

# Object-Oriented Programming in Python

Inteligencia Artificial en los Sistemas de Control Autónomo  
Máster Universitario en Ingeniería Industrial

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

# Table of Contents

1. Programming paradigms
  - Understanding concepts
  - Programming paradigms types
2. Object-Oriented Programming
  - Objectives
  - Basic concepts
  - Constructors
  - Game example
3. Inheritance
  - Definition
  - Types of inheritance
  - Examples
  - Example of multiple inheritance
4. Concepts of OOP
  - Polymorphism
  - Abstraction
  - Encapsulation
  - More about methods
  - Overriding methods
5. Arcade
6. Exercises
  - Exercise 1: Asteroids
  - Exercise 2: Tetris
  - Exercise 3: Pac-Man

# 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

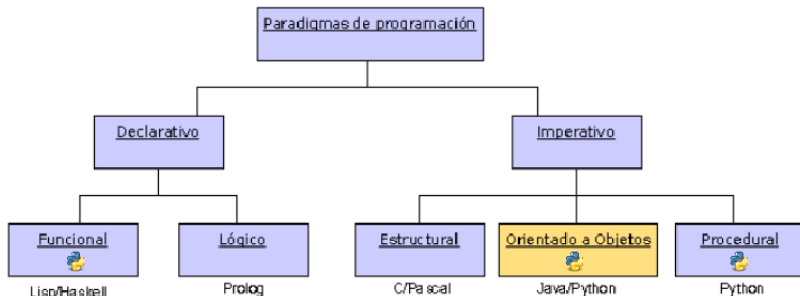
Evolves from imperative programming. It is based on **objects** that allow express the **characteristics** and **behavior** in a closer way to real life (Java, Python, C++).

- **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 and Imperative paradigms.



# 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.
- **Robustness:** Ability of software systems to react appropriately to exceptional conditions.
- **Correction:** Ability of software products to perform their tasks accurately, as defined in their specifications.

# 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)

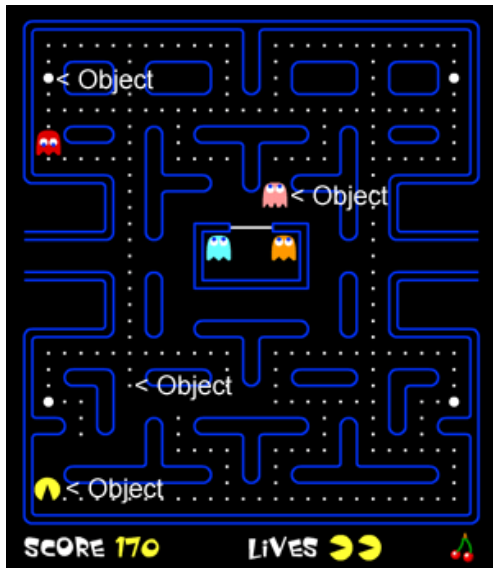
### Object or instance

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



# Object-Oriented Programming

## Concepts (V)



# Object-Oriented Programming

## Concepts (VI)

### Two operations on classes

#### Instantiation

Creates a new object  
Standard functional notation

```
x = MyClass()
```

#### Example

```
time = Time()
```

#### Attribute references

Accesses an attribute value  
Standard dot syntax

```
obj.name
```

#### Example

```
time.hour = 4  
print(time.hour)  
hour = time.hour
```

# 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

# Object-Oriented Programming

## Constructors (III)

```
class Time:
    """ Represents the time of day

    attributes: hour, minute, second
    """
    def __init__(self, hour=0, minute=0, second=0):
        self.hour = hour
        self.minute = minute
        self.second = second

    def print_time(self):
        print(' {0}:{1}:{2} '.format(self.hour, self.minute,
                                     self.second))

timer = Time()
timer.print_time()
time2 = Time(11, 40, 23)
time2.print_time()
```



## dogs.py

```
class Dog:
    def __init__(self): # Constructor
        self.name = "Unknown" # Attribute
        self.age = 10         # Attribute

    def bit(self):         # Method
        print(self.name + " has bitten")

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

if __name__ == '__main__':
    snoopy = Dog() # Instanciate class Dog ...
    laika = Dog() # snoopy and laika are objects

    snoopy.name = "Snoopy"
    snoopy.age = 4

    laika.name = "Laika"

    snoopy.bit()

    snoopy.describe()
    print()
    laika.describe()
```

## Output

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

```
Name:  Laika
Age:  10
```

(Source code)

## dogs.py

```
class Dog:
    def __init__(self): # Constructor
        self.name = "Unknown" # Attribute
        self.age = 10 # Attribute

    def bit(self): # Method
        print(self.name + " has bitten")

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

if __name__ == '__main__':
    snoopy = Dog() # Instanciate class Dog ...
    laika = Dog() # snoopy and laika are objects

    snoopy.name = "Snoopy"
    snoopy.age = 4

    laika.name = "Laika"

    snoopy.bit()

    snoopy.describe()
    print()
    laika.describe()
```

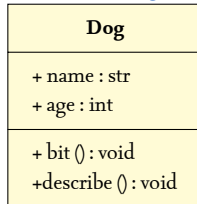
## Output

Snoopy has bitten  
Name: Snoopy  
Age: 4

Name: Laika  
Age: 10

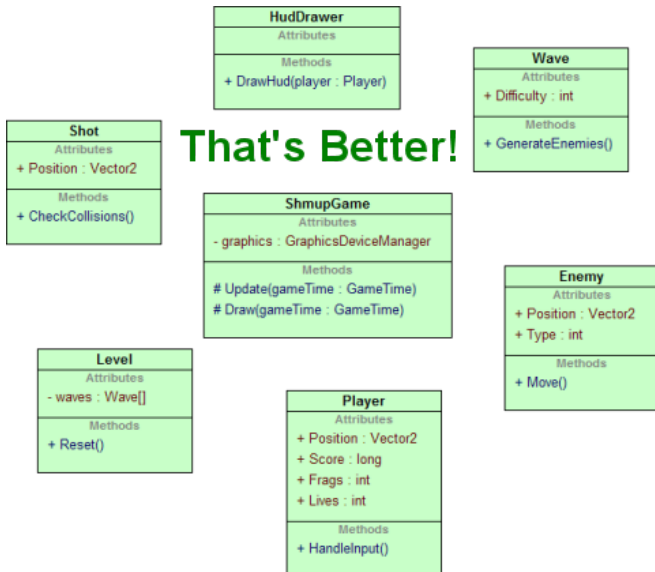
(Source code)

## UML class diagram



# Object-Oriented Programming

## 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

- Superclass: “Father” of a class
- Subclass: “Child” of a class
- A subclass inherits all the attributes and methods from its superclass
- Class hierarchy: A set of classes related by inheritance

# Inheritance

## Types of inheritance

### 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

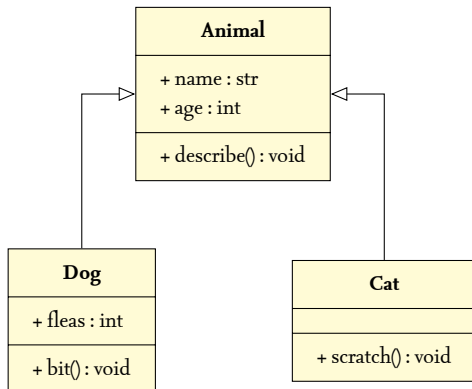
## Examples of simple inheritance (I)

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

Cat
+ name : str + age : int
+ 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)

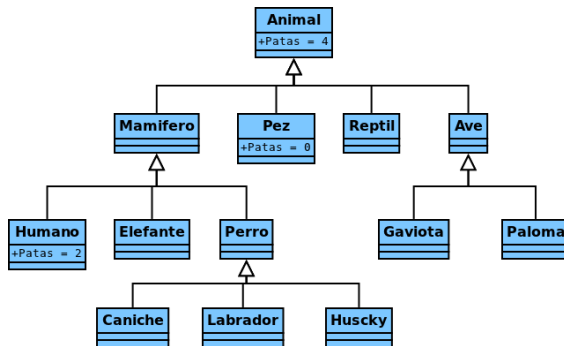


Figura 1: Example of simple Inheritance in OOP. Obtained from: <http://android.scenebeta.com>

# Inheritance

## Example of multiple inheritance

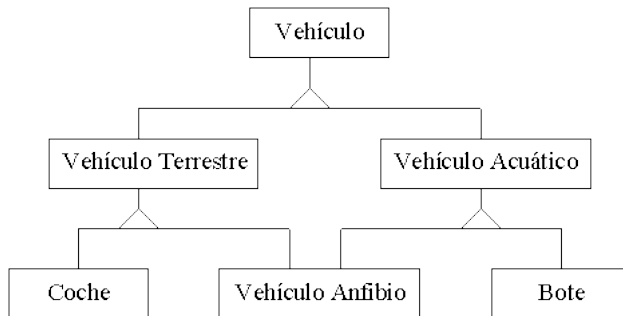


Figura 2: Example of multiple Inheritance in OOP. Obtained from: <http://www.avizora.com>

# 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.

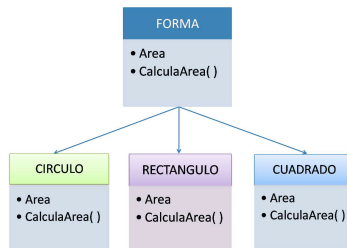


Figura 3: Example of polymorphism. Obtained from: <http://virtual.uaeh.edu.mx>

```
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()
```

(Source code)

# Concepts of OOP

## Abstraction

### Abstraction

Mechanism that allows the isolation of the not relevant information to a level of knowledge.

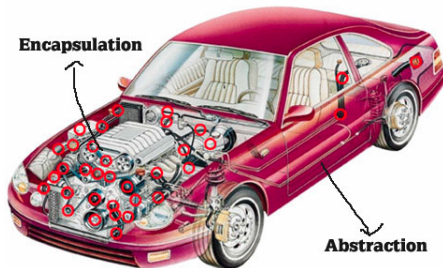
- A driver does not need to know how the carburetor works.
- To talk on the phone does not need to know how the voice is transferred.
- To use a computer do not need to know the internal composition of their materials.

# 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 (I)

The most common access levels are:

- **public:** visible for everyone [default in Python]
- **private:** visible for the creator class [start 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 < 20:
            self.__age = age

    def getAge(self):
        return self.__age

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

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

(Source code)



# 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 `self` information. When `print()` is invoked with the object, if the method `__str__()` is defined, Python shows the result of running this method on the object.
- `__len__(self)` It should return the length or “size” of object (number of elements if is a set or queue).
- `__add__(self, otro_obj)` It allows to apply the addition operator (+) to objects of the class in which it is defined.
- `__mul__(self, otro_obj)` It allows to apply the multiplication operator (\*) to objects of the class in which it is defined.
- `__comp__(self, otro_obj)` It allows to apply the comparison operators (<, >, <=, >=, ==, !=) to objects of the class in which it is defined. It should return 0 if they are equal, -1 if `self` is smaller than `other_obj` and 1 if `self` is greater than `other_obj`.

# Concepts of OOP

## Overriding methods (I)

Often we need to adapt an inheritanced 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()
```

```
import arcade

SCREEN_WIDTH = 800
SCREEN_HEIGHT = 600

class MyGame(arcade.Window):
    """ Our Custom Window Class """

    def __init__(self):
        """ Initializer """

        # Call the parent class initializer
        super().__init__(SCREEN_WIDTH, SCREEN_HEIGHT, "Lab 7 -
            User Control")

    def on_draw(self):
        arcade.start_render()

def main():
    window = MyGame()
    arcade.run()

main()
```

```
import arcade

class MyGame(arcade.Window):
    def __init__(self, width, height, title):
        super().__init__(width, height, title)

        arcade.set_background_color(arcade.color.ASH_GREY)

        self.ball_x = 50
        self.ball_y = 50

    def on_draw(self):
        arcade.start_render()

        arcade.draw_circle_filled(self.ball_x, self.ball_y, 15,
                                  arcade.color.AUBURN)

    def update(self, delta_time):
        self.ball_x += 1
        self.ball_y += 1

def main():
    window = MyGame(640, 480, "Drawing Example")
    arcade.run()

main()
```

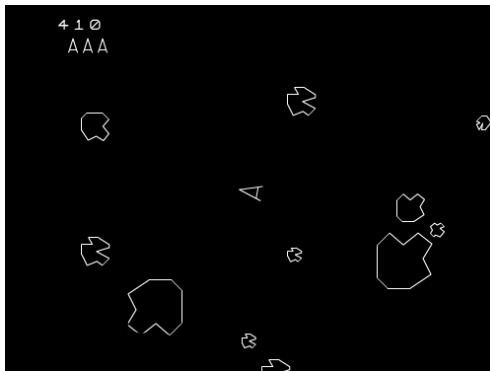
# Arcade

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)

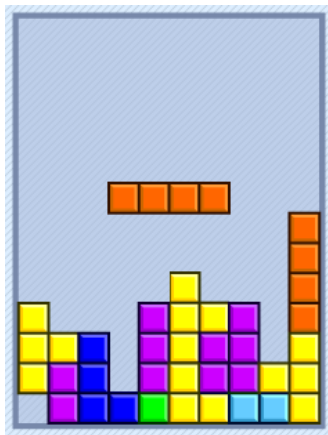
## Exercise 1: Asteroids



(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

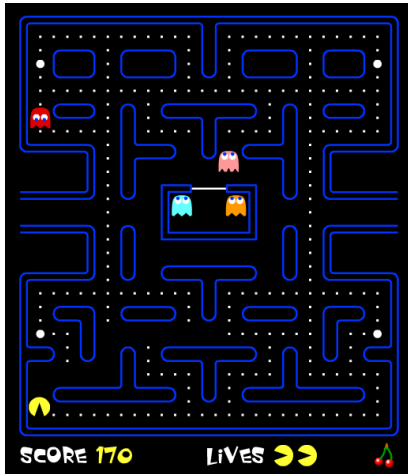


(Source)

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



(Source)

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