ECE 20875
Python for Data Science
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objects and classes
Python is OOP

- Like C++ and Java, Python is an object-oriented programming (OOP) language

- An object is Python’s abstraction for data
  - A bundle of data and operations that execute on this data

- Everything in Python is an object
  - All data is represented by objects or relations between objects
  - This includes “simple” data like integers and floats
  - Even functions are special objects in Python
we’ve been using OOP all along

• Some classes we’ve used so far or will use soon (you can see all of their source code on github):

  • sklearn.linear_model.LinearRegression (https://github.com/scikit-learn/scikit-learn/blob/fd237278e/sklearn/linear_model/_base.py#L389)

  • sklearn.svm.SVC (https://github.com/scikit-learn/scikit-learn/blob/fd237278e/sklearn/svm/_classes.py#L428)

• Some instance variables we’ve used so far or will use soon:

  • sklearn.linear_model.Ridge.coef_

  • sklearn.linear_model.LogisticRegression.intercept_

• Some methods we’ve used so far or will use soon:

  • re.sub(...)  

  • np.sort(...)  

  • LogisticRegression.fit(...) (https://github.com/scikit-learn/scikit-learn/blob/fd237278e/sklearn/linear_model/_logistic.py#L1011)
every object in Python has ... 

1. an **identity**, accessed through the `id()` function
   - Unique “name” for an object, like its address in memory, which never changes

2. a **type**, accessed through the `type()` function
   - This defines the operations that you can perform on an object (asking for its length, adding to it, etc.)
   - Also defines the possible values this object can take

3. a **value**, which defines the data associated with the object
   - Think the contents of a list, or the value of an integer
   - Objects whose values can change (e.g., a dictionary) are **mutable**, while objects whose values cannot be changed (e.g., a tuple) are **immutable**

```python
# Integers, lists, functions and objects (and even classes) are objects in Python
my_integer = 5
my_list = [1.0, 2, 3]
def my_function(): return 0
class MyClass: pass
my_object = EmptyClass()

# Show id and type of each object
for o in [my_integer, my_list, my_function, my_object, MyClass]:
    print(f'id={id(o)}, type={type(o)}')
```

Output:
```
id=4308932128, type=<class 'int'>
id=4364494984, type=<class 'list'>
id=4363413160, type=<class 'function'>
id=4368615744, type=<class '__main__.EmptyClass'>
id=140649053790680, type=<class 'type'>
```
defining an object

• Intuition: an object is defined by
  
  1. Where it is (what box of memory contains its information)
  2. What it can do (what operations you can perform on it)
  3. What it has (what data those operations will operate on)

• Formally, an object is defined as an instance of a class
  
  • A class is like a fill-in-the-blank sheet, template, or blueprint
  • An instance is like a template that has been filled in with particular values or an actual building/object

• Any data scientist can write their own ML class and submit it to scikit-learn
  
  • Must follow the common basic API (https://scikit-learn.org/stable/developers/develop.html): estimator, predictor, transformer, model
We define what an object has (variables) and what it can do (methods) by creating a class for that object. Think of this as a template for an object that specifies what information and actions this object has.

There are two types of class attributes:

1. **variables** (either class variables or instance variables), which hold the data we want in an object

2. **methods**, which are the functions we want to be able to invoke on an object

__init__(): Special constructor method automatically invoked for each new class instance

class Foo:
    x = 7  #this will be accessible to all Foos
    #it is a class variable
    
    #this is called when a new Foo is created
def __init__(self, i):
    self.y = i  #this is specific to each Foo
    #it is an instance variable
    
    #this will be available to all Foos
    #it is a class method
def bar(self):
    return self.x + self.y

#defining objects as instances of class Foo
a = Foo(1)  #a.x = 7, a.y = 1
b = Foo(2)  #b.x = 7, b.y = 2

#invoking the bar method on the objects
print(a.bar())  #prints 8
print(b.bar())  #prints 9
Manipulating objects

- Manipulating an object involves *invoking operations* on the object.
- Intuition: Think of this as “sending a message” to an object, i.e., asking an object to handle an action.
- Including things you might not think of!
  - \( x = a + b \) is invoking the \( \texttt{__add__()} \) method on object \( a \).
  - \( \texttt{len(s)} \) is invoking the \( \texttt{__len__()} \) method on object \( s \).
  - We can also **overwrite** these default methods if we want different functionality! (see example on the right)

```python
class MultipleLists():
    def __init__(self):
        self.lists = []
    def __add__(self, a):
        newlists = MultipleLists()
        newlists.lists = self.lists.copy()
        newlists.lists.append(a)
        return newlists
    def __len__(self):
        return sum([len(a) for a in self.lists])
    def __str__(self):
        return ', '.join([f'L{i+1}={a}'
                          for i, a in enumerate(self.lists)])

many_lists = MultipleLists()
print(many_lists)  # ''
print(len(many_lists))  # 0

many_lists = many_lists + [3, 5, 1]
print(many_lists)  # ['L1=[3, 5, 1]'
print(len(many_lists))  # 3

many_lists += [8, 4]
print(many_lists)  # 'L1=[3, 5, 1], L2=[8, 4]'
print(len(many_lists))  # 5
```
creating, updating and accessing variables in objects

• Accessing variables in objects uses the “.” notation: my_object.x (MyClass.x for class variables)

• Under the hood, this is also invoking methods!

• Object variables can generally be:
  • created/deleted (if mutable object and user-created)
  • updated (if mutable object)
  • accessed

• Variable updates can be done either internally (via object methods, preferred) or externally (via “hard coding”, need to be careful when doing this)

```python
class SimpleClass():
    def __init__(self, x):
        # internal created
        self.myx = x
    def add(self, y):
        # internal access and update
        self.myx = self.myx + y

my_object = SimpleClass(10)
# external access
print(my_object.myx) # 10
# internal update
my_object.add(15)
print(my_object.myx) # 25
# external update
my_object.myx = 200
print(my_object.myx) # 200
# external variable creation
my_object.myz = 18
print(my_object.myz) # 18
# external variable deletion
del my_object.myz
print(my_object.myz) # Error
```
the special role of \texttt{self} in defining or calling methods on objects

- When you call a method on an object, the object itself is always passed as the \textit{first argument} of the method.
- The object is called \texttt{self}.
- Think of this like the \texttt{this} parameter in Java or C++ (except that it shows up explicitly in the argument list).
- By accessing \texttt{self.x}, we can create or access variables that are \textit{specific to this object}.

```python
class Employee:
    empCount = 0

    def __init__(self, name, salary):
        self.name = name
        self.salary = salary
        Employee.empCount += 1

    def displayCount(self):
        print("Total employees: ", Employee.empCount)

    def displayEmployee(self):
        print("Name: ", self.name, ", Salary: ", self.salary)

emp1 = Employee("Alice", 100000)
emp2 = Employee("Bob", 50000)
emp1.displayEmployee()
emp1.displayCount() # Total Employees: 2
emp2.displayCount() # Total Employees: 2
```

outside of the class, \texttt{self} is implicitly the first argument.

within the class, we have to use \texttt{self} as the first argument.