Object-Oriented Programming

OOP

By Ryan Henning

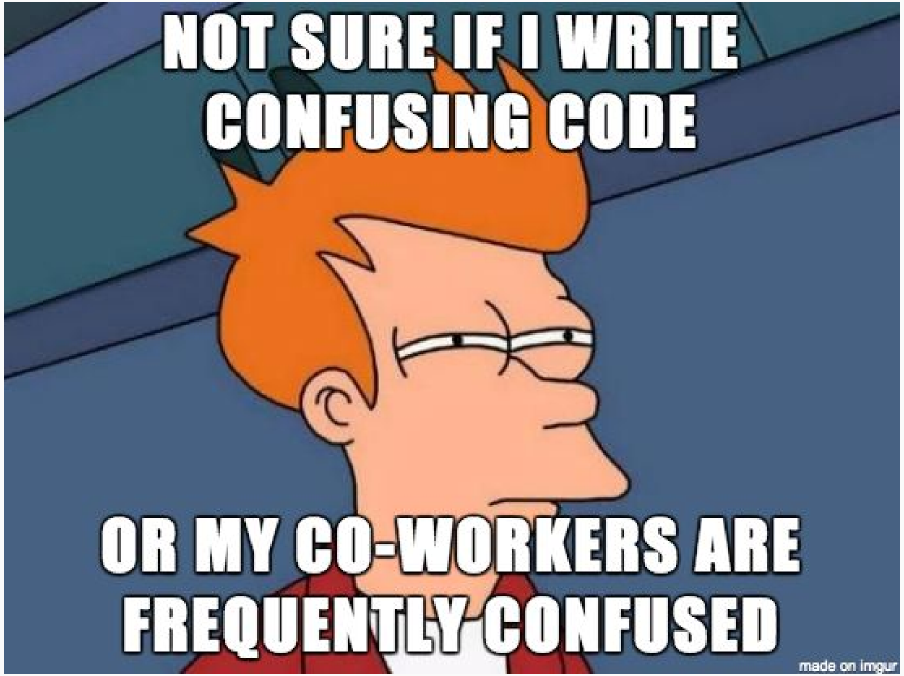
- What / Why OOP?
- OOP Terminology
- OOP in Python
- Design Example
- Encapsulation
- Composition
- Inheritance
- Polymorphism

Why OOP?

Software Engineering is the topic today.

Goal is to write code that is:

- split into logical components
- easy to understand
- easy to use / re-use
- easy to modify
- easy to maintain
- easy to test


NOT SURE IF I WRITE CONFUSING CODE
OR MY CO-WORKERS ARE FREQUENTLY CONFUSED
made on imgur

OOP is a programming paradigm

Paradigm: a distinct set of concepts or thought patterns

Other programming paradigms:

- **Functional:** no global state, deeply nested function calls
- **Imperative:** explicit sequence of commands (often called sequential)
- **Procedural:** like imperative, but also supports procedures (e.g., functions)
- **Declarative:** declare the result you want, not how to obtain it (e.g. SQL)
- ...

Most programming languages offer a mix of paradigms.

What’s in a program?

“A program by any other name would smell as sweet.” - Shakespeare’s Juliet

Program = Data + Algorithm

For this presentation, we’ll say:

Program = State + Behavior

So, what is the OOP paradigm all about?

Group the program’s state and behavior inside **objects** and **classes**.

Inspired by how humans categorize and manipulate the physical world.

E.g. Consider the concept of “Mug”:

- Mug has state: color, volume, location
- Mug has behavior: drink, fill, refill, break, clean

What is the current state of this mug?

OOP Terminology: “Object”

An **object** is:

- A collection of variables (the “state” of the object)
- A collection of methods (the “behavior” of the object)

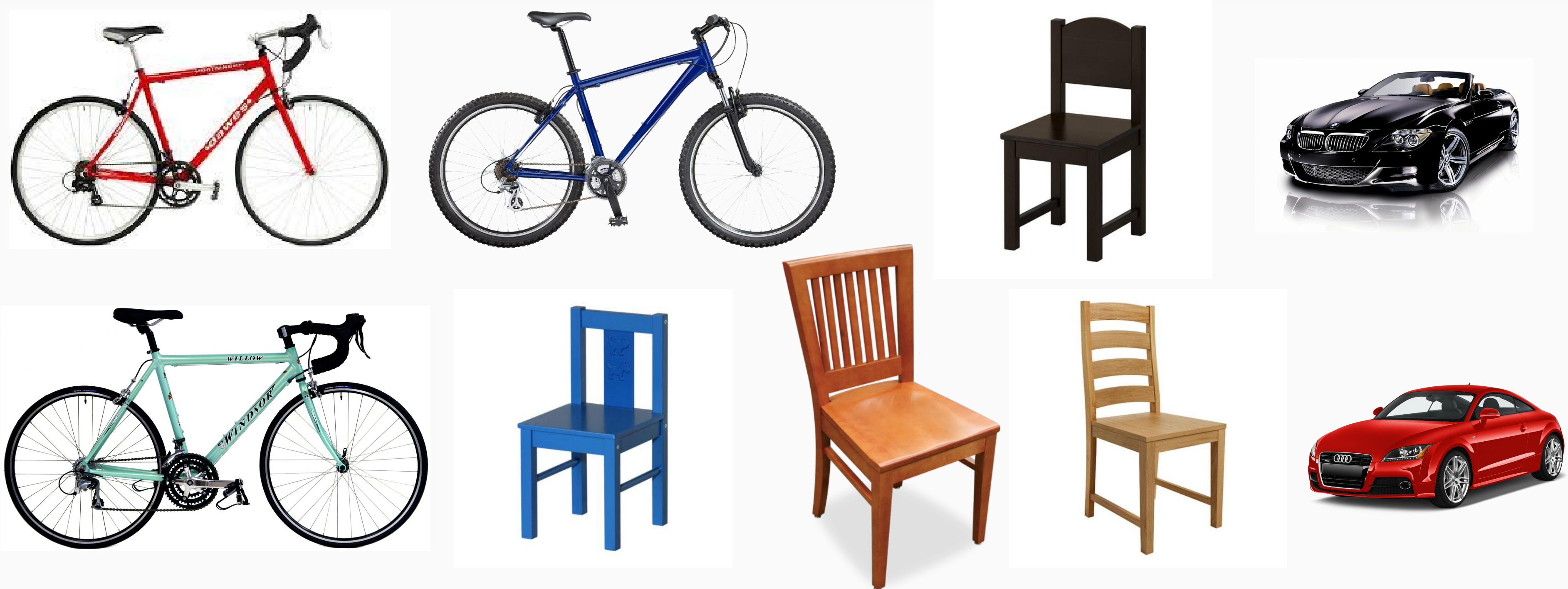
There are 5 “Mug” objects on this page. Each has distinct state, but the same behavior.

OOP Terminology: “Class”

A **class** is a category/blueprint for objects.

E.g. The previous slide showed 5 mug objects. Each of those 5 objects is an **instance** of the class: <u>Mug</u>.   5 objects, 1 class.

How many objects? How many classes?



OOP Terminology: “Member variable”

Every object has a set of **member variables**. Member variables are variables that are bound to that object and only that object. You can think of it like that object “owns” those variables.

An object’s member variables define that object’s current state.

OOP Terminology: “Method”

Every object has a set of **methods**. Each method is a procedure that the object knows how to perform. Most of the time the methods will change the object’s state (i.e. modify the object’s member variables).

An object’s methods define that object’s behavior.

OOP in Python (quick review)

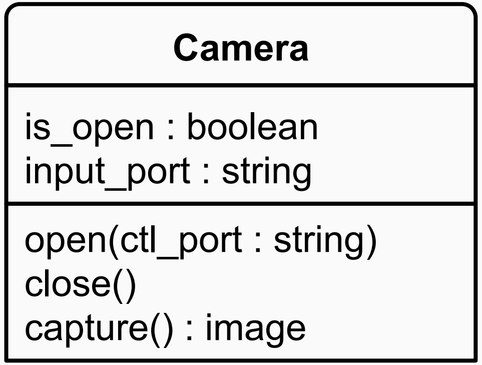
Review:

- Python classes you use every day! (list, dict, string, …)
- Declaring the Fraction class
- Instantiating Fraction objects
- Using Fraction objects
- Magic methods

UML Class Diagram

UML: Unified Modeling Language

What are the parts of this class diagram?



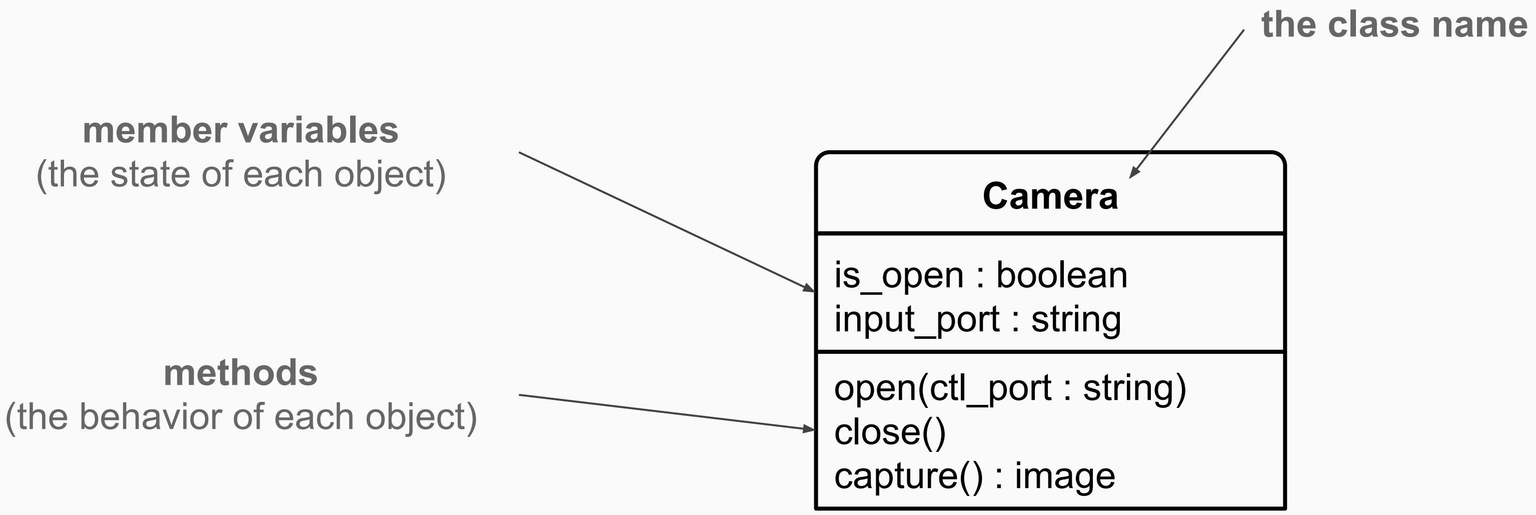
Camera

is_open : boolean
input_port : string

open(ctl_port : string)
close()
capture() : image

UML Class Diagram

UML: Unified Modeling Language



the class name

member variables
(the state of each object)

methods
(the behavior of each object)

Camera

is_open : boolean
input_port : string

open(ctl_port : string)
close()
capture() : image

Let’s design a program in OO fashion.

Smart Recycling Robot (SRR)

Build a robot that sorts physical objects into three categories:

1. recycle,
2. compost,
3. landfill

The robot brain is a computer program that you will write. The robot has an arm for grasping each piece of trash and delivering it to one of three bins.

Software Engineering: Designing the SRR

Nouns and Verbs

Capture frames from the camera.

Process frames.

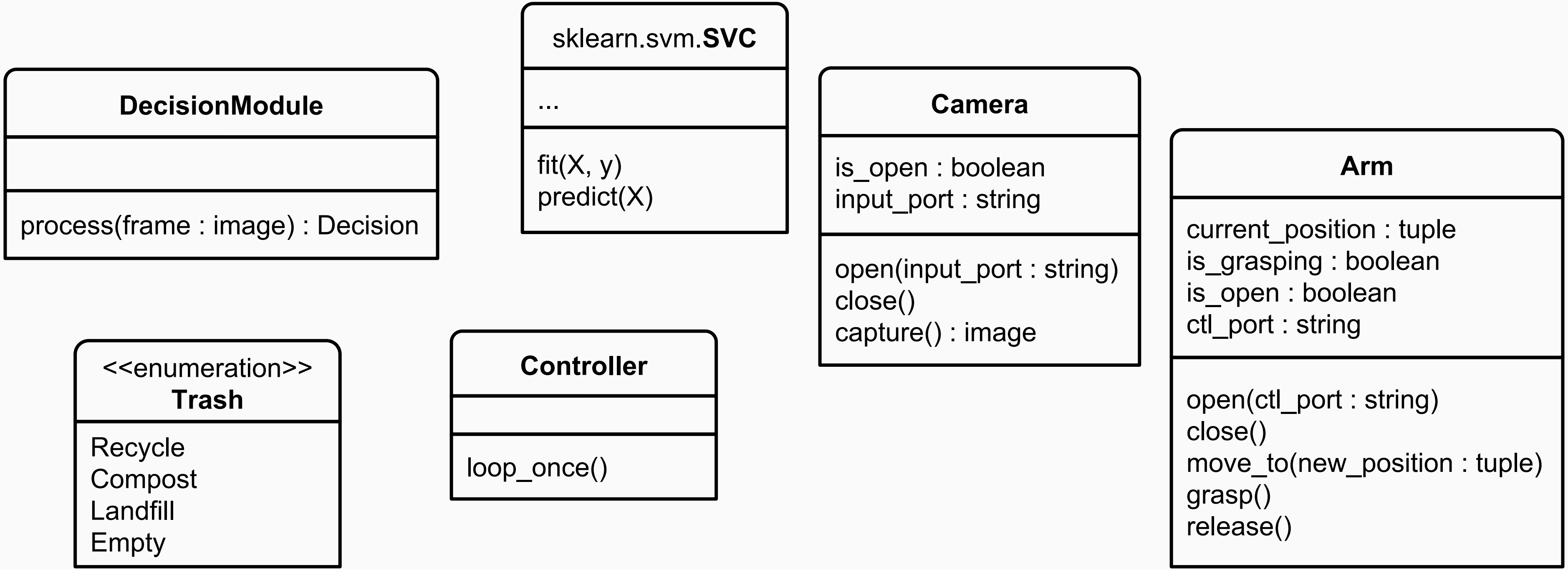
Move the arm into position.
Grasp the trash using the arm.
Release the trash.

Loop the detection/action cycle.

Types of trash are: Recycle, Compost, Landfill, Empty

Software Engineering: Designing the SRR

UML Class Diagram with Relationships



DecisionModule

process(frame : image) : Decision

sklearn.svm.**SVC**

...

fit(X, y)
predict(X)

Camera

is_open : boolean
input_port : string

open(input_port : string)
close()
capture() : image

Arm

current_position : tuple
is_grasping : boolean
is_open : boolean
ctl_port : string

open(ctl_port : string)
close()
move_to(new_position : tuple)
grasp()
release()

<<enumeration>>
Trash

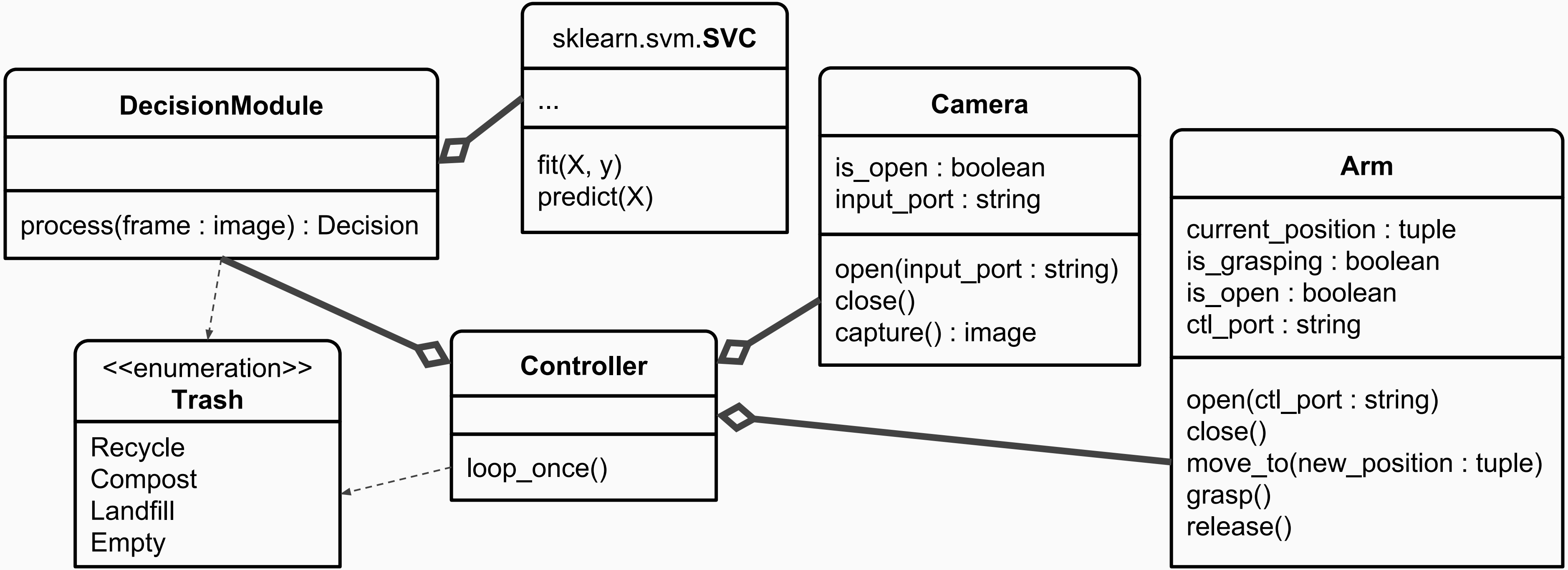
Recycle
Compost
Landfill
Empty

Controller

loop_once()

Software Engineering: Designing the SRR

UML Class Diagram with Relationships



Python Demo: construct the SRR

OOP FTW in (at least) 3 ways: what are they?

Encapsulation

Hiding the confusing details/complexity of your code inside a class.

Good because:

1. Code outside the class is safe (encouraged, even) to ignore the details inside the class.
2. The details/complexity inside the class are free to change without affecting the code outside the class.

Encapsulation (example)

```
>>> import numpy as np
>>> X = np.array([[-1, -1], [-2, -1], [1, 1], [2, 1]])
>>> y = np.array([1, 1, 2, 2])
>>> from sklearn.svm import SVC
>>> clf = SVC()
>>> clf.fit(X, y)
>>> print(clf.predict([[-0.8, -1]]))
[1]
```

Composition

Storing objects inside objects. The “has-a” relationship. Triangle has Points.

```
class Point:
    ... details omitted ...
    def calculate_distance(self, other_point):
        ... details omitted ...


if __name__ == '__main__':
    p1 = Point(0, 2)
    p2 = Point(4, 5)
    p3 = Point(3, 0)
    triangle = Traingle(p1, p2, p3)
    print triangle.calculate_perimeter()
```

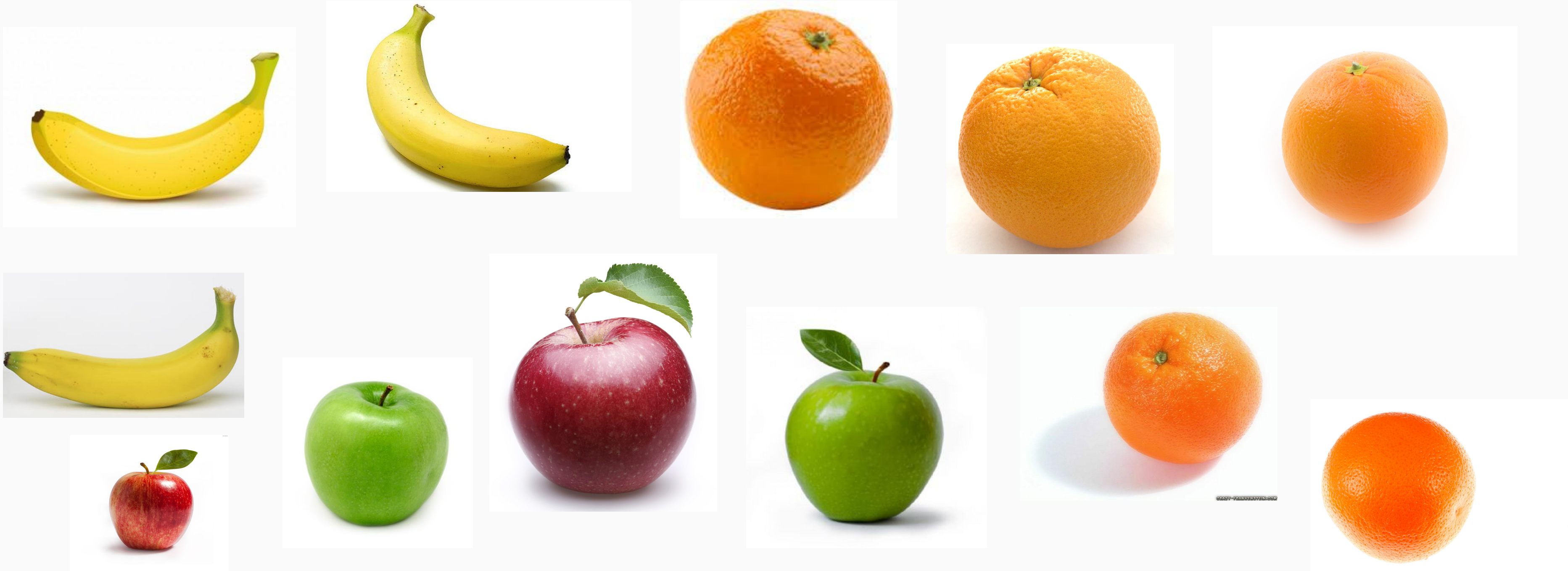
```
class Triangle:
    def __init__(point1, point2, point3):
        self.point1 = point1
        self.point2 = point2
        self.point3 = point3


    def calculate_perimeter(self):
        a, b, c = self.point1, self.point2, self.point3
        return a.calculate_distance(b) +
               b.calculate_distance(c) +
               c.calculate_distance(a)
```

Morning Exercise

Modify an existing OOP-style program: The (card)game of WAR.

How many objects? How many classes?



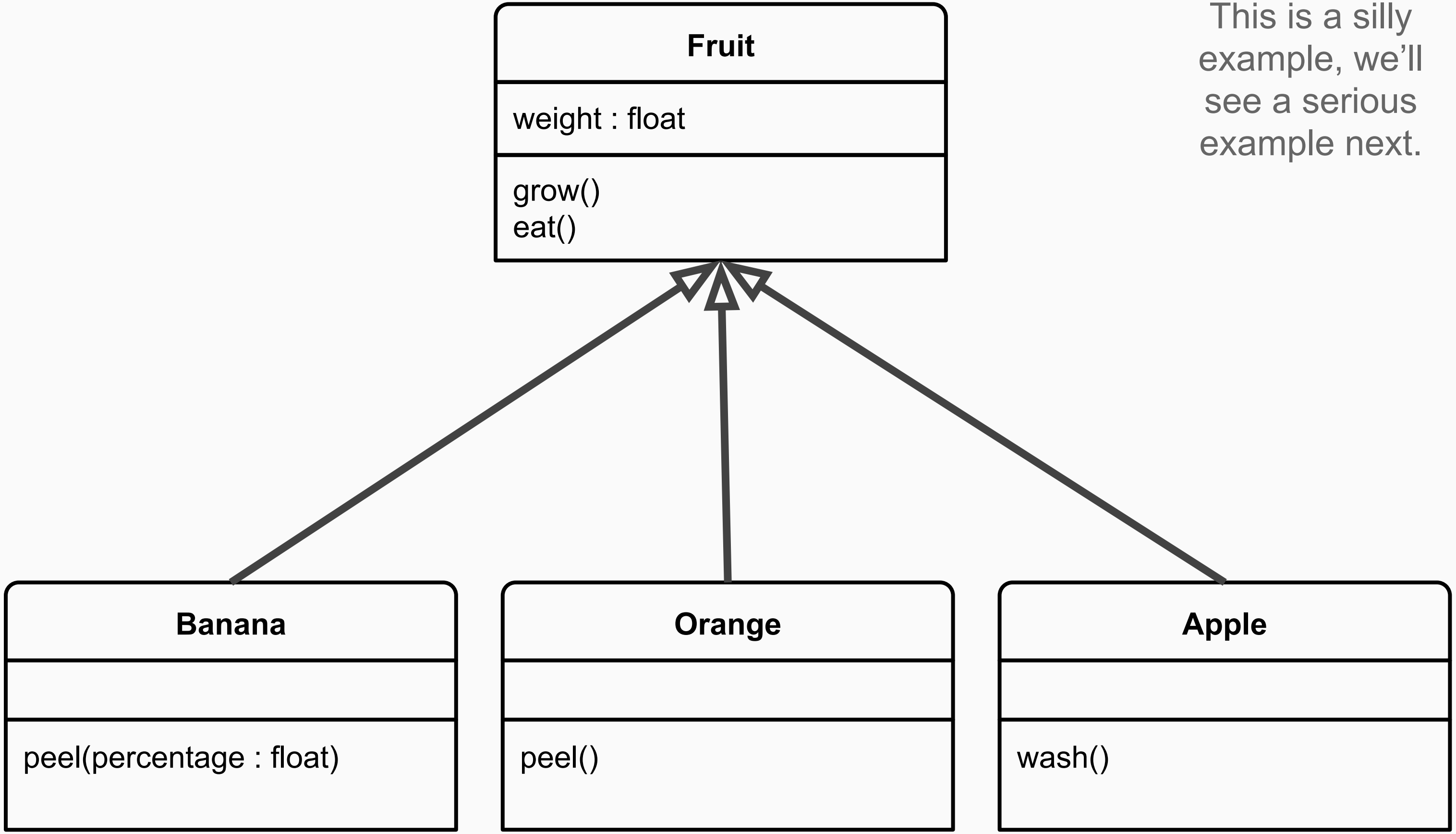
Inheritance

The "is-a" relationship. Banana is a Fruit.

This is a silly example, we'll see a serious example next.

"Parent" class:

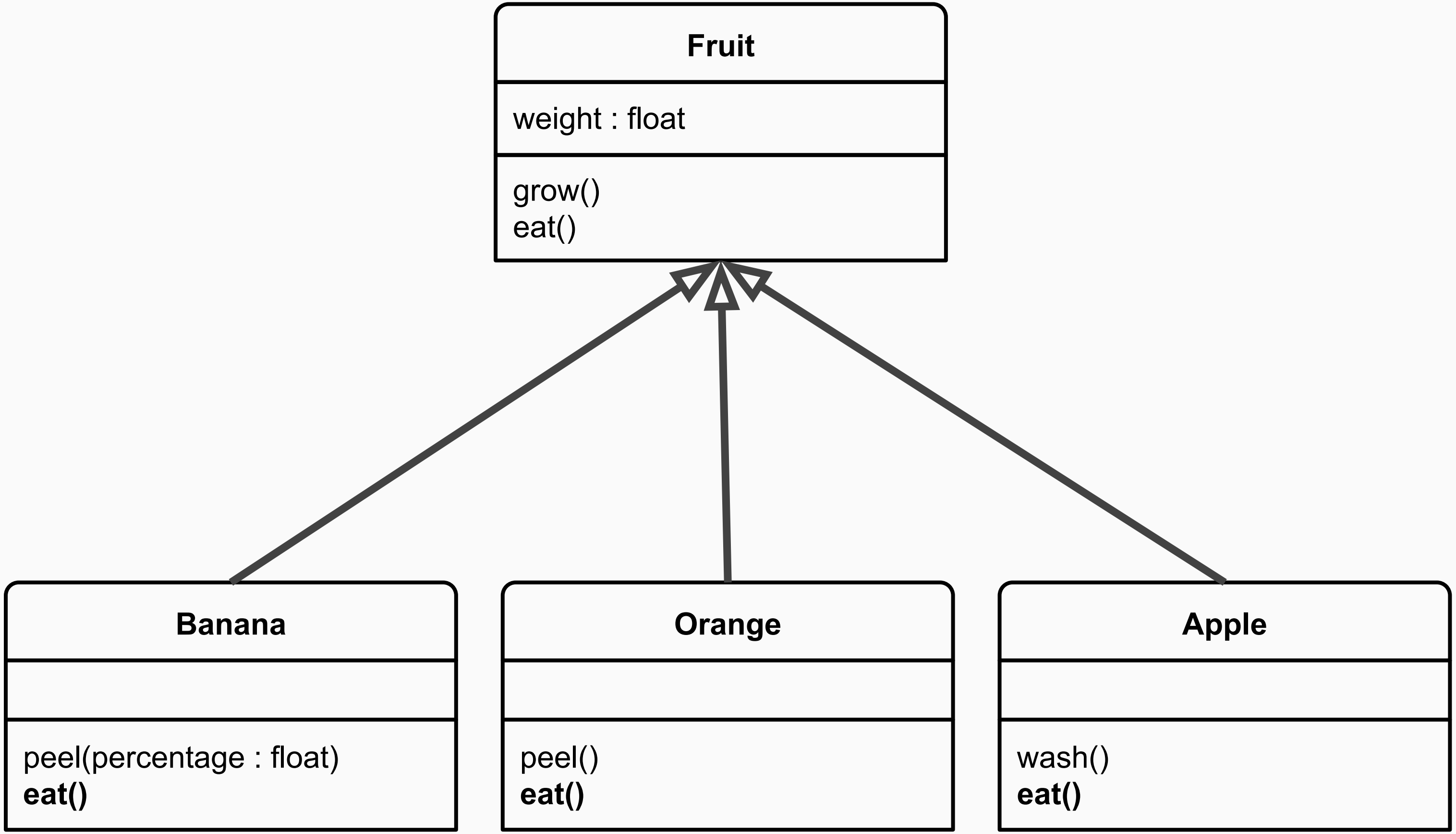
"Child" classes:



Polymorphism

“Parent” class:

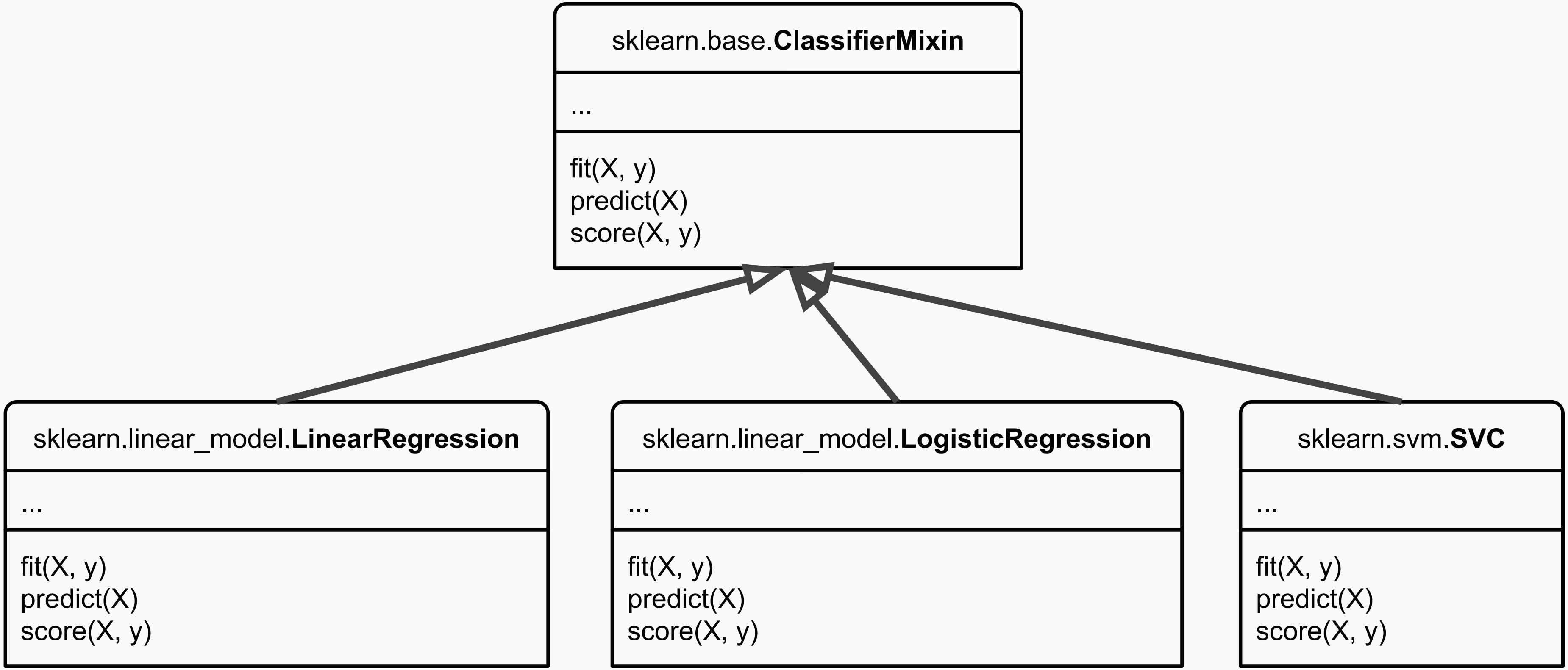
“Child” classes:



Inheritance/Polymorphism in Python

Fruit / Banana / Orange / Apple

Polymorphism in sci-kit learn



sklearn.base.**ClassifierMixin**

...

fit(X, y)
predict(X)
score(X, y)

sklearn.linear_model.**LinearRegression**

...

fit(X, y)
predict(X)
score(X, y)

sklearn.linear_model.**LogisticRegression**

...

fit(X, y)
predict(X)
score(X, y)

sklearn.svm.**SVC**

...

fit(X, y)
predict(X)
score(X, y)

Notes about Python convention

Classes:

- Class names are nouns.
- Class names must begin with a capital letter.

Methods:

- Method names are (usually) verbs.
- Method names begin with a capital letter.
- Method names that begin with an underscore should be treated as “private”.

Testing code via mock objects (in python)

Testing the Controller.

Afternoon Exercise

Simulate the game of Blackjack in an OOP-style program.