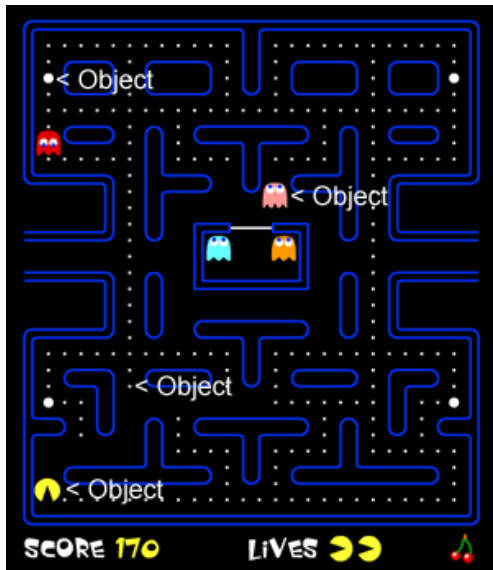
Object or instance

Specific representation of a class, namely, a class member with their corresponding attributes.



Object-Oriented Programming

Concepts (V)



(Source)

Object-Oriented Programming

Concepts (VI)

Two operations on classes

Instantiation

Creates a new object
Standard functional notation

```
x = MyClass()
```

Example

```
>>> snoopy = Dog()
>>> laika = Dog("Laika")
```

Attribute references

Accesses an attribute value
Standard dot syntax

```
obj.name
```

Example

```
>>> snoopy.name = "Snoopy"
>>> print(snoopy.name)
>>> name = snoopy.name
```

Object-Oriented Programming

Constructors (I)

Constructor

Method called when an object is created. It allows the initialization of attributes.



Concepts of OOP

Constructors (II)

Instantiation creates empty objects

- We usually need to initialize attributes
- Initialization operations

Constructor: Method called when an object is created

- In Python, it is the `__init__()`
- A constructor can get arguments

dog.py

```
1 class Dog:
2     def __init__(self, name="Unknown", age=0):
3         # Constructor
4         self.name = name        # Attribute
5         self.age = age          # Attribute
6
7     def bit(self):               # Method
8         print(self.name + " has bitten")
9
10    def describe(self):          # Method
11        print("Name: ", self.name)
12        print("Age: ", self.age)
13
14    if __name__ == '__main__':
15        snoopy = Dog() # Instantiate class Dog ...
16        laika = Dog("Laika")
17        # snoopy and laika are objects
18
19        snoopy.name = "Snoopy"
20        snoopy.age = 4
21
22        snoopy.bit()
23        snoopy.describe()
24
25        print() # Print empty line
26        laika.age = 10
27        laika.describe()
```

Output

```
Snoopy has bitten
Name:  Snoopy
Age:   4

Name:  Laika
Age:   10
```

(Source code)

dog.py

```
1 class Dog:
2     def __init__(self, name="Unknown", age=0):
3         # Constructor
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22        snoopy.bit()
23        snoopy.describe()
24
25    print() # Print empty line
26    laika.age = 10
27    laika.describe()
```

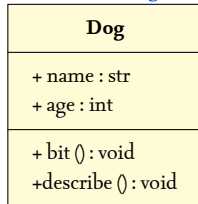
Output

```
Snoopy has bitten
Name:  Snoopy
Age:   4

Name:  Laika
Age:   10
```

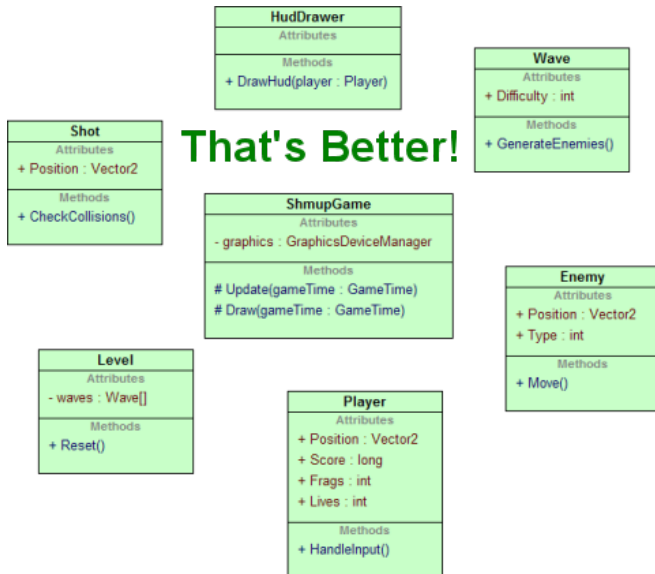
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UML class diagram



Object-Oriented Programming

OO game example



Inheritance

Definition

Inheritance

Mechanism of **reusing** code in OOP. Consists of generating child classes from other existing (**super-class**) allowing the use and adaptation of the attributes and methods of the parent class to the child class

A subclass inherits all the attributes and methods from its superclass

- Superclass: “Father” of a class
- Subclass: “Child” of a class

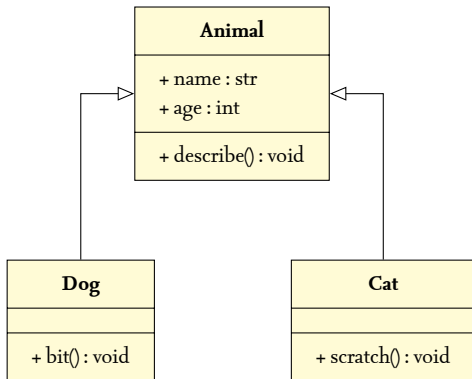
Inheritance

Examples of simple inheritance (I)

Dog	Cat
+ name : str + age : int	+ name : str + age : int
+ bit() : void + describe() : void	+ scratch() : void + describe() : void

Inheritance

Examples of simple inheritance (II)



```
class Animal:
    def __init__(self):
        self.name = "Unknown"
        self.age = 10

    def describe(self):
        print("Name: ", self.name)
        print("Age: ", self.age)

class Dog(Animal):
    def bit(self):
        print(self.name + " has bitten")

class Cat(Animal):
    def scratch(self):
        print(self.name + " has scratched")

if __name__ == '__main__':
    snoopy = Dog()
    garfield = Cat()

    snoopy.name = "Snoopy"
    garfield.name = "Garfield"

    snoopy.bit()
    garfield.scratch()

    garfield.bit() # Error!
```

(Source code)

Inheritance

Examples of simple inheritance (III)

Class hierarchy: A set of classes related by inheritance

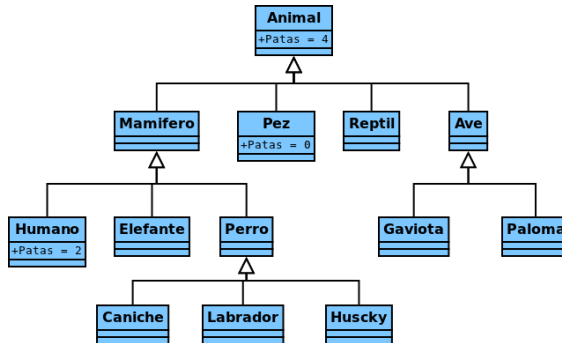
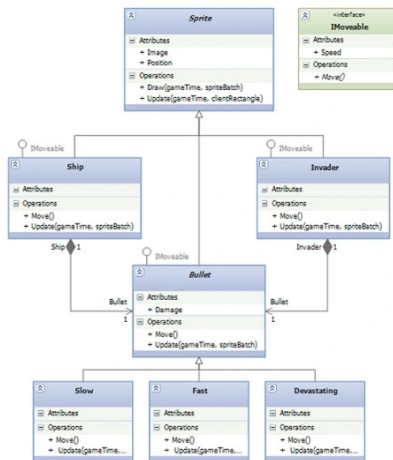


Figura 1: Example of simple Inheritance in OOP. Obtained from: <http://android.scenebeta.com>

Inheritance

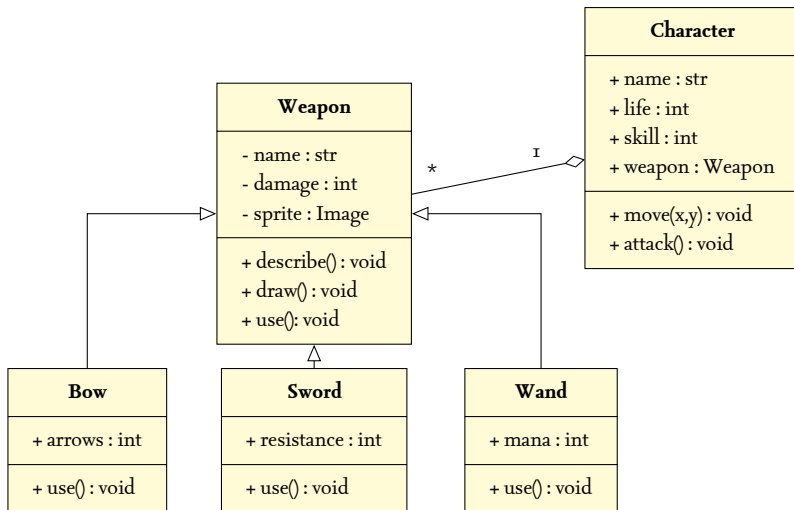
Examples of simple inheritance (IV)



("Comments on my design v3 - Stack
Overflow," 2011)

Inheritance

Examples of simple inheritance (V)



Inheritance

Types of inheritance (I)

Types of inheritance

- If the child class inherits from a single class is called **single inheritance**.
- if it inherits from more classes is **multiple inheritance**.

Python allows both; simple and multiple inheritance.

Inheritance

Types of inheritance (II)

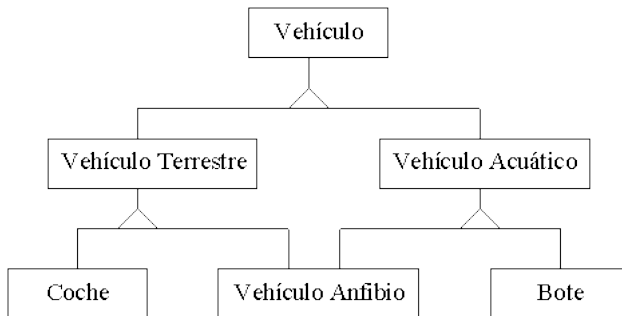


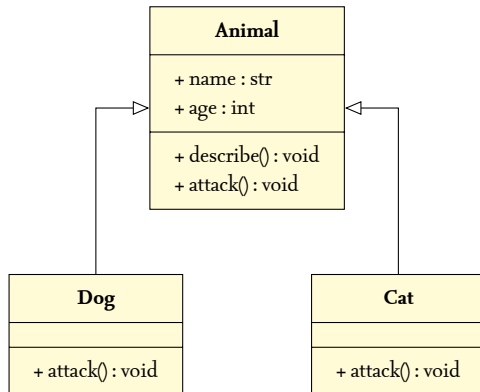
Figura 2: Example of multiple Inheritance in OOP. Obtained from: <http://www.avizora.com>

Concepts of OOP

Polymorphism (I)

Polymorphism

Mechanism of object-oriented programming that allows to invoke a method whose implementation will depend on the object that does it.



```
class Animal:
    def __init__(self):
        self.name = "Unknown"
        self.age = 10

    def describe(self):
        print("Name: ", self.name)
        print("Age: ", self.age)

    def attack(self):
        pass

class Dog(Animal):
    def attack(self):
        print(self.name + " has bitten")

class Cat(Animal):
    def attack(self):
        print(self.name + " has scratched")

if __name__ == '__main__':
    snoopy = Dog()
    snoopy.name = "Snoopy"
    garfield = Cat()
    garfield.name = "Garfield"

    for animal in (snoopy, garfield):
        animal.attack()
```

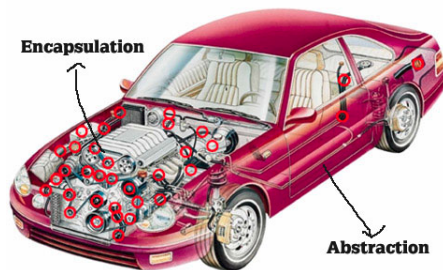
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Concepts of OOP

Encapsulation (I)

Encapsulation

Mechanism use to provide an access level to methods and attributes for avoiding unexpected state changes



(Source)

Concepts of OOP

Encapsulation (II)

The most common access levels are:

- **public:** visible for everyone [default in Python]
- **private:** visible for the class
 - By convention in Python, start with underscore
 - Superprivate starts with a double underscore and does not end in the same manner
- **protected:** visible for the creator class and its descendents [does not exist in Python]

Methods “getters” and “setters” to control the access to attributes

```
class Dog:
    def __init__(self):
        self._name = "Unknown"
        self.__age = 10

    def setName(self, name):
        self._name = name

    def getName(self):
        return self._name

    def setAge(self, age):
        if age > 0:
            self.__age = age

    def getAge(self):
        return self.__age

if __name__ == '__main__':
    snoopy = Dog()
    snoopy.setName("Snoopy")
    print(snoopy.getName())

    snoopy._name = "Laika" # No error, do not do this

    print(snoopy.__name) # Error!
```

(Source code)

Concepts of OOP

Encapsulation: The “pythonic” way

getters and setters comes with some drawbacks

- Verbose and repetitive code
- Linked to the API

A more pythonic way to define getters and setters is using **properties**

- It is a **decorator** that transform methods into getters or setters
- **@property**: Getter
- **@object.setter**: Setter
- Nevertheless, getters and setters are still used in Python under certain circumstances

Better with an example ...

```
class Dog:
    def __init__(self, name="Unknown", age=0):
        self._name = name

    @property
    def name(self):
        return self._name

    @name.setter
    def name(self, name):
        self._name=name.upper()

if __name__ == '__main__':
    snoopy = Dog()
    snoopy.name = "Snoopy" ## Calls setter

    print(snoopy.name)      ## Calls getter
```

Concepts of OOP

Other special methods

In addition to special method `__init__`, there are several others, including:

- `__str__(self)` It should return a string with information
- `__len__(self)` It should return the length or “size” of object (number of elements if is a set or queue)

```
class Dog:
    def __init__(self, name="Unknown", age=0):
        self.name = name
        self.age = age

    def __str__(self):
        return self.name + ': ' + str(self.age)

    def __len__(self):
        return 1

if __name__ == '__main__':
    snoopy = Dog("Snoopy", 10)
    print(snoopy)           # Outputs "Snoopy: 10"
    print(len(snoopy))      # Outputs "1"
```

Concepts of OOP

Overriding methods (I)

Often we need to adapt an inheritance method: **Overriding**

Overriding example

```
class A:
    def hello(self):
        print("A says hello")

class B(A):
    def hello(self):
        print("B says hello")

b = B()
b.hello()
```

Concepts of OOP

Overriding methods (II)

Still possible to get superclass' method with `super()`

`super()` example

```
class A:
    def hello(self):
        print("A says hello")

class B(A):
    def hello(self):
        print("B says hello")
        super().hello()

b = B()
b.hello()
```

```
1 import arcade
2
3 SCREEN_WIDTH = 800
4 SCREEN_HEIGHT = 600
5
6 class MyGame(arcade.Window):
7     """ Our Custom Window Class """
8
9     def __init__(self):
10         """ Initializer """
11
12         # Call the parent class initializer
13         super().__init__(SCREEN_WIDTH, SCREEN_HEIGHT, "My Game")
14
15     def on_draw(self):
16         arcade.start_render()
17
18
19 def main():
20     window = MyGame()
21     arcade.run()
22
23
24 main()
```

```
1 import arcade
2
3 class MyGame(arcade.Window):
4     def __init__(self, width, height, title):
5         super().__init__(width, height, title)
6
7         arcade.set_background_color(arcade.color.ASH_GREY)
8
9         self.ball_x = 50
10        self.ball_y = 50
11
12    def on_draw(self):
13        arcade.start_render()
14
15        arcade.draw_circle_filled(self.ball_x, self.ball_y, 15,
16                                  arcade.color.AUBURN)
17
18    def update(self, delta_time):
19        self.ball_x += 1
20        self.ball_y += 1
21
22    def main():
23        window = MyGame(640, 480, "Drawing Example")
24        arcade.run()
25
26 main()
```

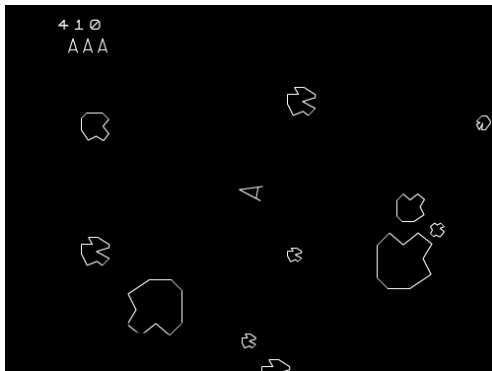
Arcade

The `arcade.Window` class.

- `on_draw()`. Override this function to add your custom drawing code
- `on_update(delta_time: float)`. Move everything. Perform collision checks. Do all the game logic here
- `on_key_release(symbol: int, modifiers: int)`
- `on_mouse_release(x: float, y: float, button: int, modifiers: int)`.
Override this function to add mouse button functionality
- `set_viewport(left: float, right: float, bottom: float, top: float)`.
Set the coordinates we can see

Check out (reference documentation)

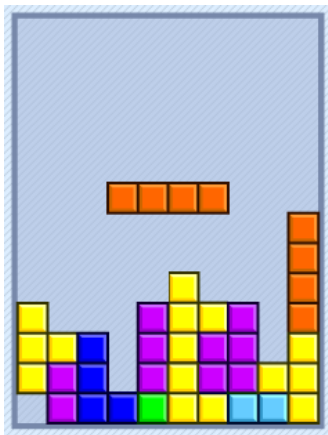
Exercise 1: Asteroids



(Source)

1. Identify the classes in the Asteroids videogame
2. Identify attributes contained in the previous classes
3. Identify methods contained in the previous classes

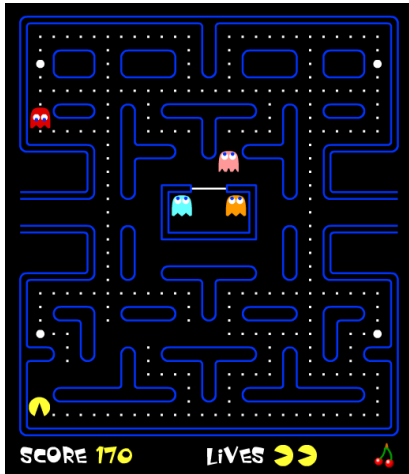
Exercise 2: Tetris



(Source)

1. Identify the classes in the Tetris videogame
2. Identify attributes contained in the previous classes
3. Identify methods contained in the previous classes

Exercise 3: Pac-Man



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1. Identify the classes in the Pac-Man videogame
2. Identify attributes contained in the previous classes
3. Identify methods contained in the previous classes