

Lec 17 - classes + custom transformers

Statistical Computing and Computation

Sta 663 | Spring 2022

Dr. Colin Rundel

Classes

Basic syntax

These are the basic component of Python's object oriented system - we've been using them regularly all over the place and will now look at how they are defined and used.

```
class rect:  
    """An object representation of a rectangle"""\n\n    # Attributes  
    p1 = (0,0)  
    p2 = (1,2)\n\n    # Methods  
    def area(self):  
        return ((self.p1[0] - self.p2[0]) *  
                (self.p1[1] - self.p2[1]))\n\n    def set_p1(self, p1):  
        self.p1 = p1\n\n    def set_p2(self, p2):  
        self.p2 = p2
```

```
x = rect()  
x.area()
```

```
## 2
```

```
x.set_p2((1,1))  
x.area()
```

```
## 1
```

```
x.p1
```

```
## (0, 0)
```

```
x.p2
```

```
## (1, 1)
```

```
x.p2 = (0,0)
```

Instantiation (constructors)

When instantiating a class object (e.g. `rect()`) we invoke the `__init__()` method if it is present in the classes' definition.

```
class rect:  
    """An object representation of a rectangle"""\n  
    # Constructor  
    def __init__(self, p1 = (0,0), p2 = (1,1)):  
        self.p1 = p1  
        self.p2 = p2  
  
    # Methods  
    def area(self):  
        return ((self.p1[0] - self.p2[0]) *  
                (self.p1[1] - self.p2[1]))  
  
    def set_p1(self, p1):  
        self.p1 = p1  
  
    def set_p2(self, p2):  
        self.p2 = p2
```

```
x = rect()  
x.area()
```

```
## 1
```

```
y = rect((0,0), (3,3))  
y.area()
```

```
## 9
```

```
z = rect((-1,-1))  
z.p1
```

```
## (-1, -1)
```

```
z.p2
```

```
## (1, 1)
```

Method chaining

We've seen a number of objects (i.e. Pandas DataFrames) that allow for method chaining to construct a pipeline of operations. We can achieve the same by having our class methods return `self`.

```
class rect:  
    """An object representation of a rectangle"""  
  
    # Constructor  
    def __init__(self, p1 = (0,0), p2 = (1,1)):  
        self.p1 = p1  
        self.p2 = p2  
  
    # Methods  
    def area(self):  
        return ((self.p1[0] - self.p2[0]) *  
                (self.p1[1] - self.p2[1]))  
  
    def set_p1(self, p1):  
        self.p1 = p1  
        return self  
  
    def set_p2(self, p2):
```

```
rect().area()  
## 1  
  
rect().set_p1((-1,-1)).area()  
## 4  
  
rect().set_p1((-1,-1)).set_p2((2,2)).area()  
## 9
```

Class object string formatting

All class objects have a default print method / string conversion method, but the default behavior is not very useful,

```
print(rect())
```

```
## <__main__.rect object at 0x290aa1a60>
```

```
str(rect())
```

```
## '<__main__.rect object at 0x290aa1ca0>'
```

Both of the above are handled by the `__str__()` method which is implicitly created for our class - we can override this,

```
def rect_str(self):  
    return f"Rect[{self.p1}, {self.p2}] => area={self.area()}"
```

```
rect.__str__ = rect_str
```

```
rect()
```

```
## <__main__.rect object at 0x290a98070>
```

```
print(rect())
```

Class representation

There is another special method which is responsible for the printing of the object (see `rect()` above) called `__repr__()` which is responsible for printing the classes representation. If possible this is meant to be a valid Python expression capable of recreating the object.

```
def rect_repr(self):
    return f"rect({self.p1}, {self.p2})"

rect.__repr__ = rect_repr
```

```
rect()
```

```
## rect((0, 0), (1, 1))
```

```
repr(rect())
```

```
## 'rect((0, 0), (1, 1))'
```

Inheritance

Part of the object oriented system is that classes can inherit from other classes, meaning they gain access to all of their parents attributes and methods. We will not go too in depth on this topic beyond showing the basic functionality.

```
class square(rect):
    pass

square()
## rect((0, 0), (1, 1))

square().area()
## 1

square().set_p1((-1,-1)).area()
## 4
```

Overriding methods

```
class square(rect):
    def __init__(self, p1=(0,0), l=1):
        assert isinstance(l, (float, int)), \
            "l must be a number"

        p2 = (p1[0]+l, p1[1]+l)

        self.l = l
        super().__init__(p1, p2)

    def set_p1(self, p1):
        self.p1 = p1
        self.p2 = (self.p1[0]+self.l, self.p1[1]+self.l)
        return self

    def set_p2(self, p2):
        raise RuntimeError("Squares take l not p2")

    def set_l(self, l):
        assert isinstance(l, (float, int)), \
            "l must be a number"

        self.l = l
        self.p2 = (self.p1[0]+l, self.p1[1]+l)
```

```
square()
## square((0, 0), 1)

square().area()
## 1

square().set_p1((-1,-1)).area()
## 1

square().set_l(2).area()
## 4

square((0,0), (1,1))
## AssertionError: l must be a numnber

square().set_l((0,0))
## AssertionError: l must be a numnber
```

Making an object iterable

When using an object with a for loop, python looks for the `__iter__()` method which is expected to return an iterator object (e.g. `iter()` of a list, tuple, etc.).

```
class rect:  
    """An object representation of a rectangle"""  
  
    # Constructor  
    def __init__(self, p1 = (0,0), p2 = (1,1)):  
        self.p1 = p1  
        self.p2 = p2  
  
    # Methods  
    def area(self):  
        return ((self.p1[0] - self.p2[0]) *  
                (self.p1[1] - self.p2[1]))  
  
    def __iter__(self):  
        return iter([  
            self.p1,  
            (self.p1[0], self.p2[1]),  
            self.p2,  
            (self.p2[0], self.p1[1])  
        ] )
```

```
for pt in rect():  
    print(pt)  
  
## (0, 0)  
## (0, 1)  
## (1, 1)  
## (1, 0)
```

Fancier iteration

A class itself can be made iterable by adding a `__next__()` method which is called until a `StopIteration` exception is encountered. In which case, `__iter__()` is still needed but should just return `self`.

```
class rect:  
    def __init__(self, p1 = (0,0), p2 = (1,1)):  
        self.p1 = p1  
        self.p2 = p2  
        self.vertices = [self.p1, (self.p1[0], self.p1[1]),  
                        self.p2, (self.p2[0], self.p2[1])]  
        self.index = 0  
  
    # Methods  
    def area(self):  
        return ((self.p1[0] - self.p2[0]) *  
                (self.p1[1] - self.p2[1]))  
  
    def __iter__(self):  
        return self  
  
    def __next__(self):  
        if self.index == len(self.vertices):
```

```
r = rect()  
for pt in r:  
    print(pt)
```

```
## (0, 0)  
## (0, 1)  
## (1, 1)  
## (1, 0)
```

```
for pt in r:  
    print(pt)
```

```
## (0, 0)  
## (0, 1)  
## (1, 1)  
## (1, 0)
```

Generators

There is a lot of bookkeeping in the implementation above - we can simplify this significantly by using a generator function with `__iter__()`. A generator is a function which uses `yield` instead of `return` which allows the function to preserve state between `next()` calls.

```
class rect:  
    """An object representation of a rectangle"""  
  
    # Constructor  
    def __init__(self, p1 = (0,0), p2 = (1,1)):  
        self.p1 = p1  
        self.p2 = p2  
  
    # Methods  
    def area(self):  
        return ((self.p1[0] - self.p2[0]) *  
                (self.p1[1] - self.p2[1]))  
  
    def __iter__(self):  
        vertices = [ self.p1, (self.p1[0], self.p2[1])  
                    self.p2, (self.p2[0], self.p1[1])]  
  
        for v in vertices:
```

```
r = rect()  
  
for pt in r:  
    print(pt)
```

```
## (0, 0)  
## (0, 1)  
## (1, 1)  
## (1, 0)
```

```
for pt in r:  
    print(pt)
```

```
## (0, 0)  
## (0, 1)  
## (1, 1)  
## (1, 0)
```

Class attributes

We can examine all of a classes' methods and attributes using `dir()`,

```
dir(rect)
```

```
##['__class__', '__delattr__', '__dict__', '__dir__', '__doc__', '__eq__', '__format__', '__ge__', '__getattr__']
```

Where did p1 and p2 go?

```
dir(rect())
```

```
##['__class__', '__delattr__', '__dict__', '__dir__', '__doc__', '__eq__', '__format__', '__ge__', '__getattr__']
```

Custom Transformers

FunctionTransformer

The simplest way to create a new transformer is to use `FunctionTransformer()` from the preprocessing submodule which allows for converting a Python function into a transformer.

```
from sklearn.preprocessing import FunctionTransformer  
  
X = pd.DataFrame({"x1": range(1,6), "x2": range(5, 0, -1)})
```

```
log_transform = FunctionTransformer(np.log)  
lt = log_transform.fit(X)  
lt.transform(X)
```

```
##          x1          x2  
## 0  0.000000  1.609438  
## 1  0.693147  1.386294  
## 2  1.098612  1.098612  
## 3  1.386294  0.693147  
## 4  1.609438  0.000000
```

```
lt
```

```
## FunctionTransformer(func=<ufunc 'log'>)
```

```
lt.get_params()
```

```
## {'accept_sparse': False, 'check_inverse': True, 'fun
```

```
dir(lt)
```

```
## ['__class__', '__delattr__', '__dict__', '__dir__',
```

Input types

```
def interact(X, y = None):
    return np.c_[X, X[:,0] * X[:,1]]  
  
X = pd.DataFrame({"x1": range(1,6), "x2": range(5, 0, -1)})
Z = np.array(X)
```

```
FunctionTransformer(interact).fit_transform(X)
```

```
## InvalidIndexError: (slice(None, None, None), 0)
```

```
FunctionTransformer(
    interact, validate=True
).fit_transform(X)
```

```
## array([[1, 5, 5],
##        [2, 4, 8],
##        [3, 3, 9],  
The validate argument both checks that x is 2d as well as converts it to an np.array
```

```
FunctionTransformer(interact).fit_transform(Z)
```

```
## array([[1, 5, 5],
##        [2, 4, 8],
##        [3, 3, 9],
##        [4, 2, 8],
##        [5, 1, 5]])
```

```
FunctionTransformer(
    interact, validate=True
).fit_transform(Z)
```

```
## array([[1, 5, 5],
##        [2, 4, 8],
##        [3, 3, 9],  
The validate argument both checks that x is 2d as well as converts it to an np.array
```

Build your own transformer

For a more full features transformer, it is possible to construct it as a class that inherits from `BaseEstimator` and `TransformerMixin` classes from the base submodule.

```
from sklearn.base import BaseEstimator, TransformerMixin

class scaler(BaseEstimator, TransformerMixin):
    def __init__(self, m = 1, b = 0):
        self.m = m
        self.b = b

    def fit(self, X, y=None):
        return self

    def transform(self, X, y=None):
        return X*self.m + self.b
```

```
X = pd.DataFrame({"x1": range(1,6), "x2": range(5,0,-1)})
```

```
double = scaler(2)
double.fit_transform(X)
```

```
##      x1   x2
## 0      2   10
## 1      4     8
## 2      6     6
## 3      8     4
## 4     10     2
```

```
double.get_params()
```

```
## {'b': 0, 'm': 2}
```

```
double.set_params(b=-3).fit_transform(X)
```

```
##      x1   x2
```

What else do we get?

```
print(  
    pd.DataFrame(np.array(dir(double)).reshape(-1,4)).to_string(index=False, header=False, col_space=20)  
)
```

```
##          __class__           __delattr__           __dict__           __dir__  
##          __doc__            __eq__            __format__          __ge__  
##          __getattribute__   __getstate__          __gt__            __hash__  
##          __init__          __init_subclass__      __le__            __lt__  
##          __module__         __ne__            __new__            __reduce__  
##          __reduce_ex__       __repr__          __setattr__        __setstate__  
##          __sizeof__          __str__          __subclasshook__  __weakref__  
## _check_feature_names  _check_n_features  _get_param_names  _get_tags  
##          _more_tags         _repr_html_          _repr_html_inner  _repr_mimebundle_  
##          _validate_data             b                  fit          fit_transform  
##          get_params             m          set_params          transform
```

Demo - Interaction Transformer

Useful methods

We employed a couple of special methods that are worth mentioning in a little more detail.

- `_validate_data()` & `_check_feature_names()` are methods that are inherited from `BaseEstimator` they are responsible for setting and checking the `n_features_in_` and the `feature_names_in_` attributes respectively.
- In general one or both is run during `fit()` with `reset=True` in which case the respective attribute will be set.
- Later, in `transform()` one or both will again be called with `reset=False` and the properties of `x` will be checked against the values in the attribute.
- These are worth using as they promote an interface consistent with `sklearn` and also provide convenient error checking with useful warning and error messages.

check_is_fitted()

This is another useful helper function from `sklearn.utils` - it is fairly simplistic in that it checks for the existence of the specified attribute. If no attribute is given then it checks for any attributes ending in `_` that do not begin with `__`.

Again this is useful for providing a consistent interface and useful error / warning messages.