Python by smell

Advanced Python constructs for scientists

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What's this smell?

- You're here because you started feeling the "code smell"

- Scientists in the wild tend to write this…
- What is the smell of the code in the notebooks?

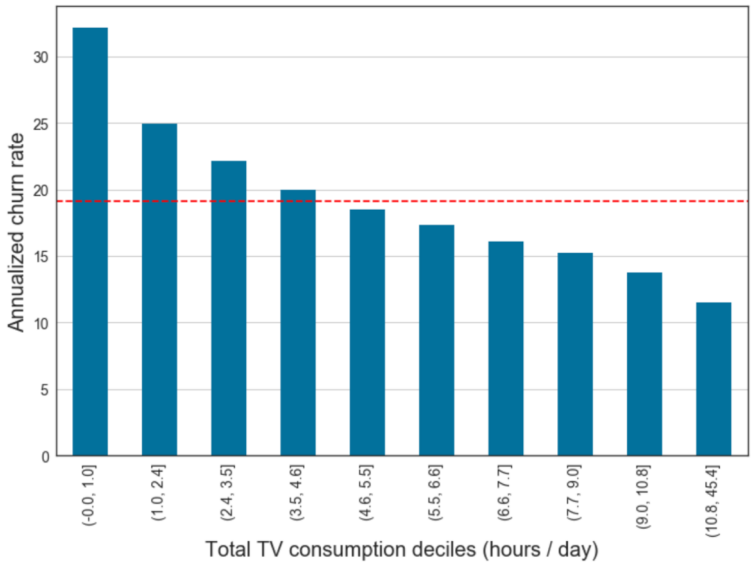
What about this smell?

7.1 Total TV

In [118]:
```
ttv_h_deciles = pd.qcut(ttv_h, 10)
ttv_deciles_churn = tv_merged.groupby(ttv_h_deciles).churned_all.mean() * 12 / 10 * 100
```

In [119]:
```
with plt.rc_context(rc=get_style(figsize=(12 ,8))):
    ax = ttv_deciles_churn.plot.bar(color=blue)
    plt.grid(axis='y')
    plt.xlabel('Total TV consumption deciles (hours / day)')
    plt.ylabel('Annualized churn rate')
    plt.axhline(annual_tv_churn * 100, c='r', ls='--')

    t = ['({:.1f}, {:.1f}]'.format(x.left, x.right) for x in ttv_deciles_churn.index]
    plt.xticks(range(len(t)), t)
```



What about this smell?

7.1 Total TV

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ttv_deciles_churn = tv_merged.groupby(ttv_h_deciles).churned_all.mean() * 12 / 10 * 100
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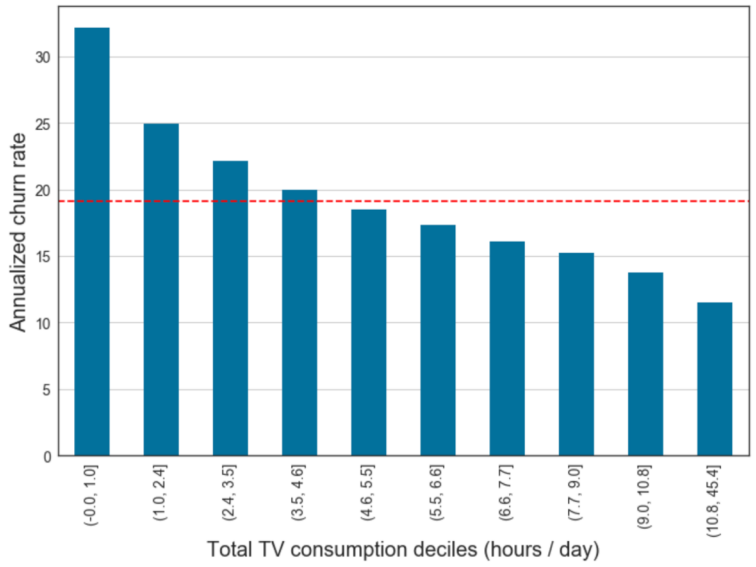
```



7.2 Playback

In [120]:
```
replay_deciles = pd.qcut(tv_merged.PLAYBACK / ttv_sec_to_hpd, 10)
replay_deciles_churn = tv_merged.groupby(replay_deciles).churned_all.mean() * 12 / 10 * 100
```

In [121]:
```
with plt.rc_context(rc=get_style(figsize=(12 ,8))):
    ax = replay_deciles_churn.plot.bar(color=blue)
    plt.grid(axis='y')
    plt.xlabel('Replay TV consumption deciles (hours / day)')
    plt.ylabel('Annualized churn rate')
    plt.axhline(annual_tv_churn * 100, c='r', ls='--')

    t = ['({:.1f}, {:.1f})'.format(x.left, x.right) for x in replay_deciles_churn.index]
    plt.xticks(range(len(t)), t)
```

In [122]:
```
replay_h = pd.cut(tv_merged.PLAYBACK / ttv_sec_to_hpd, np.arange(0, 8), include_lowest=True)
replay_churn = tv_merged.groupby(replay_h).churned_all.mean() * 12 / 10 * 100
```

In [123]:
```
with plt.rc_context(rc=get_style(figsize=(12 ,8))):
    ax = replay_churn.plot.bar(color=blue)
    plt.grid(axis='y')
    plt.xlabel('Replay TV consumption (hours / day)')
    plt.ylabel('Annualized churn rate')
    plt.axhline(annual_tv_churn * 100, c='r', ls='--')
```

7.3 Trends

In [137]:
```
tv_delta = pd.cut(tv_merged.TTV_201703_delta, np.arange(-5.5, 5.6, 1.0))
tv_delta_churn = tv_merged.groupby(tv_delta).churned_all.mean() * 12 / 10 * 100
```

In [138]:
```
with plt.rc_context(rc=get_style(figsize=(12 ,8))):
    ax = tv_delta_churn.plot.bar(color=blue)
    plt.grid(axis='y')
    plt.xlabel('TV consumption trend')
    plt.ylabel('Annualized churn rate')
    plt.axhline(annual_tv_churn * 100, c='r', ls='--')
```

In [1651]:
```
tv_delta = pd.cut(tv_merged.TTV_201703_delta, np.arange(-5.5, 5.6, 1.0))
tv_delta_churn_some = tv_merged[at_least_some_ttv_mask].groupby(tv_delta[at_least_some_ttv_mas
```

In [1652]:
```
with plt.rc_context(rc=get_style(figsize=(12 ,8))):
    ax = tv_delta_churn_some.plot.bar(color=blue)
    plt.grid(axis='y')
    plt.xlabel('TV consumption trend')
    plt.ylabel('Annualized TV+Vodafone churn rate')
    plt.axhline(annual_tv_churn * 100, c='r', ls='--')
```

What is wrong with smelly code?

- **Redundant, not flexible**: an update in one place would need to be duplicated everywhere
- **Hard to read and test**: the code that performs the interesting computation is mixed with the code that does the repetitive boilerplate

Objective

- This is a code smell detection crash course for scientific programming
- **Advanced Python constructs are the way to get rid of the smell!**

All the “advanced Python constructs” smells

The smell of **generators**

```
for ... :
    # Transform / filter
    for ... :
        # Transform / filter
        # The interesting part of the code
```

The smell of **context managers**

```
# Prepare
try:
    # The code you care about
finally:
    # Clean up
```

The smell of **classes**

```
def first_function(x, y, z):
    # Something

def second_function(x, y, z):
    # Something else

def third_function(x, y, z):
    # Something more
```

The smell of **decorators**

```
def my_function(x, y, z):
    # Common boilerplate at beginning
    # Function-specific part
    # Common boilerplate at end
```

The smell of generators

One or more nested loops, variables over which one iterates requires some extra transformation or filtering

```
for ... :
    # Transform / filter
    for ... :
        # Transform / filter
        # The interesting part of the code
```

This is the part that actually does some interesting computation. At the moment, it's hard to test it!

… becomes …

```
for ... in my_generator():
    # The interesting part of the code
```

The smell of context managers

Before executing the code, something needs to happen: open a file, connect to a DB, initialize some hardware

Once the code has executed, we need to clean up, **even if an error occurred**: close the file, commit / revert SQL transactions, disconnect from hardware

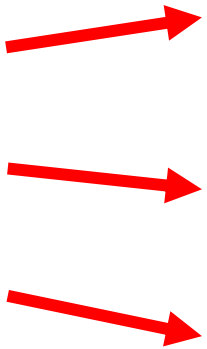
```
# Initialize context
try:
    # The code you care about
finally:
    # Clean up context
```

… becomes …

```
with my_context_manager():
    # The code you care about
```

The smell of classes

The same set of parameters is needed for a set of functions. In code calling this function, one needs extra code to keep these parameters in sync.



```
def first_function(x, y, z):
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def second_function(x, y, z):
    # Something else

def third_function(x, y, z):
    # Something more
```

… becomes …

```
class Xyz:
    def __init__(self, x, y, z):
        ...
```

```
def first_function(xyz):
    # Something

def second_function(xyz):
    # Something else

def third_function(xyz):
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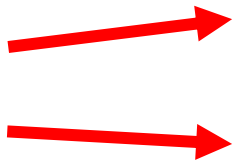
```

The smell of decorators

Boilerplate code at the start and/or end of functions. Typical cases: logging, deprecation, conditions checks, caching



```
def my_function(x, y, z):
    # Boilerplate at start
    # Function-specific part
    # Boilerplate at end
```

This is the part that is specific to what the function actually does

… becomes …

```
@my_decorator
def my_function(x, y, z):
    # Function-specific part
```

One smell at the time: generators first

The smell of generators

One or more nested loops, variables over which one iterates requires some extra transformation or filtering

```
for ... :
    # Transform / filter
    for ... :
        # Transform / filter
        # The interesting part of the code
```

This is the part that actually does some interesting computation. At the moment, it's hard to test it!

… becomes …

```
for ... in my_generator():
    # The interesting part of the code
```

Example

```
comment_prefixes = ['# ', '-- ', 'REM ']

filename1 = 'first_commented_data.csv'
print('Load data from', filename1)
with open(filename1, 'rt') as f:
    valid_lines = []
    for line in f:
        for prefix in comment_prefixes:
            if line.startswith(prefix):
                break
        else:
            data = [int(x) for x in line.split(',')]
            valid_lines.append(data)

data1 = pd.DataFrame(valid_lines, columns=['unci', 'dunci', 'trinci', 'quari'])
```

Ideally…

```
parse_data(filter_comments(readfiles(filenames)))
```

This is actually what we'd like to write:

1. Extract each for-loop step in a reusable element and give it a nice name
2. Do all of this without actually loading all the data in memory for the intermediate steps!

Let's get there step by step…

Go to “generators” notebooks

Recap: Generators

- Generators are used to get rid of repetitive loops, often nested ”for” loops followed by filtering of the data
- Generators return one item at the time, the list of items does not need to be in memory
- A generator is defined as a function containing the keyword ”yield”:

```
def odd_numbers(n):
    """ Generator for the first `n` odd numbers. """
    for i in range(n):
        # Use `yield` instead of `return`: execution will start again from here
        yield i * 2 + 1

for i in odd_numbers(5):
    print(i)
```

One smell at the time: Context managers

The smell of context managers

Before executing the code, something needs to happen: open a file, connect to a DB, initialize some hardware

Once the code has executed, we need to clean up, **even if an error occurred**: close the file, commit / revert SQL transactions, disconnect from hardware

```
# Initialize context
try:
    # The code you care about
finally:
    # Clean up context
```

… becomes …

```
with my_context_manager():
    # The code you care about
```

Go to “context managers” notebooks

Recap: Context managers

- Context managers eliminate the smell of repeatedly setting up and cleaning up an environment in which code needs to run

```
from contextlib import contextmanager

@contextmanager
def my_context(params):
    print('Set up environment')
    try:
        yield  # Here the block of code is executed
    finally:
        print('Clean up environment')

with my_context(params):
    print('Do something interesting here')
```

FYI: most general way of defining context manger

- `@contextmanager` is a shortcut for writing a class with magic methods `__enter__` and `__exit__`:

```
class MyContext():

    def __init__(self, params):
        self.params = params

    def __enter__(self):
        print('Set up environment')

    def __exit__(self, *args):
        # This is called even if there is an exception!
        print('Clean up environment')


with MyContext(params):
    print('Do something interesting here')
```

Keep your nose ready!

The smell of **generators**

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```

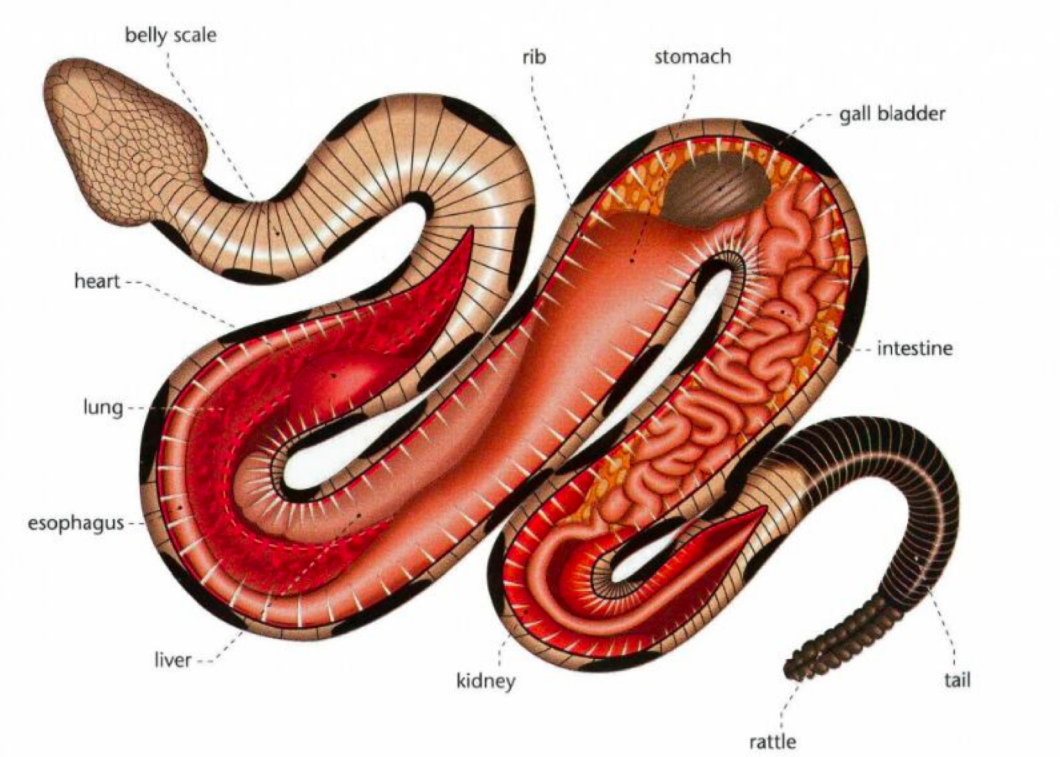
The smell of **decorators**

```
def my_function(x, y, z):
    # Common boilerplate at beginning
    # Function-specific part
    # Common boilerplate at end
```

Where to go from here…

realpython.com

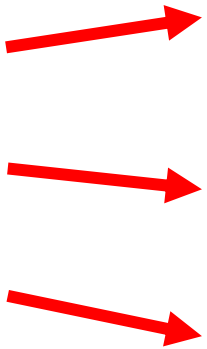
Thank you!



One smell at the time: classes (an introduction)

The smell of classes

The same set of parameters is needed for a set of functions. In code calling this function, one needs extra code to keep these parameters in sync.



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… becomes …

```
class Xyz:
    def __init__(self, x, y, z):
        ...
```

```
def first_function(xyz):
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def third_function(xyz):
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```

Go to “classes” notebooks

Recap: Classes

- Classes are used to get rid of set of parameters that belong together and are passed over and over to a set of functions
- Classes are templates for bundles of data and “methods”, i.e. functions that have access to the data stored in an instance
- A ”class method” is used to build an instance in some alternative way, e.g. using data from a file

Recap: Class structure

```
class MyClass:
    def __init__(self, param1, param2):
        self.param1 = param1
        if param2 is None:
            param2 = 12.3
        self.param2 = param2

    def my_method(self, foo, bar):
        result = self.param2 * foo + self.param2 * bar
        return result

    def to_json(self):
        params = {
            'param1': self.param1,
            'param2': self.param2,
        }
        return json.dumps(params)

    @classmethod
    def from_json(cls, json_str):
        json_dict = json.loads(json_str)
        instance = cls(json_dict['params1'], json_dict['params2'])
        return instance


instance = MyClass(5, 18)
instance = MyClass.from_json(json_str)
```

The constructor is used to first populate an instance, called by convention “self”

Classes can define “methods”, i.e. functions that have access to the data stored in an instance

A ”class method” is used to build an instance in some alternative way, e.g. using data from a file

Here is how you create instances from the constructor or a class method

What belongs to a class?

- YES
  + Data that always belongs together: better create several simple classes than one class that contains everything
  + Methods to load/save data, create data bundle in different ways (factory methods)
  + Methods to update parameters
- NO
  - Methods to visualize data: follow the Model-View pattern.
    You will want to visualize the data in many different ways, better have separate utility visualization functions that take one of the instances as input and visualize them.
  - Similarly, anything for which you can imagine to write 5 different variants depending on your mood

Another smell of classes

Several “specializations” of conceptually similar functions

```
for data in list_of_data:
    if data['type'] == 'TYPE1':
        type1_foo(data)
        type1_bar(data)
    elif data['type'] == 'TYPE2':
        type2_foo(data)
        type2_bar(data)
```

… becomes …

Classes may have methods with the same interface, the class type determines the “specialization”.

```
for instance in instances:
    instance.foo(data)
    instance.bar(data)
```

One can even define a hierarchy of classes where some methods are re-used!

Another smell of classes – simple example

Several “specializations” of conceptually similar functions

```
for data in geometric_objects:
    if data['type'] == ‘SQUARE':
        area = area_square(data)
    elif data['type'] == ‘CIRCLE':
        area = area_circle(data)
```

… becomes …

Classes may have methods with the same interface, the class type determines the “specialization”.

```
for instance in geometric_objects:
    area = instance.area()
```

One can even define a hierarchy of classes where some methods are re-used!

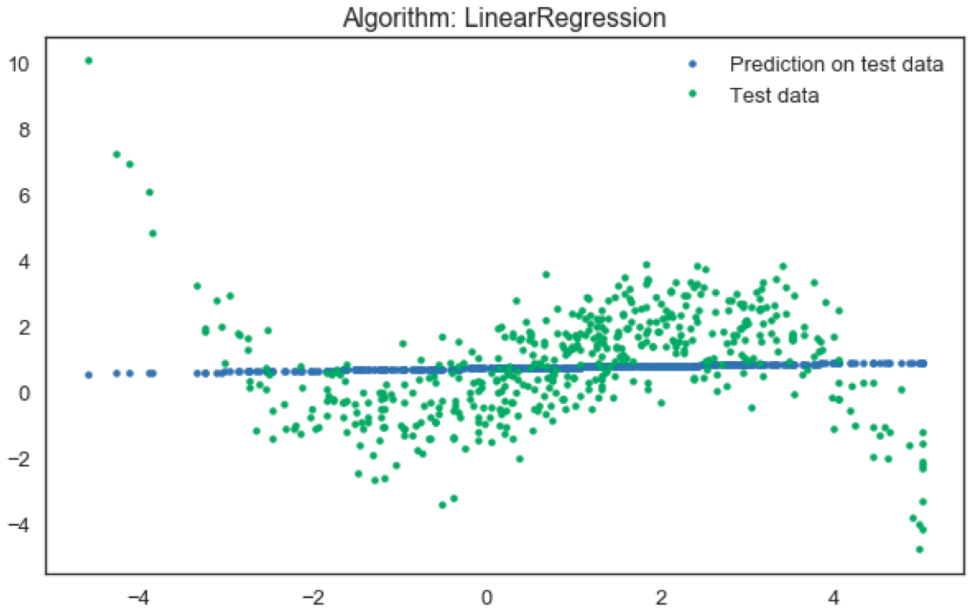
Real example: sklearn

```
from sklearn.linear_model import LinearRegression

model = LinearRegression()
model.fit(X_train, y_train)

score = model.score(X_test, y_test)
print('Model score:', round(score, 4))

y_pred = model.predict(X_test)
with plt.rc_context(rc={'figure.figsize': (10, 6)}):
    plt.plot(X_test, y_pred, '.', label='Prediction on test data')
    plt.plot(X_test, y_test, '.', label='Test data')
    plt.legend()
    plt.title('Algorithm: ' + model.__class__.__name__)
```




```
Model score: 0.0066
```

Real example: sklearn

```
from sklearn.svm import SVR

model = SVR(kernel='rbf')
model.fit(X_train, y_train)

score = model.score(X_test, y_test)
print('Model score:', round(score, 4))

y_pred = model.predict(X_test)
with plt.rc_context(rc={'figure.figsize': (10, 6)}):
    plt.plot(X_test, y_pred, '.', label='Prediction on test data')
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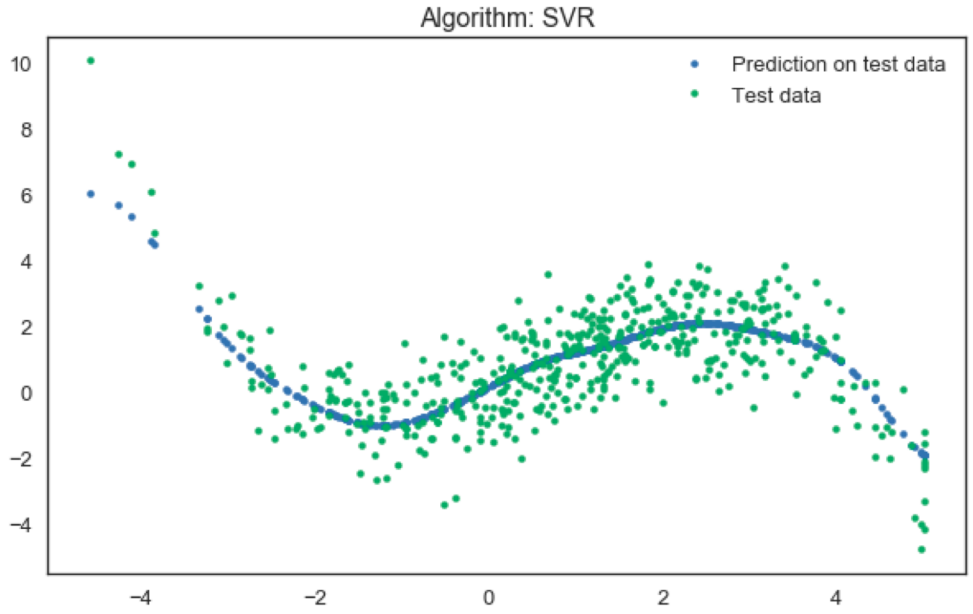


```
Model score: 0.6144
```