Hunting Bugs While Sleeping

Property-Based Testing with **Hypothesis**

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PyCon AU 2018: Asyncio in (Micro)Python
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Container image security – Notary
Image repository.
Digitally signs images to be published.
The Update Framework (TUF) underlays the tool to maintain up-to-date software.
Allows user to verify content that they download.
Honourable mentions go to Clair
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Polylingualism
kboy3742
INTERNATIONAL CONVENTION CENTRE
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iress
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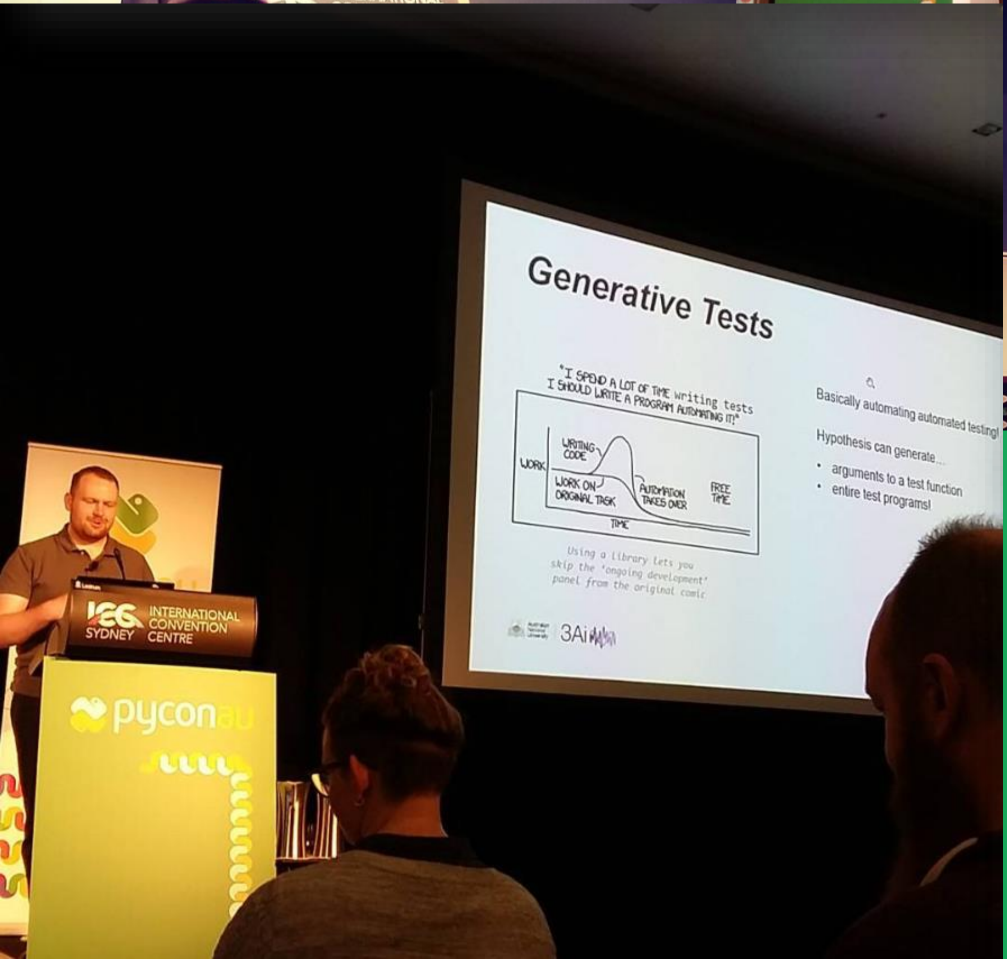
Generative Tests
"I SPEND A LOT OF TIME WRITING TESTS
I SHOULD WRITE A PROGRAM AUTOMATING IT!"
WRITING CODE
WORK
WORK ON ORIGINAL TASK
AUTOMATION TAKES OVER
FREE TIME
TIME
Using a library lets you skip the 'ongoing development' panel from the original comic
Basically automating automated testing!
Hypothesis can generate...
arguments to a test function
entire test programs!
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The Plan

- Hypothesis Overview
  - Property-Based Testing
  - Using Hypothesis
- Contributing to the Project
  - PyCon Sprints

Example Based Testing

```
class TestArithmetic(unittest.TestCase):
  def test_add(self):
    result = add(1, 2)
    self.assertEqual(3, result)
```

1. Set up some data.
2. Perform some operations on the data.
3. Assert something about the result.

Example Based Testing

```python
class TestArithmetic(unittest.TestCase):
  def test_add(self):
    result = add(1, 2)
    self.assertEqual(3, result)
```

```
Still rockin' @08:05:45 AM> python .\test_arithmetic.py
.
----------------------------------------------------------------------
Ran 1 test in 0.000s

OK
Still rockin' @08:08:25 AM>
```

Example Based Testing

```python
def add(x, y):
  if (x==1 and y==2):
    return 3
  else:
    return 0
```

Example Based Testing

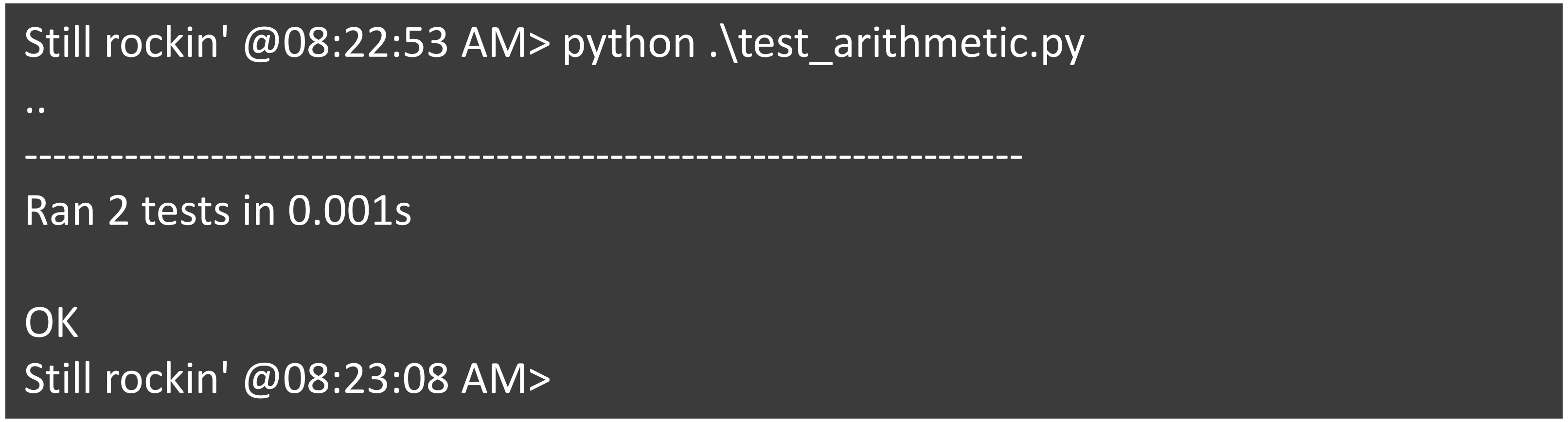
```
def test_add(self):
    result = add(1, 2)
    self.assertEqual(3, result)

def test_add2(self):
    result = add(2, 2)
    self.assertEqual(4, result)
```

Example Based Testing

```python
def test_add(self):
    result = add(1, 2)
    self.assertEqual(3, result)

def test_add2(self):
    result = add(2, 2)
    self.assertEqual(4, result)
```

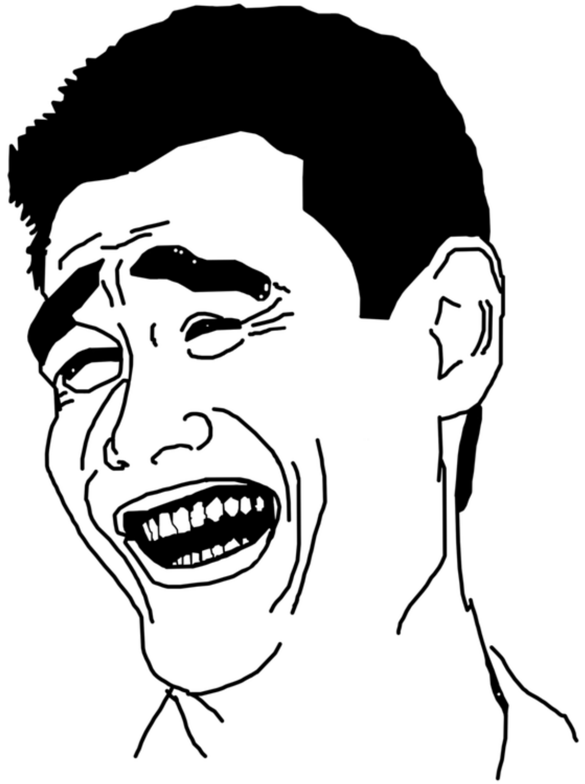


```
Still rockin' @08:22:53 AM> python .\test_arithmetic.py
..
----------------------------------------------------------------------
Ran 2 tests in 0.001s

OK
Still rockin' @08:23:08 AM>
```

Example Based Testing

```
def add(x, y):
    if (x==1 and y==2):
        return 3
    elif (x==2 and y==2):
        return 4
    else:
        return 0
```



Example Based Testing

```
def test_add(self):
    x = random.randint(0,1000)
    y = random.randint(0,1000)
    result = add(x, y)
    self.assertEqual(x + y, result)
```

Example Based Testing

```python
def test_add(self):
    x = random.randint(0,1000)
    y = random.randint(0,1000)
    result = add(x, y)
    self.assertEqual(x + y, result)
```

```
FAIL: test_add (__main__.TestArithmetic)
----------------------------------------------------------------------
Traceback (most recent call last):
  File ".\test_arithmetic.py", line 18, in test_add
    self.assertEqual(x + y, result)
AssertionError: 86 != 0


----------------------------------------------------------------------
Ran 3 tests in 0.001s

FAILED (failures=1)
```

Example Based Testing

```
def test_add(self):
  for i in range(0, 100):
    x = random.randint(0,1000)
    y = random.randint(0,1000)
    result = add(x, y)
    self.assertEqual(x + y, result)
```

Example Based Testing

```
def test_add(self):
  for i in range(0, 100):
    x = random.randint(0,1000)
    y = random.randint(0,1000)
    result = add(x, y)
    self.assertEqual(x + y, result)
```

Implementation duplication

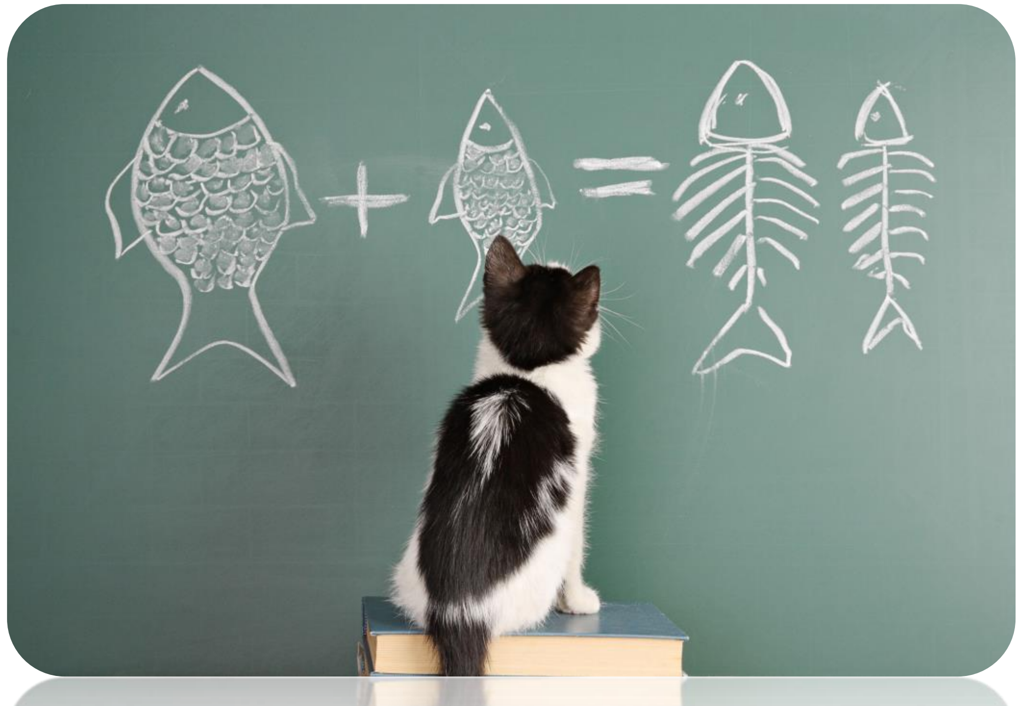
Example Based Testing

```python
def test_add(self):
  for i in range(0, 100):
    x = random.randint(0,1000)
    y = random.randint(0,1000)
    result = add(x, y)
    self.assertEqual(x + y, result)
```

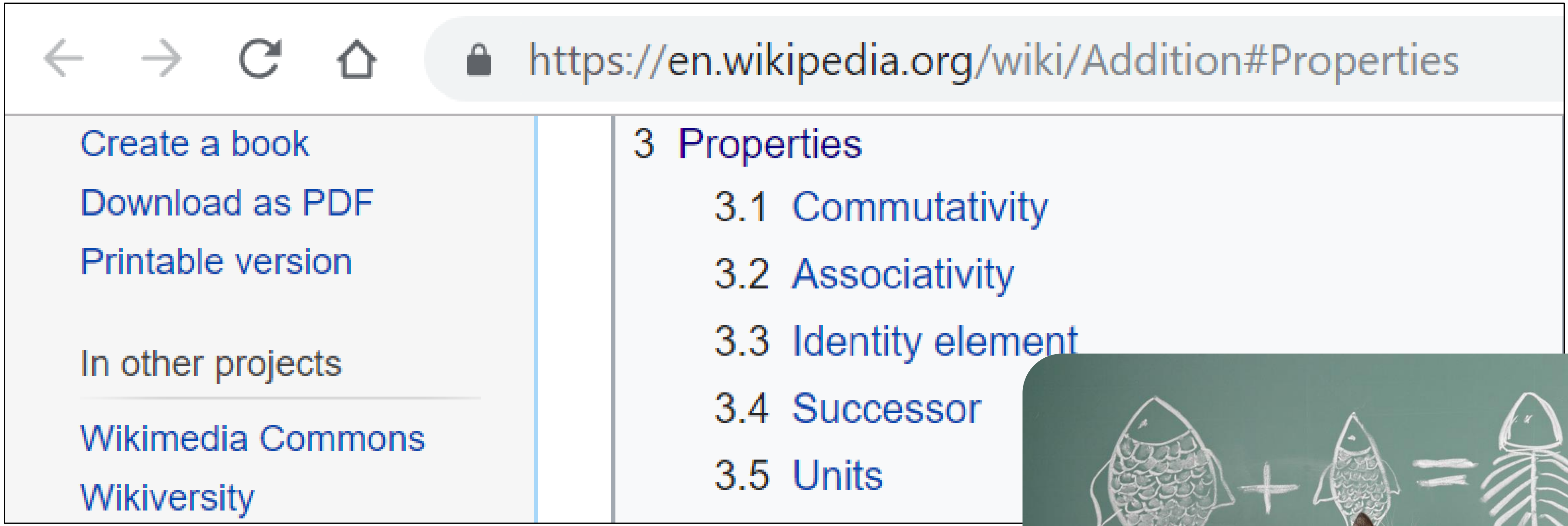
Implementation duplication

But, how else can you test?

What is Addition?



What is Addition?



https://en.wikipedia.org/wiki/Addition#Properties

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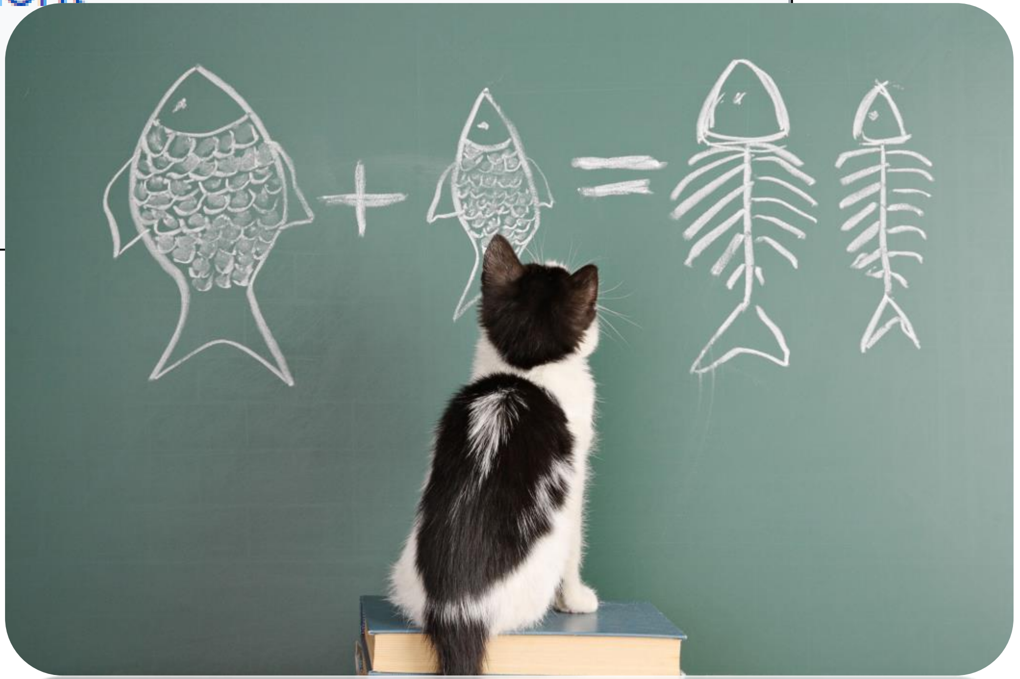
3 Properties
- 3.1 Commutativity
- 3.2 Associativity
- 3.3 Identity element
- 3.4 Successor
- 3.5 Units



Property-Based Testing

```python
from arithmetic import *
from hypothesis import given, strategies as st

@given(st.integers(), st.integers())
def test_commutative_property(x, y):
    assert add(x,y) == add(y,x)

@given(st.integers())
def test_add1twice_is_add2once_property(x):
    assert add(add(x,1),1) == add(x,2)

@given(st.integers())
def test_identity_property(x):
    assert add(x, 0) == x
```

1. For all data matching some specification.
2. Perform some operations on the data.
3. Assert something about the result.

Hypothesis is a library designed to help you write what are called *property-based tests*.

Property-Based Testing

1. For all data matching some specification.
2. Perform some operations on the data.
3. Assert something about the result.

```python
from arithmetic import *
from hypothesis import given, strategies as st

@given(st.integers(), st.integers())
def test_commutative_property(self, x, y):
    assert add(x,y) == add(y,x)

@given(st.integers())
def test_add1twice_is_add2once_property(self, x):
    assert add(add(x,1),1) == add(x,2)

@given(st.integers())
def test_identity_property(self, x):
    assert add(x, 0) == x
```

```
Still rockin' @09:05:16 AM> pytest .\test_arithmetic_properties.py --hypothesis-show-statistics
============================ test session starts ============================
platform win32 -- Python 3.6.6, pytest-3.7.3, py-1.5.4, pluggy-0.7.1
rootdir: D:\Laboratory\Sandbox\PythonStuff\hypothesis_stuff\pugs_demo\rosetta, inifile:
plugins: xdist-1.23.0, forked-0.2, flaky-3.4.0, hypothesis-3.69.2
collected 3 items

test_arithmetic_properties.py ...                                   [100%]
============================ Hypothesis Statistics ============================

test_arithmetic_properties.py::TestArithmetic::test_add1twice_is_add2once_property:

  - 100 passing examples, 0 failing examples, 0 invalid examples
  - Typical runtimes: 0-15 ms
  - Fraction of time spent in data generation: ~ 66%
  - Stopped because settings.max_examples=100

test_arithmetic_properties.py::TestArithmetic::test_commutative_property:
  - 100 passing examples, 0 failing examples, 0 invalid examples
  - Typical runtimes: 0-15 ms
  - Fraction of time spent in data generation: ~ 23%
  - Stopped because settings.max_examples=100

test_arithmetic_properties.py::TestArithmetic::test_identity_property:
  - 100 passing examples, 0 failing examples, 0 invalid examples
  - Typical runtimes: 0-15 ms
  - Fraction of time spent in data generation: ~ 15%
  - Stopped because settings.max_examples=100


===Flaky Test Report===
===End Flaky Test Report===


========================= 3 passed in 1.00 seconds ============================
```

Property-Based Testing

```python
def add(x, y):
    if (x==1 and y==2):
        return 3
    elif (x==2 and y==2):
        return 4
    else:
        return 0
```

```
…

self = <test_arithmetic_properties.TestArithmetic
testMethod=test_add1twice_is_add2once_property>
x = 1

    @given(st.integers())
    def test_add1twice_is_add2once_property(self, x):
>       assert add(add(x,1),1) == add(x,2)
E       AssertionError: assert 0 == 3
E        +  where 0 = add(0, 1)
E        +    where 0 = add(1, 1)
E        +  and   3 = add(1, 2)
…
```

What can you generate?

integers, booleans, floats, tuples, sample_from, lists, sets, iterables, dictionaries, streaming, characters, text, binary, fractions, decimals, permutations, datetimes, etc… etc… etc

https://tinyurl.com/hypo-data

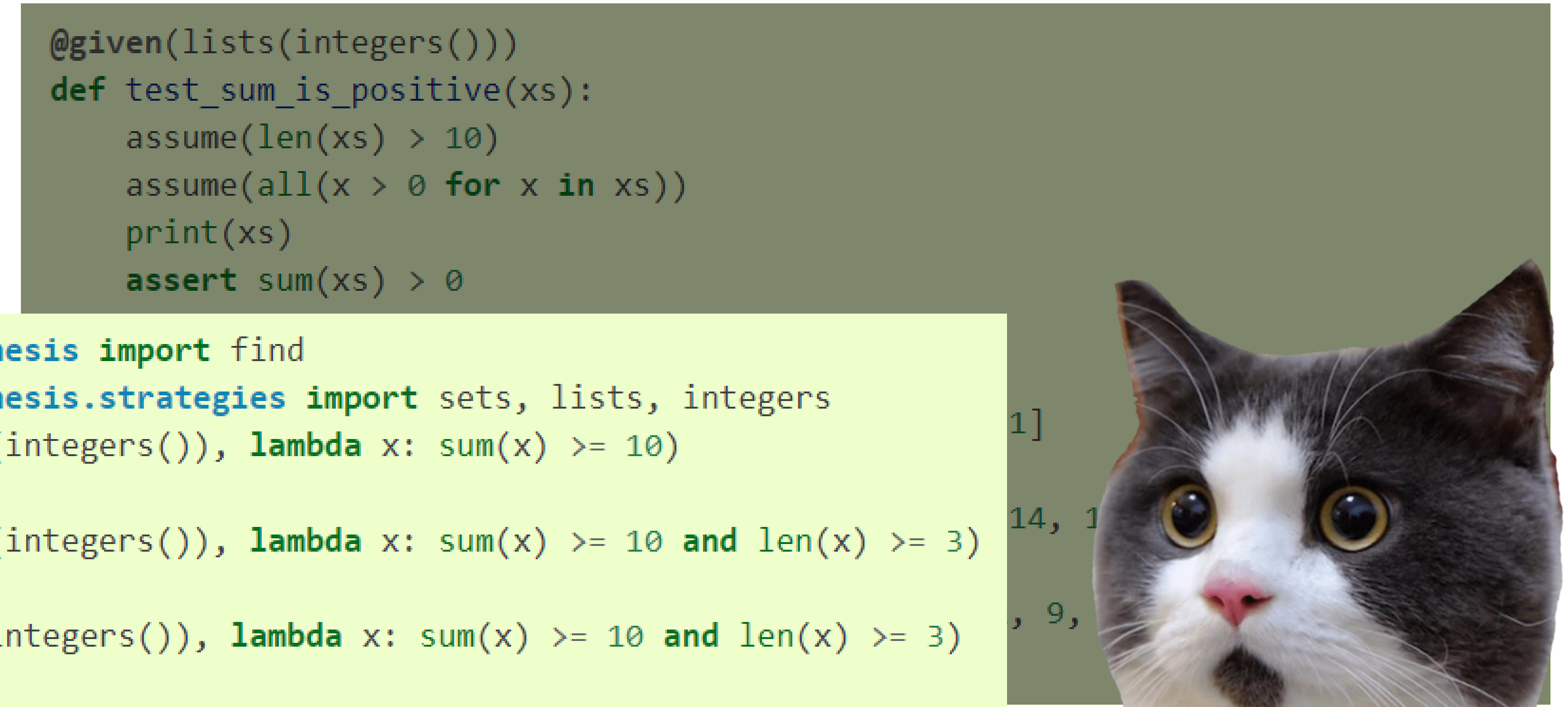
Other notable features

- Example Database
- Assumptions

```
@given(lists(integers()))
def test_sum_is_positive(xs):
    assume(len(xs) > 10)
    assume(all(x > 0 for x in xs))
    print(xs)
    assert sum(xs) > 0

In: test_sum_is_positive()
[17, 12, 7, 13, 11, 3, 6, 9, 8, 11, 47, 27, 1, 31, 1]
[6, 2, 29, 30, 25, 34, 19, 15, 50, 16, 10, 3, 16]
[25, 17, 9, 19, 15, 2, 2, 4, 22, 10, 10, 27, 3, 1, 14, 1
[17, 65, 78, 1, 8, 29, 2, 79, 28, 18, 39]
[13, 26, 8, 3, 4, 76, 6, 14, 20, 27, 21, 32, 14, 42, 9,
[2, 1, 2, 2, 3, 10, 12, 11, 21, 11, 1, 16]
```

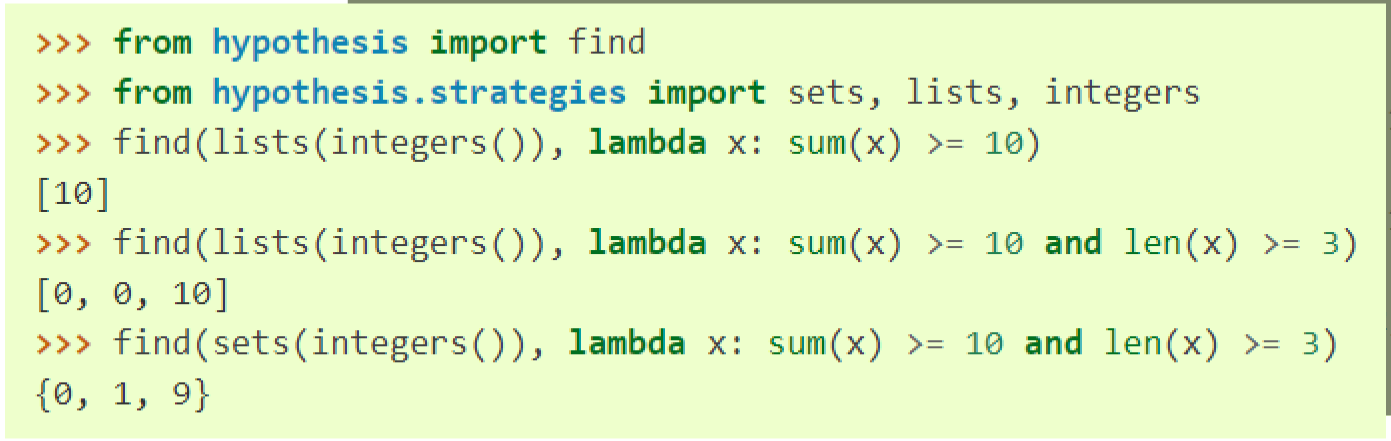
Other notable features

- Example Database
- Assumptions



```
@given(lists(integers()))
def test_sum_is_positive(xs):
    assume(len(xs) > 10)
    assume(all(x > 0 for x in xs))
    print(xs)
    assert sum(xs) > 0
```

```
1]
14, 1
, 9,
```



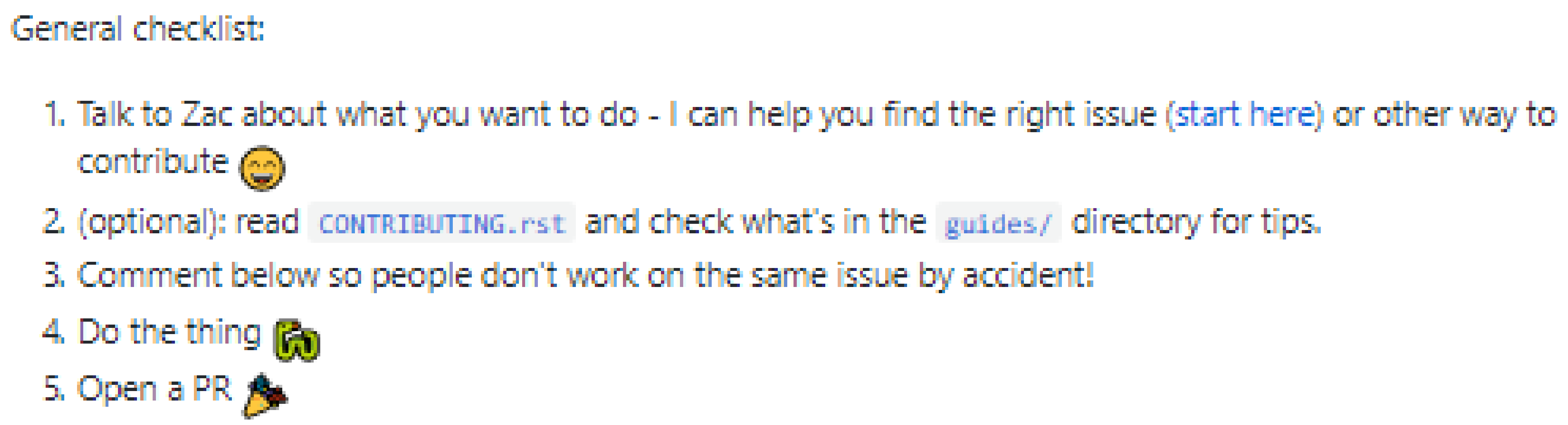
```
>>> from hypothesis import find
>>> from hypothesis.strategies import sets, lists, integers
>>> find(lists(integers()), lambda x: sum(x) >= 10)
[10]
>>> find(lists(integers()), lambda x: sum(x) >= 10 and len(x) >= 3)
[0, 0, 10]
>>> find(sets(integers()), lambda x: sum(x) >= 10 and len(x) >= 3)
{0, 1, 9}
```

- Finding Values

PyCon Sprints

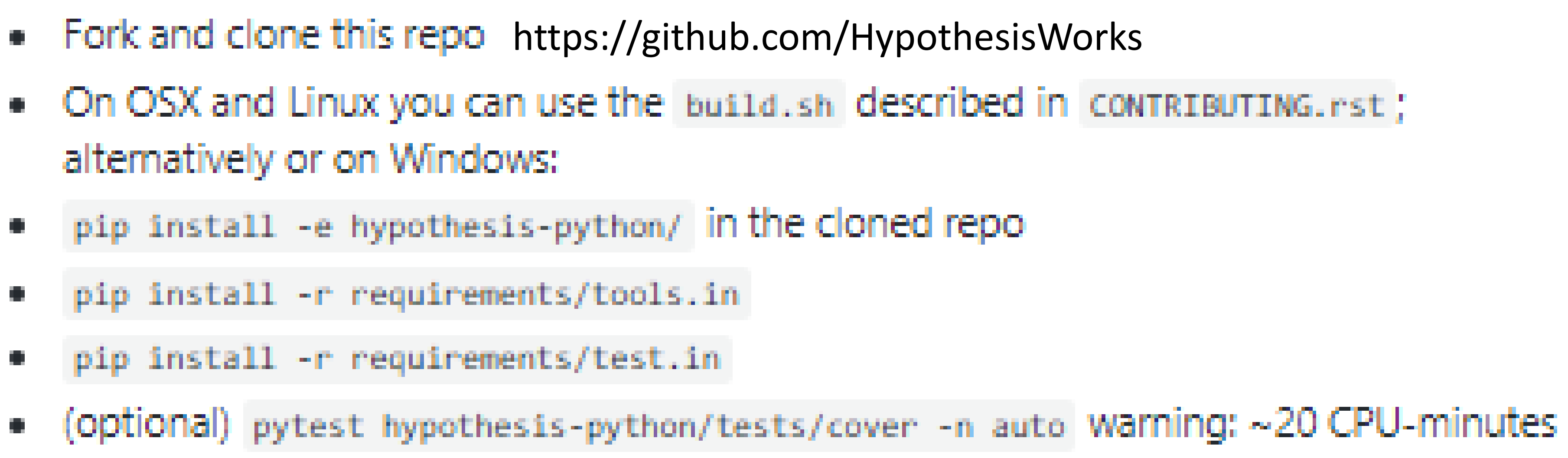
- Fix a bug
  - Issue: https://github.com/HypothesisWorks/hypothesis/issues/1317
  - Solution: https://github.com/HypothesisWorks/hypothesis/pull/1515
- Test some code (Debugging)
  - https://github.com/HypothesisWorks/hypothesis/issues/1493

PyCon Sprints



General checklist:

1. Talk to Zac about what you want to do - I can help you find the right issue (start here) or other way to contribute 😄
2. (optional): read `CONTRIBUTING.rst` and check what's in the `guides/` directory for tips.
3. Comment below so people don't work on the same issue by accident!
4. Do the thing
5. Open a PR 🎉

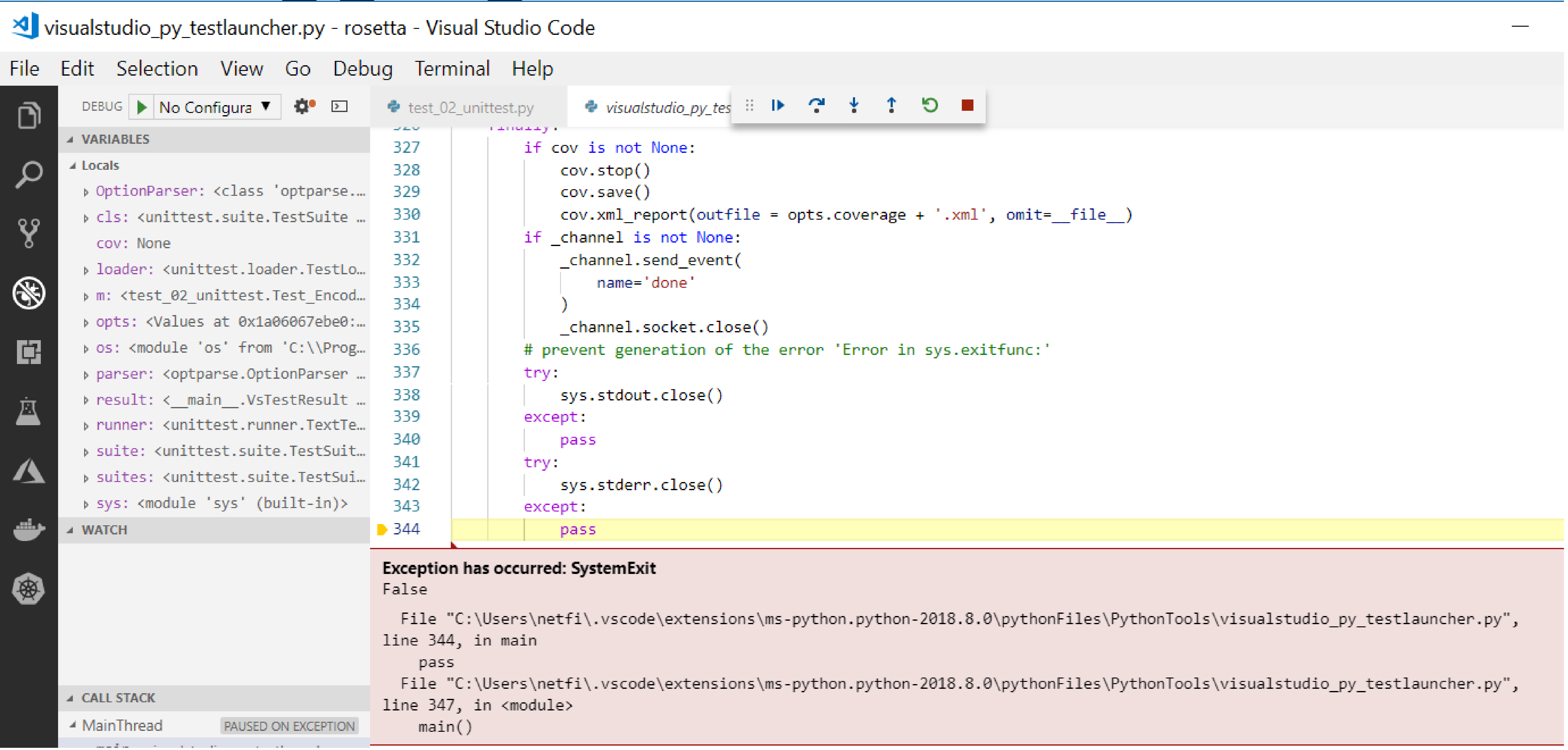


- Fork and clone this repo https://github.com/HypothesisWorks
- On OSX and Linux you can use the `build.sh` described in `CONTRIBUTING.rst`; alternatively or on Windows:
- `pip install -e hypothesis-python/` in the cloned repo
- `pip install -r requirements/tools.in`
- `pip install -r requirements/test.in`
- (optional) `pytest hypothesis-python/tests/cover -n auto` warning: ~20 CPU-minutes

Debugging

```
from run_length_encoding import *

from hypothesis import given, example
from hypothesis.strategies import text

import unittest

class Test_Encoding(unittest.TestCase):
@given(text())
def test_decode_inverts_encode(self, s):
    self.assertEqual(decode(encode(s)), s)

if __name__ == '__main__’:
    unittest.main()
```

Debugging



```
OptionParser: <class 'optparse....
cls: <unittest.suite.TestSuite ...
cov: None
loader: <unittest.loader.TestLo...
m: <test_02_unittest.Test_Encod...
opts: <Values at 0x1a06067ebe0:...
os: <module 'os' from 'C:\\Prog...
parser: <optparse.OptionParser ...
result: <__main__.VsTestResult ...
runner: <unittest.runner.TextTe...
suite: <unittest.suite.TestSuit...
suites: <unittest.suite.TestSui...
sys: <module 'sys' (built-in)>
```

```python
        if cov is not None:
            cov.stop()
            cov.save()
            cov.xml_report(outfile = opts.coverage + '.xml', omit=__file__)
        if _channel is not None:
            _channel.send_event(
                name='done'
            )
            _channel.socket.close()
        # prevent generation of the error 'Error in sys.exitfunc:'
        try:
            sys.stdout.close()
        except:
            pass
        try:
            sys.stderr.close()
        except:
            pass
```

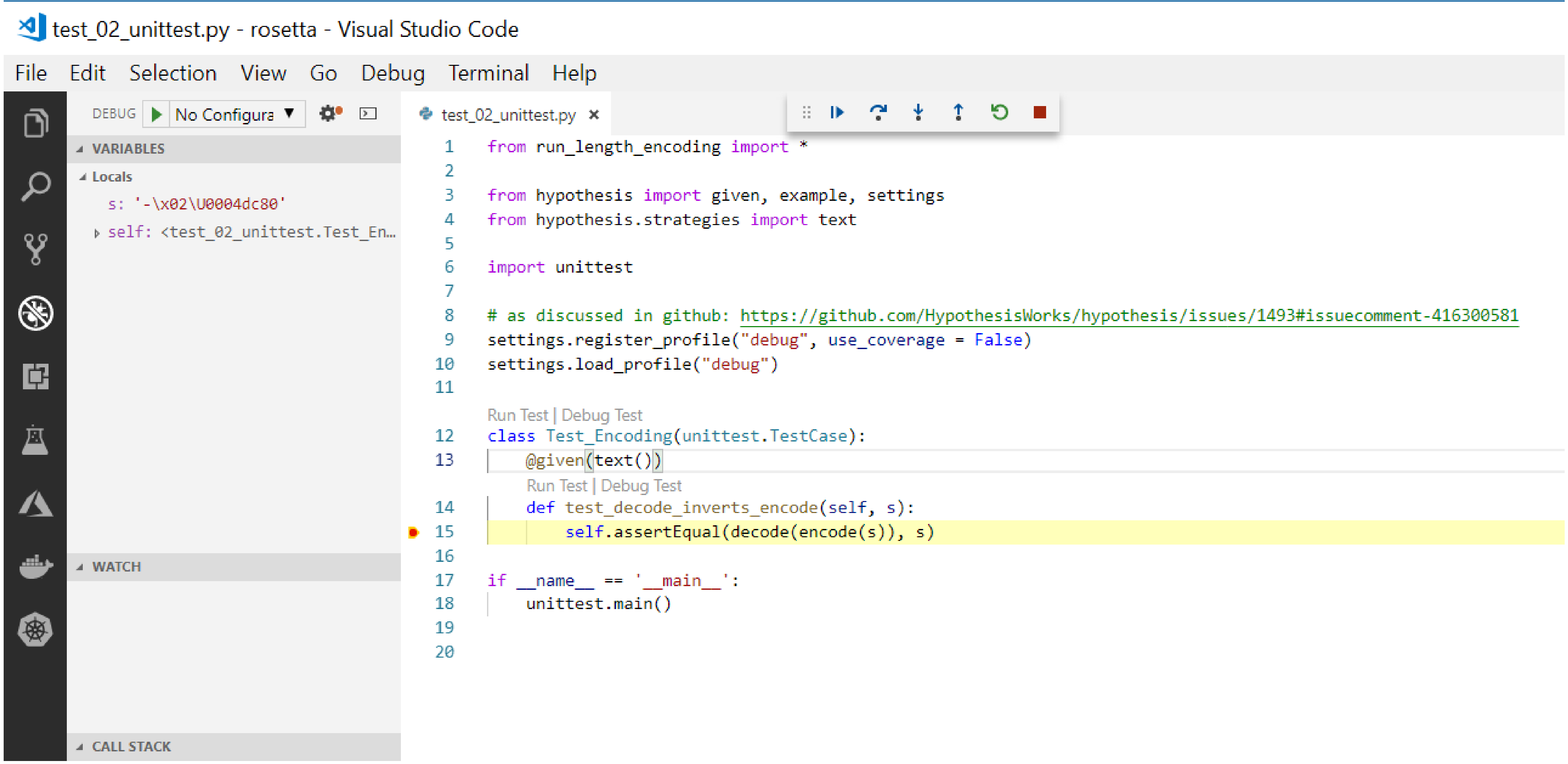
Exception has occurred: SystemExit

```
False

  File "C:\Users\netfi\.vscode\extensions\ms-python.python-2018.8.0\pythonFiles\PythonTools\visualstudio_py_testlauncher.py", line 344, in main
    pass
  File "C:\Users\netfi\.vscode\extensions\ms-python.python-2018.8.0\pythonFiles\PythonTools\visualstudio_py_testlauncher.py", line 347, in <module>
    main()
```

Debugging

```
from run_length_encoding import *

from hypothesis import given, example, settings
from hypothesis.strategies import text

import unittest

# as discussed in github: https://github.com/HypothesisWorks/hypothesis/issues/1493#issuecomment-416300581
settings.register_profile("debug", use_coverage = False)
settings.load_profile("debug")

class Test_Encoding(unittest.TestCase):
@given(text())
def test_decode_inverts_encode(self, s):
    self.assertEqual(decode(encode(s)), s)

if __name__ == '__main__’:
    unittest.main()
```

Debugging


test_02_unittest.py - rosetta - Visual Studio Code
File Edit Selection View Go Debug Terminal Help
DEBUG
No Configura
VARIABLES
Locals
WATCH
CALL STACK
test_02_unittest.py
Run Test | Debug Test

```
s: '-\x02\U0004dc80'
self: <test_02_unittest.Test_En…
```

```python
from run_length_encoding import *

from hypothesis import given, example, settings
from hypothesis.strategies import text

import unittest

# as discussed in github: https://github.com/HypothesisWorks/hypothesis/issues/1493#issuecomment-416300581
settings.register_profile("debug", use_coverage = False)
settings.load_profile("debug")

class Test_Encoding(unittest.TestCase):
    @given(text())
    def test_decode_inverts_encode(self, s):
        self.assertEqual(decode(encode(s)), s)

if __name__ == '__main__':
    unittest.main()
```

Resources

- https://hypothesis.works
- https://hypothesis.readthedocs.io

"The larger purpose of Hypothesis is to drag the world kicking and screaming into a new and terrifying age of high quality software."
- David R. MacIver