

Secret Session: Master coding in your research environment

Testing your code

Mathieu Boudreau, PhD

Research Fellow, Montreal Heart Institute

Software Developer for qMRLab & AxonDeepSeg @ NeuroPoly, Polytechnique de Montréal



INSTITUT DE
CARDIOLOGIE
DE MONTRÉAL



AxonDeepSeg



Quantitative MRI. Under one umbrella.

qMR
Lab



POLYTECHNIQUE
MONTRÉAL



What are tests?

A way to reproduce and automate an evaluation of the expected behaviour of your code.

Tests will...

- inform you of where your code is behaving unexpectedly
- describe expected behaviour and the actual behaviour

Broad types of tests

Unit tests

- For individual pieces of code (e.g. one function/file in isolation)

Integration Tests

- Interaction between multiple functions/files (i.e. a user experience)

How do I start?

Most coding languages have testing frameworks!

MATLAB → *MATLAB Unit Test Framework* and *MOxUnit*

Python → *PyTest* and *unittest*

Octave → *MOxUnit*

R → *testthat* and *RUnit*

C++ → *Catch2* and *Googletest*

C → *Check* and *Unity*

... and many more!

Simple example

Example function

 add.py ×

You, 3 days ago | 1 author (You)

```
1
2
3 def add(a, b):
4     """ Add two mathematical objects together
5     :return: sum of a and b
6     """
7
8     return a + b
9
```

Simple example

Example test

test_add.py x

```
You, 3 days ago | 1 author (You)
1  # coding: utf-8
2
3  import pytest
4  from testing_your_code.math.add import add
5
6
You, 3 days ago | 1 author (You)
7  class TestCore(object):
8
9      # -----add.py tests----- #
10     def test_add_known_integer_case(self):
11         a = 2
12         b = 2
13
14         expected_value = 4
15         actual_value = add(a,b)
16
17         assert actual_value == expected_value
18
```

Simple example

Run the tests!

```
[(base) mathieuboudreau@brassens:~/neuropoly/github/testing-your-code$ py.test
===== test session starts =====
platform darwin -- Python 3.7.1, pytest-3.6.0, py-1.7.0, pluggy-0.6.0
rootdir: /Users/mathieuboudreau/neuropoly/github/testing-your-code, inifile:
plugins: remotedata-0.3.1, openfiles-0.3.1, doctestplus-0.2.0, cov-2.5.1, arraydiff-0.3
collected 1 item

tests/math/test_add.py . [100%]

===== 1 passed in 0.04 seconds =====
```

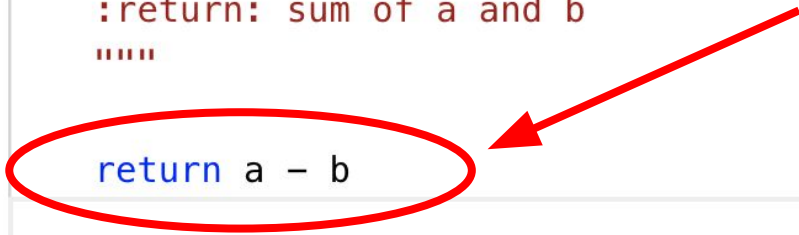
Simple example

Without realizing, while developing a “subtract” function, you accidentally save this...

add.py ×

You, a few seconds ago | 1 author (You)

```
1
2
3 def add(a, b):
4     """ Add two mathematical objects together
5     :return: sum of a and b
6     """
7
8     return a - b
9
```



Simple example

Run the test again, and...

```
[(base) mathieuboudreau@brassens:~/neuropoly/github/testing-your-code$ py.test
===== test session starts =====
platform darwin -- Python 3.7.1, pytest-3.6.0, py-1.7.0, pluggy-0.6.0
rootdir: /Users/mathieuboudreau/neuropoly/github/testing-your-code, inifile:
plugins: remotedata-0.3.1, openfiles-0.3.1, doctestplus-0.2.0, cov-2.5.1, arraydiff-0.3
collected 1 item

tests/math/test_add.py F [100%]

===== FAILURES =====
----- TestCore.test_add_known_integer_case -----

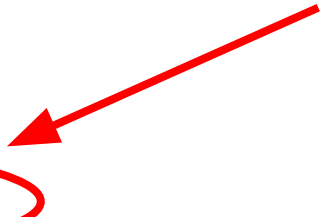
self = <tests.math.test_add.TestCore object at 0x109377b38>

    def test_add_known_integer_case(self):
        a = 2
        b = 2

        expected_value = 4
        actual_value = add(a,b)

> assert actual_value == expected_value
E assert 0 == 4

tests/math/test_add.py:17: AssertionError
===== 1 failed in 0.09 seconds =====
```



Real-world example

2 year old PhD code: <https://github.com/mathieuboudreau/qmt-optimization>

Updated a software dependency (qMRLab)

Failure Summary:

Name	Failed	Incomplete	Reason(s)
SPGR_MonteCarlo_Test/test_SPGR_MonteCarlo_fit_returns_expected_sizes	X	X	Errored.
generateSPGRSimParam_Test/testgenerateSPGRSimParam_generates_demo_values	X	X	Errored.

result =

1×68 [TestResult](#) array with properties:

Name
Passed
Failed
Incomplete
Duration
Details

Totals:

66 Passed, 2 Failed ([rerun](#)), 2 Incomplete.
1167.0458 seconds testing time.

>>

Real-world example

Where and why did they fail?

Running generateSPGRSimParam_Test

```
=====
Error occurred while setting up or tearing down generateSPGRSimParam_Test.
As a result, all generateSPGRSimParam_Test tests failed and did not run to completion.
```

```
-----
Error ID:
```

```
-----
'MATLAB:load:couldNotReadFile'
```

```
-----
Error Details:
```

```
-----
Error using load
```

```
Unable to read file
```

```
'../../../../qMRLab/Models_Functions/SPGRfun/Parameters/DefaultSim.mat'. No such file
or directory.
```

```
Error in generateSPGRSimParam\_Test/getDefaultSPGRParams (line 18)
```

```
load('../../../../qMRLab/Models_Functions/SPGRfun/Parameters/DefaultSim.mat')
```

```
=====
Done generateSPGRSimParam_Test
```

Real-world example

Where and why did they fail?

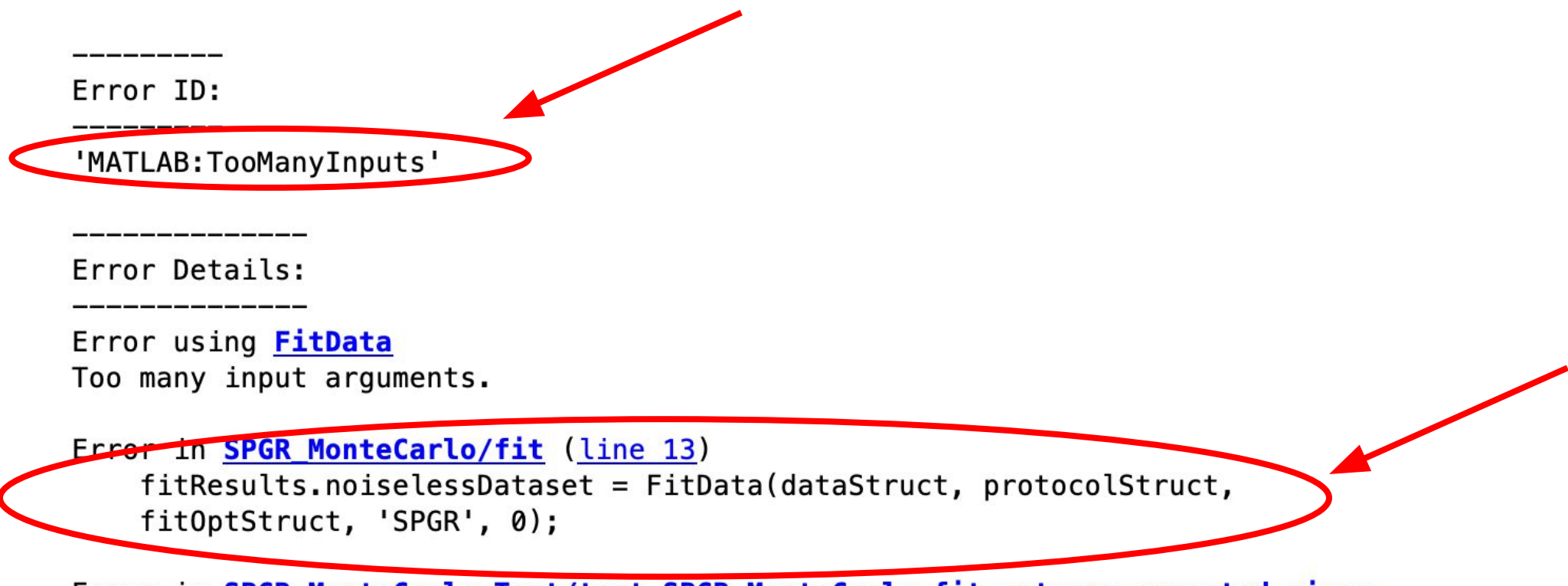
```
=====
Error occurred in SPGR_MonteCarlo_Test/test_SPGR_MonteCarlo_fit_returns_expected_sizes and it did not run to complet

-----
Error ID:
-----
'MATLAB:TooManyInputs'

-----
Error Details:
-----
Error using FitData
Too many input arguments.

Error in SPGR\_MonteCarlo/fit (line 13)
    fitResults.noiselessDataset = FitData(dataStruct, protocolStruct,
    fitOptStruct, 'SPGR', 0);

Error in SPGR\_MonteCarlo\_Test/test\_SPGR\_MonteCarlo\_fit\_returns\_expected\_sizes
(line 251)
    MCobj.fit();
=====
```



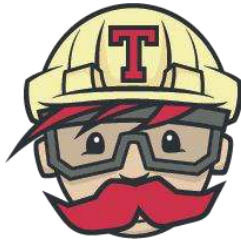
If you there's a possibility that you encounter one of these situations, tests are for you!

- A software, library, or operating system upgrade
 - MATLAB 2015a → MATLAB 2019a, numpy 1.8.0 → 1.16.2
- A change in operating system or hardware (new computer)
 - MacOS Mojave → Windows 10
- You have a bad memory
 - How do I use this function again...?
- Plan on using your code in the future
 - (in the year 2023) Why won't this work anymore..?
- You make mistakes writing code
 - **i.e. everyone should write tests!**

Awesome features that having tests open up

Continuous Integration

- Automatically runs your tests when you commit to GitHub



Travis CI



Jenkins

Code Coverage

- Informs you of which code lines your tests are evaluating, and those that missed.



COVERALLS



(CodeCov)

Example repositories containing tests

Simple examples

- <https://github.com/ismrm-coding-secret-session/testing-your-code>

Real-world examples

- Python: <https://github.com/neuropoly/axondeepseq>
- Octave/MATLAB: <https://github.com/qmrlab/qmrlab>
- MATLAB: <https://github.com/mathieuboudreau/qmt-optimization>