FactoryFactories and so can you

Software design and testing patterns for maintainable machine learning code

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Machine Learning Tokyo
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Chris Gerpheide

- CTO at Bespoke, makers of Bebot
- *Previous*:
  - B.A. Mathematics
  - M.Sc. Computer Science
  - 4 publications on software quality
  - Engineering Manager at AWS

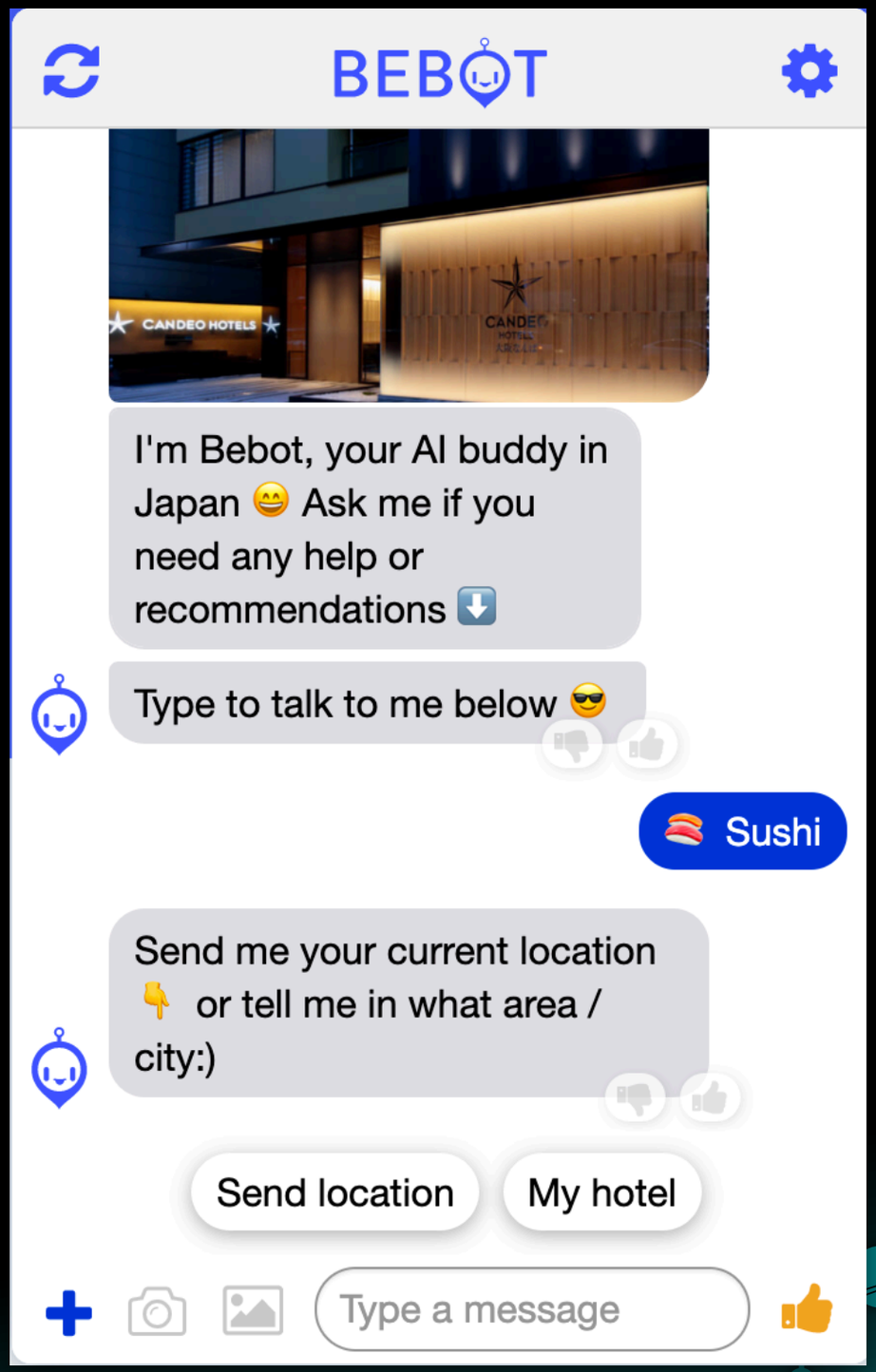
Bebot

Chatbot for tourists

Narita Airport
Connecting Japan to the World

Tampa International Airport

Machine learning for NLU



BESPOKE

Production code
Owned by **R&D team**

1. What is the user’s request?

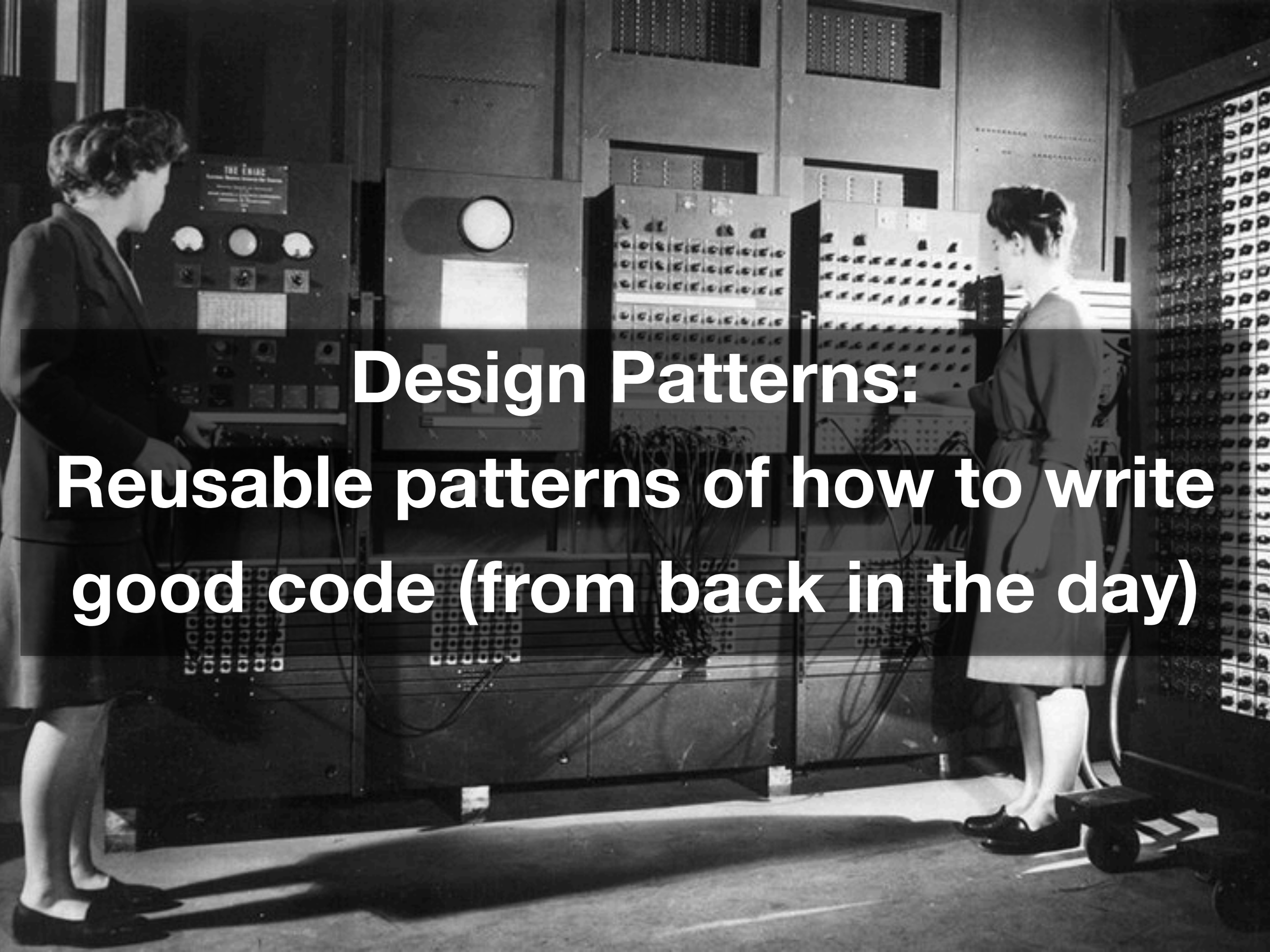
NLU

WebApp

3. Build & return answer

2. “find_veg_restaurant”

https://www.smithjournal.com.au/



Design Patterns:

Reusable patterns of how to write good code (from back in the day)

```
query = "SELECT " + t1_col1 + "," + t1_col2 + "," +
    t2_col1 + " FROM " + t1_name  + " JOIN " +
    t2_name + " ON (" + t1_idcol + " = " + t2_idcol +
    ") ORDER BY " + t1_col1
```

```
query = "SELECT {},{},{} FROM {} JOIN {} ON ({} = {}) ORDER BY {}"
    .format(t1_col1, t1_col2, t2_col1, t1_name,
        t2_name, t1_idcol, t2_idcol,  t1_col1)
```

```
query = QueryBuilder(t1_name)
        .columns(t1_col1, t1_col2, t2_col1)
        .join(t2_name, t1_idcol, t2_idcol)
        .order_by(t1_col1)
        .build()
```

Focus on the ***UX*** of your code

(Or the Coder Experience, if you prefer)

- Spend time on this
- …And write a lot of tests

Object-oriented design patterns

- Builder
- Factory
- Facade
- Decorator
- Adapter

Builder (1/5)

Simplify creation of complex objects

```
query = "SELECT " + t1_col1 + "," + t1_col2 + "," +
    t2_col1 + " FROM " + t1_name  + " JOIN " +
    t2_name + " ON (" + t1_idcol + " = " + t2_idcol +
    ") ORDER BY " + t1_col1
```

```
query = "SELECT {},{},{} FROM {} JOIN {} ON ({} = {}) ORDER BY {}"
    .format(t1_col1, t1_col2, t2_col1, t1_name,
        t2_name, t1_idcol, t2_idcol,  t1_col1)
```

```
query = QueryBuilder(t1_name)
        .columns(t1_col1, t1_col2, t2_col1)
        .join(t2_name, t1_idcol, t2_idcol)
        .order_by(t1_col1)
        .build()
```

Keeps track of state

Return `self` to chain

```
class QueryBuilder:

    def __init__(self, table):
        self.table = table
        self.cols = []
        self.joins = []
        self.orderbys = []

    def columns(self, *args):
        self.cols = [*, *]join(args)
        return self

    def join(self, other_table, col, other_col):
        self.joins.append('JOIN {} ON {}={}'.format(other_table, col, other_col))
        return self

    def order_by(col):
        self.orderbys.append(col)
        return self
```

Validation

Merge all the state

```
class QueryBuilder:
    ...

    def build():
        # validation
        if not self.cols:
            raise Exception('Must specify columns')
        self.cols = unique(self.cols)

        # build
        q  = 'SELECT {} '.format(','.join(self.columns))
        q += 'FROM {} '.format(self.table)
        if self.joins:
            q += '{} '.format(' '.join(self.joins))
        if self.orderbys:
            q += ' ORDER BY {} '.format(','.join(self.orderbys))
        return q
```

Builder

```
model = Sequential()
model.add(Dense(64, input_dim=20, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(64, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(1, activation='sigmoid'))

model.compile(loss='binary_crossentropy',
              optimizer='rmsprop',
              metrics=['accuracy'])
```

Factory (2/5)

Interface for creating related objects

```python
original_text = 'Hello! how are you todya? :)'

res = predict(original_text)
if not res:
    sanitized_text = make_ascii(original_text.lower())
    res = predict(sanitized_text)
if not res:
    res = predict(typo_correct(original_text))
if not res:
    ...

return res
```

```python
original_text = 'Hello! how are you todya? :)'

text_factory = TextFactory(original_text)

res = predict(original_text)
if not res:
    res = predict(text_factory.sanitized())
if not res:
    res = predict(text_factory.typo_corrected())
if not res:
    ...

return res
```

Nice to use with `@property` decorator too

```
class TextFactory:

    def __init__(self, text):
        self.raw = text

    @property
    def sanitized(self):
        return make_ascii(self.raw.lower())
    @property
    def typo_corrected(self):
        return typo_correct(self.raw)
    @property
    def sanitized_and_typo_corrected(self):
        return typo_correct(self.sanitized())
```

Optional: Add caching

```
class TextFactory:

    def __init__(self, text):
        self.raw = text

    def sanitized(self):
        if not self._sanitized:
            self._sanitized = make_ascii(self.raw.lower())
        return self._sanitized

    def typo_corrected(self):
        if not self._typo_corrected:
            self._typo_corrected = typo_correct(self.raw)
        return self._typo_corrected

    def sanitized_and_typo_corrected(self):
        if not self._sanitized_and_typo_corrected:
            self._sanitized_and_typo_corrected = typo_correct(self.sanitized())
        return self._sanitized_and_typo_corrected
```

Factory

```
original_text = 'Hello! how are you todya? :)'

text_factory = TextFactory(original_text)

res = predict(original_text)
if not res:
    res = predict(text_factory.sanitized())
if not res:
    res = predict(text_factory.typo_corrected())
if not res:
    res = predict(text_factory.sanitized_and_typo_corrected())

return res
```

Facade (3/5)

Unified, higher-level interface to another system

```python
s3.write('some_s3_bucket', 'corpora/1234/corpus.json', corpus)
s3.write('some_s3_bucket', 'models/classifier_1234.gz',
        gzip(pickle.dump(classifier)))
db.insert('database1', 'current_model_id', 1234)

...

model_id = db.get('database1', 'current_model_id')
corpus = json.loads(s3.read('some_s3_bucket',
    'corpora/{}/corpus.json'.format(model_id)))
classifier = pickle.loads(gunzip(s3.read('some_s3_bucket'),
        'models/classifier_{}}.gz'.format(model_id)))

...
prediction = classifier.classify('foo')
```

```python
data_facade = DataFacade(1234)

data_facade.put_corpus(corpus)
data_facade.put_classifier(corpus)
data_facade.put_current_model_id()
...
model_id = data_facade.get_current_model_id()
corpus = data_facade.get_corpus()
classifier = data_facade.get_classifier()
```

```python
class DataFacade:

    S3_BUCKET = 'some_s3_bucket'
    DATABASE = 'database1'

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

    def get_corpus(self):
        return json.loads(s3.read(S3_BUCKET,
            'corpora/{}/corpus.json'.format(self.model_id)))

    def put_corpus(self, corpus):
        s3.write(S3_BUCKET, 'corpora/{}/corpus.json'
            .format(self.model_id), corpus)

    def get_current_model_id(self):
        return db.get(DATABASE, 'current_model_id')

    def put_current_model_id(self):
        db.insert(DATABASE, 'current_model_id', self.model_id)

    def get_classifier(self):
        return pickle.loads(gunzip(s3.read(S3_BUCKET),
                'models/classifier_{}}.gz'.format(self.model_id)))

    def put_classifier(self, classifier):
        s3.write(S3_BUCKET, 'models/classifier_{}.gz'.format(self.model_id),
                gzip(pickle.dump(classifier)))
```

Different services

Handles file names + types

Facade

```
data_facade = DataFacade(1234)

data_facade.put_corpus(corpus)
data_facade.put_classifier(corpus)
data_facade.put_current_model_id()
...
model_id = data_facade.get_current_model_id()
corpus = data_facade.get_corpus()
classifier = data_facade.get_classifier()
```

Decorator (4/5)

Attach additional responsibilities to an object dynamically

```python
def train():
    start_time = time()
    model.train()
    print("Finished training in {} secs".format(time() - start_time ))
```

```python
@timer
def train():
    model.train()
```

```python
def timer(func):

    @functools.wraps(func)
    def wrapper_timer(*args, **kwargs):
        start_time = time()
        value = func(*args, **kwargs)
        print("Finished {} in {} secs"
                  .format(func.__name__, time() - start_time))
        return value

    return wrapper_timer
```

Decorator

```
@timer
def train():
    model.train()
```

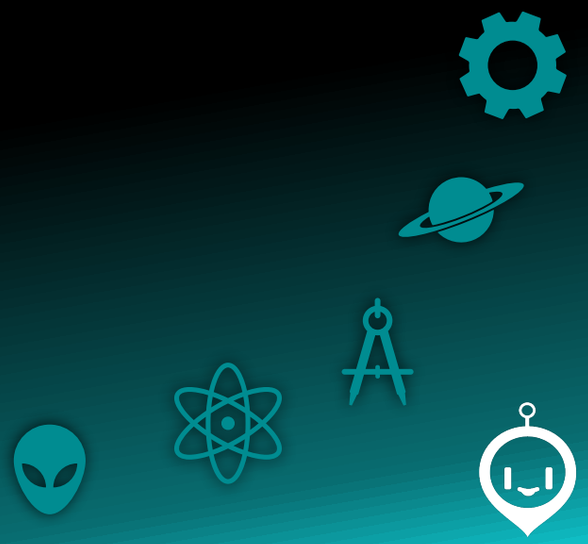
Adapter (5/5)

Convert an object to an easier-to-use class

```
{
    'meta': {
        'id': 1234
        'date': '2020/01/25'
    },
    'cases': [
        [
            {
                'text': 'I really like pancakes',
                'source': 'twitter'},
            {
                'value': 'positiveSentiment',
                'labeller': 'Chris'
            },
        ],
        ...
    ]
}
```

```python
data = json.loads(download_raw_data())

print('Processing ID {}'.format(data['meta']['id']))

inputs = []
labels = []

for item in data['cases']:
    if len(item) > 2:
        if 'text' in item[0] and 'value' in item[1]:
            cleaned_input = clean(item[0]['text'])
            inputs.append(cleaned_input)
            labels.append(item[1]['value'])

model.train(inputs, labels)
```

BESPOKE



```
data = [redacted] a())
corpu[redacted] = CorpusJsonAdapter(data)

print([redacted] rpus.id))

model.train(corpus.inputs, corpus.labels)
```

or

```
data = [redacted] ta())
corpu[redacted] = Corpus.from_json(data)

print([redacted] orpus.id))

model.train(corpus.inputs, corpus.labels)
```

All transformation logic in own class

```python
class Corpus:

    def __init__(self, id):
        self.id = None
        self.inputs = []
        self.labels = []
```

Then work with this

```python
class CorpusJsonAdapter(Corpus):

    def __init__(self, data):
        self.id = data['meta']['id']

        for item in data['cases']:
            if len(item) > 2:
                if 'text' in item[0] and 'value' in item[1]:
                    cleaned_input = clean(item[0]['text'])
                    self.inputs.append(cleaned_input)
                    self.labels.append(item[1]['value'])
```

Transformation logic in own method

```python
class Corpus:

    def __init__(self, id):
        self.id = None
        self.inputs = []
        self.labels = []

    @staticmethod
    from_json(data):
        corpus = Corpus()
        corpus.id = data['meta']['id']

        for item in data['cases']:
            if len(item) > 2:
                if 'text' in item[0] and 'value' in item[1]:
                    cleaned_input = clean(item[0]['text'])
                    corpus.inputs.append(cleaned_input)
                    corpus.labels.append(item[1]['value'])
```

```
corpus = CorpusJsonAdapter(data)
```

or

```
corpus = Corpus.from_json(data)
```

or even...

```
data_obj = RawData(data)
corpus = data_obj.to_corpus()
```

```
class RawData:

    def __init__(self, data):
        self.meta = RawData.Meta(data['meta'])
        self.cases = [RawData.Case(d) for d in data['cases']]

    class Meta:
        def __init__(self, data):
            self.id = data['id']

    class Case:

        def __init__(self, data):
            self.textinfo = RawData.Case.Text(data[0])
            self.valueinfo = RawData.Case.Value(data[1])

        class Text:
            def __init__(self, data):
                self.text = data.get('text')
                self.source = data.get('source') # not used

        class Value:
            def __init__(self, data):
                self.value = data.get('value')
                self.labeller = data.get('labeller') # not used
```

Nested classes for all sub-structures

(in all its glory)

```python
class RawData:
    ...

    def to_corpus():
        corpus = Corpus(self.meta.id)

        for case in self.cases:
            if case.textinfo.text and case.valueinfo.value:
                cleaned_input = c[redacted]
                corpus.inputs.append(cleaned_input)
                corpus.labels.append(case.valueinfo.value)
```

Adapter

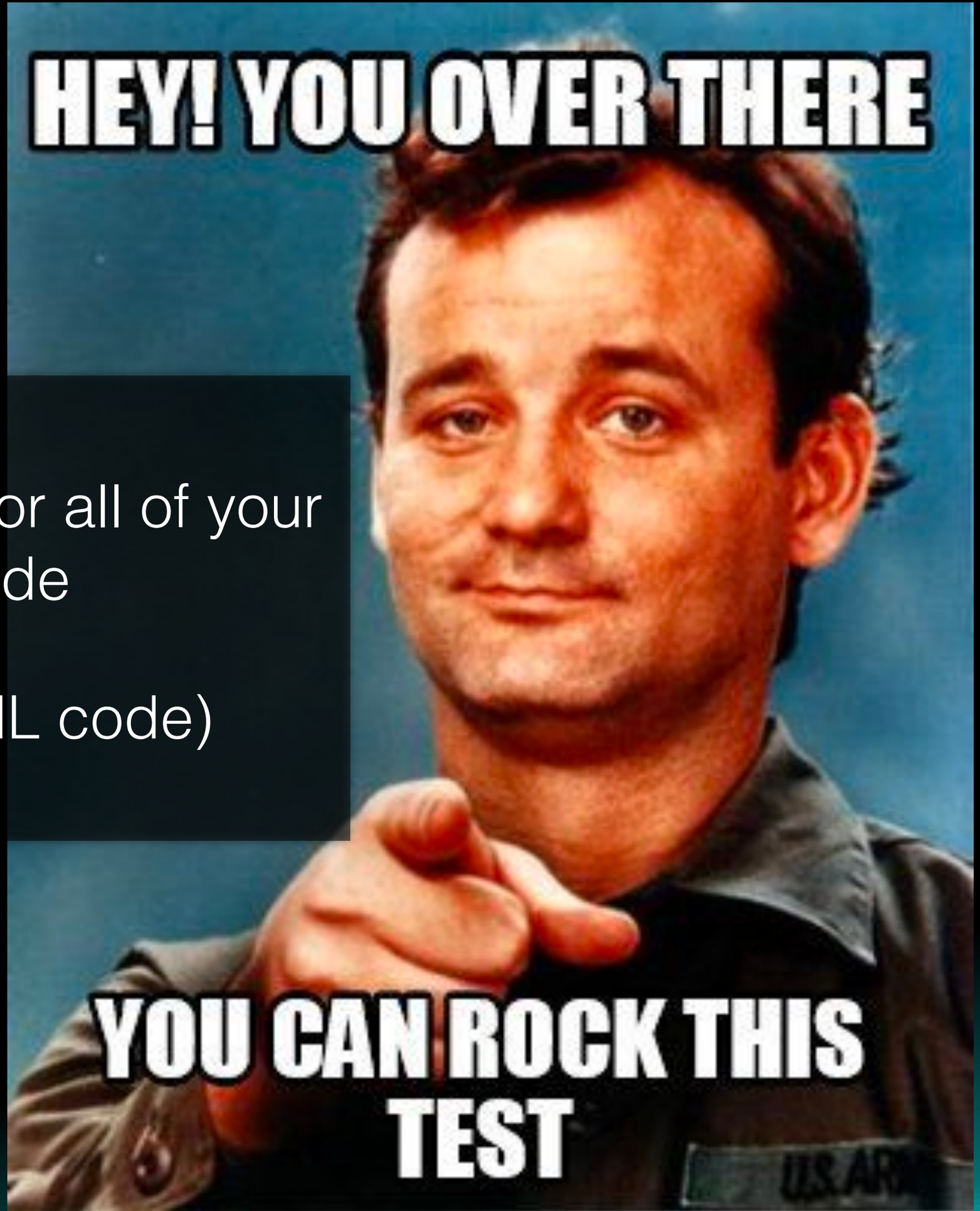
```
corpus = CorpusJsonAdapter(data)
```

```
corpus = Corpus.from_json(data)
```

```
data_obj = RawData(data)
corpus = data_obj.to_corpus()
```

Write tests for all of your code

(even ML code)



Unit test all business logic

Tiny, fast tests

Rules of thumb:

1. At least one test for every “public” function
2. Test every `if` statement
3. Don’t fear duplication

```
class QueryBuilderTest(unittest.TestCase):

    def test_build_with_no_joins_and_orderbys(self):
        # GIVEN
        builder = QueryBuilder('foo_table')
                  .columns('bar')

        # WHEN
        query = build

        # THEN
        self.assertEqual(query, 'SELECT bar FROM foo_table')
```

optional

Explicit

If I didn't have this test, could I still mess up the original function?

No?

```
    def test_build_with_joins_and_orderbys(self):
        # GIVEN
        builder = QueryBuilder('foo_table')
                  .columns('bar', 'baz')
                  .join('foo2', 'bar2', 'baz2')
                  .join('foo3', 'bar3', 'baz3')
                  .order_by('bar4')

        ...
```

Dependency injection

Pass in (mockable) dependent objects.

Test each class separately.

```python
class Algorithm():

    def predict(self):
        data_facade = DataFacade()
        data_facade.get_corpus(corpus  # Calls S3
        ...
```

Test separately

But: instantiation makes tricky to mock out

```python
class Algorithm():

    def __init__(self, _data_facade = None):
        self.data_facade = _data_facade or DataFacade()

    def predict(self):
        self.data_facade.get_corpus(corpus)
        ...
```

Dummy DataFacade
(that does your bidding)

```
def test_predict_with_simple_corpus(self):
    # GIVEN
    # configure mocks
    mock_data_facade = unittest.mock.create_autospec(DataFacade)
    mock_data_facade.get_corpus.return_value = Corpus(['foo'])

    algo = Algorithm(_data_facade=mock_data_facade)

    # WHEN
    result = algo.predict()

    # THEN
    self.assertEqual(result, 'foo', ...)
```

Integration tests

Test multiple classes together, or code that is not unit-testable (e.g. API calls)

Rules of thumb:

1. Add 1 end-to-end integration test
2. Replace large ML models with tiny, awful ones

```
class TransformerLM():

    def [illegible](self, input, model_dir):
        # Load model
        [illegible] = GPT[illegible]onfig.from_json_file(os.path.join(model_dir, 'config.bin'))
        state_dict = torch[illegible]ad(os.path.join(model_dir, 'model.bin'))

        lm = GPT2LMHeadModel(config)
        lm.load_state_dict(state_dict)

        # Use model
        [illegible]
        tokenizer(senten[illegible] pad_to_max_length=True)
        ...
        tokenizer._pad_token
        ...
        vocab.numericalize()
        ...
        torch.no_grad()
        ...
        torch.tensor()
        ...
        lm(input_ids)
        ...
        torch.exp(loss).item()
        ...
```

Too big to integ test

Annoying to unit test

```python
def test_transformers_lm(self):
        # GIVEN
        lm = TransformerLM(model_dir='test_models/')

        # WHEN
        ppl = lm.get_perplexity('test')

        # THEN we expect a valid value
        self.assertTrue(0 < ppl < 100)
```

One-off, save binaries into test repo

```python
# Tiny, essentiall
config = GPT2Conf g(vocab_size=20,n_ctx=20,n_head=2,n_embd=2,n_positions=20)
gpt2_model = GPT2

torch.save(gpt2_model.state_dict(), 'test_models/model.bin')
gpt2_model.config.to_json_file('test_models/config.bin')
```

Summary

- Builder
- Factory
- Facade
- Decorator
- Adapter

- Unit test all code paths
- Use dependency injection instead of mocking functions
- Integ test with test models

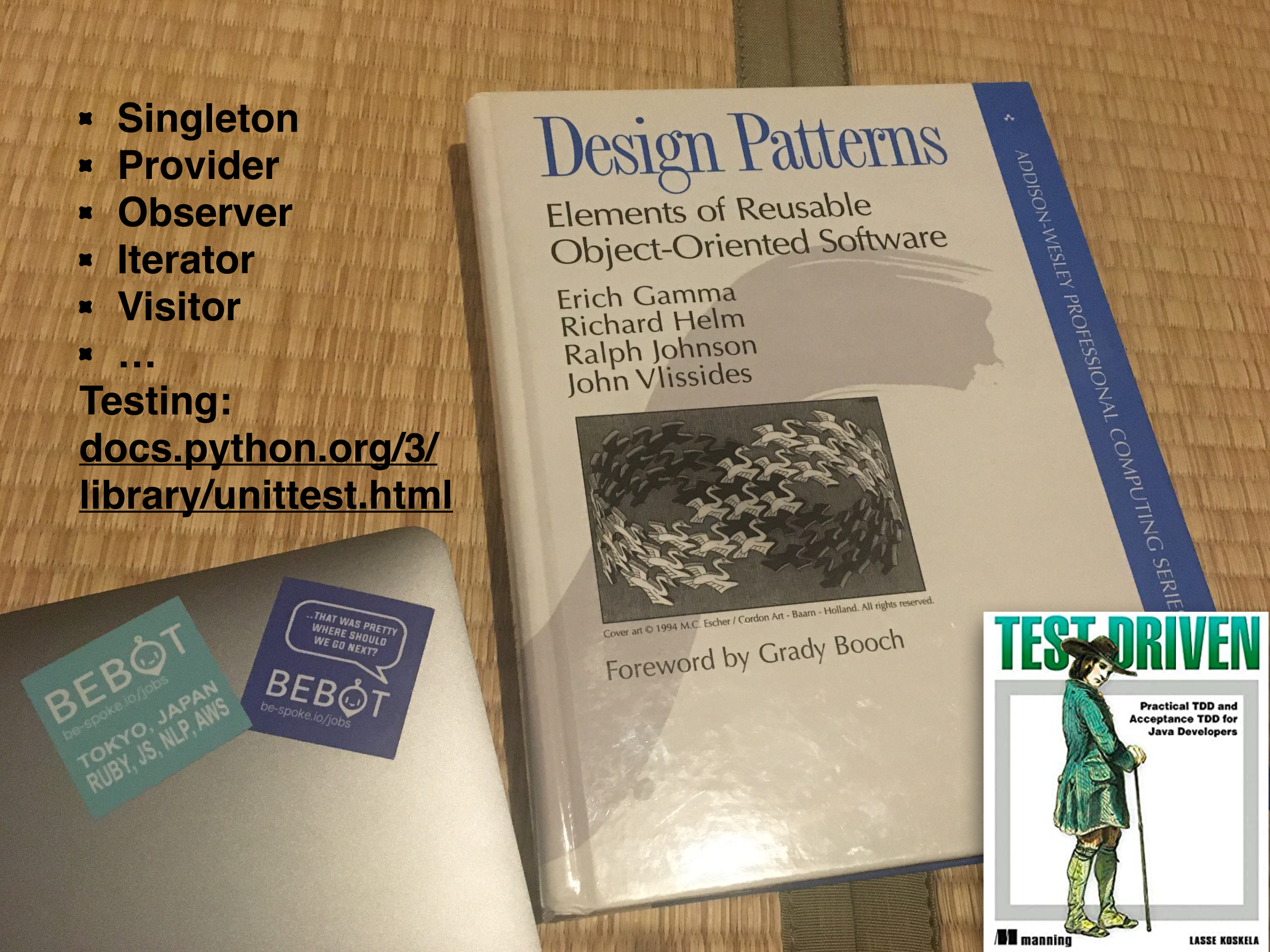
Focus on the UX of your code

```
@timer
def classify(text):
    query = QueryFactory(text)

    pipeline = Pipeline()
        .naive_bayes_classifier(query.typo_corrected)
        .string_similarity_classifier(query.sanitized)
        .naive_bayes_classifier(query.named_entities_substituted)
        .rnn_classifier(query.sanitized)

    return pipeline.first_with_probability_above(.80)
```

And test everything

- Singleton
- Provider
- Observer
- Iterator
- Visitor
- ...

Testing:
docs.python.org/3/library/unittest.html



That code you wrote was very clever…

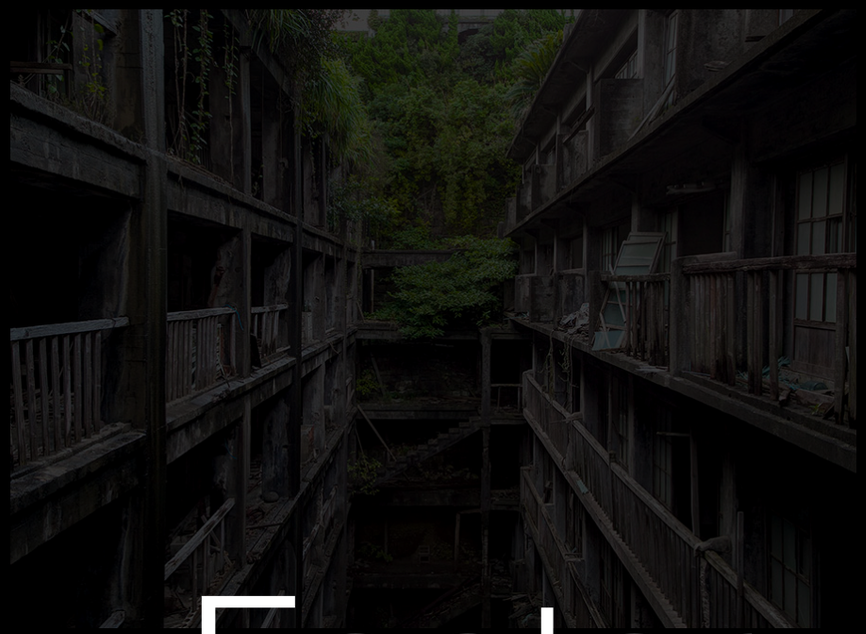
Thanks!

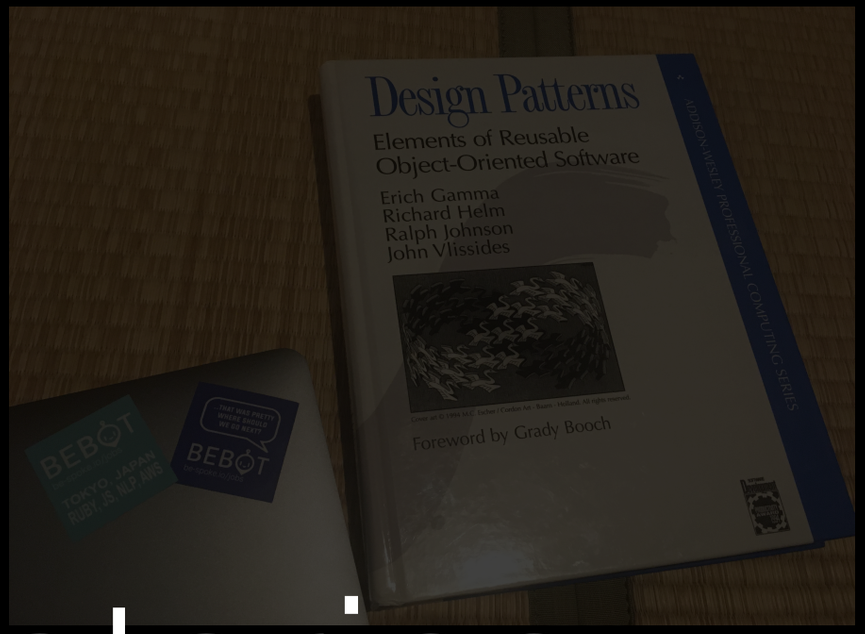
That wasn't a compliment

Senior programmer

Junior programmer

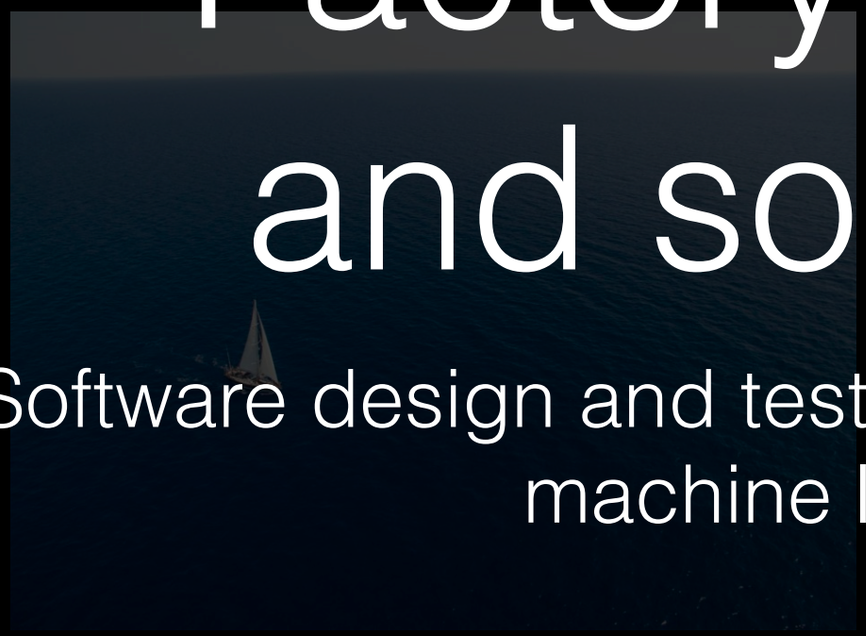
BESPOKE

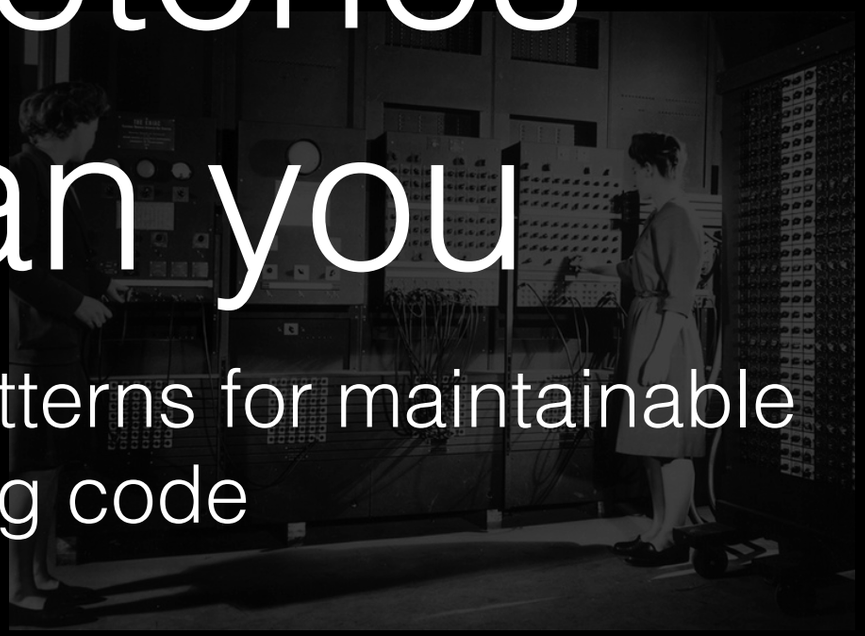




FactoryFactories and so can you

Software design and testing patterns for maintainable machine learning code





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Links and examples

- Python dataclass https://docs.python.org/3/library/dataclasses.html
- Keras Sequential https://keras.io/api/models/sequential/
- Pandas from_csv https://pandas.pydata.org/pandas-docs/version/0.23.1/generated/pandas.DataFrame.from_csv.html