Python Unittest

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Unit Testing Framework

The Python unit testing framework, sometimes referred to as “PyUnit,” is a Python language version of JUnit, by Kent Beck and Erich Gamma. JUnit is, in turn, a Java version of Kent’s Smalltalk testing framework. Each is the de-facto standard unit testing framework for its respective language.

unittest supports test automation, sharing of setup and shutdown code for tests, aggregation of tests into collections, and independence of the tests from the reporting framework. The unittest module provides classes that make it easy to support these qualities for a set of tests.

Unit Testing Framework

To achieve this, unittest supports some important concepts:

- **test case:** A test case is the smallest unit of testing. It checks for a specific response to a particular set of inputs. unittest provides a base class, TestCase, which may be used to create new test cases.

- **test fixture:** A test fixture represents the preparation needed to perform one or more tests, and any associate cleanup actions. This may involve, for example, creating temporary or proxy databases, directories, or starting a server process.

- **test suite:** A test suite aggregate tests that should be executed together. It is a collection of test cases, test suites, or both.

- **test runner:** A test runner is a component which orchestrates the execution of tests and provides the outcome to the user. The runner may use a graphical interface, a textual interface, or return a special value to indicate the results of executing the tests.

Test Cases

Test cases are supported through the **TestCase** class;

```
import unittest

class TestStringMethods(unittest.TestCase):

    def test_upper(self):
        self.assertEqual('foo'.upper(), 'FOO')

    def test_isupper(self):
        self.assertTrue('FOO'.isupper())
        self.assertFalse('Foo'.isupper())

    def test_split(self):
        s = 'hello world'
        self.assertEqual(s.split(), ['hello', 'world'])
        # check that s.split fails when the separator is not a string
        with self.assertRaises(TypeError):
            s.split(2)
```

Test Cases and Asserts

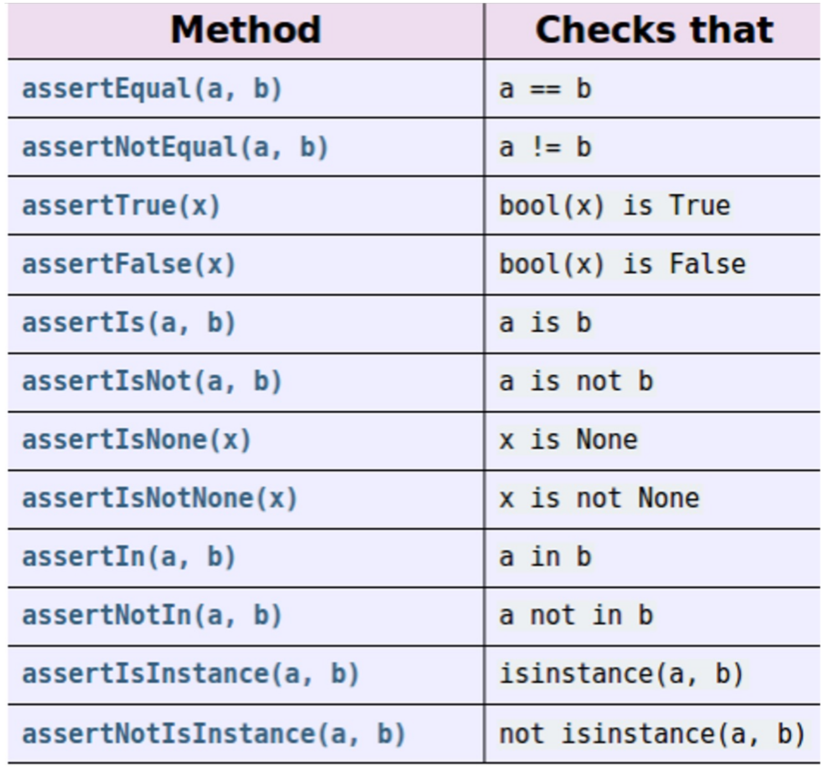
A testcase is created by subclassing **unittest.TestCase**.

The test methods are defined with names starting with the string “test”. This naming convention informs the test runner about which methods represent tests.

The **TestCase** class provides several methods to check for and report code failures. Those methods are called **Asserts.** Using those methods, the test runner can accumulate all test results and produce a report.

Asserts

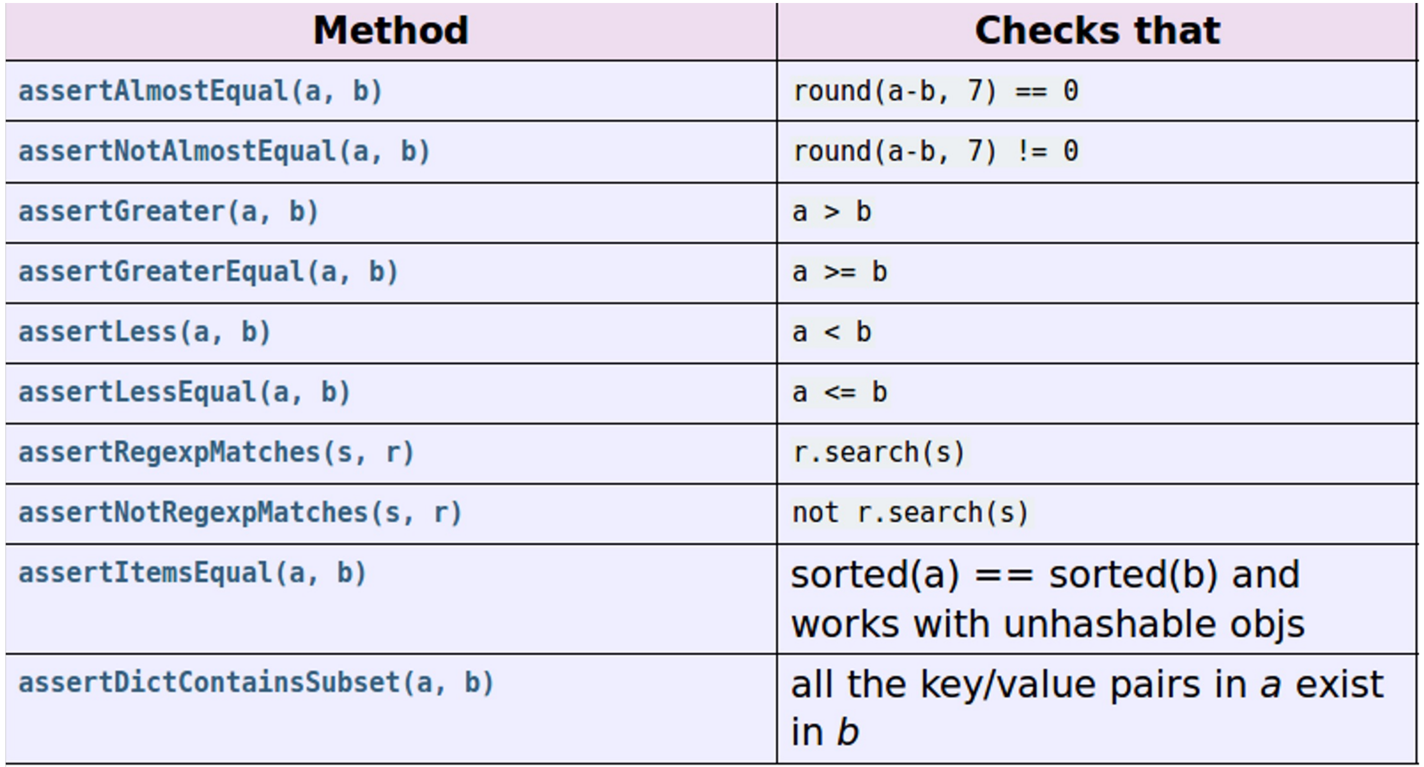
Some of the assert methods are the following:



Method	Checks that
`assertEqual(a, b)`	`a == b`
`assertNotEqual(a, b)`	`a != b`
`assertTrue(x)`	`bool(x) is True`
`assertFalse(x)`	`bool(x) is False`
`assertIs(a, b)`	`a is b`
`assertIsNot(a, b)`	`a is not b`
`assertIsNone(x)`	`x is None`
`assertIsNotNone(x)`	`x is not None`
`assertIn(a, b)`	`a in b`
`assertNotIn(a, b)`	`a not in b`
`assertIsInstance(a, b)`	`isinstance(a, b)`
`assertNotIsInstance(a, b)`	`not isinstance(a, b)`

Asserts

Some of the assert methods are the following:



Method	Checks that
`assertAlmostEqual(a, b)`	`round(a-b, 7) == 0`
`assertNotAlmostEqual(a, b)`	`round(a-b, 7) != 0`
`assertGreater(a, b)`	`a > b`
`assertGreaterEqual(a, b)`	`a >= b`
`assertLess(a, b)`	`a < b`
`assertLessEqual(a, b)`	`a <= b`
`assertRegexpMatches(s, r)`	`r.search(s)`
`assertNotRegexpMatches(s, r)`	`not r.search(s)`
`assertItemsEqual(a, b)`	sorted(a) == sorted(b) and works with unhashable objs
`assertDictContainsSubset(a, b)`	all the key/value pairs in *a* exist in *b*

Test Suite and Test Runner

Test suites are implemented by the **TestSuite** class. This class allows individual tests and test suites to be aggregated; when the suite is executed, all tests added directly to the suite and in “child” test suites are run.

A test runner is an object that provides a single method, **run(),** which accepts a **TestCase** or **TestSuite** object as a parameter, and returns a result object. The class **TestResult** is provided for use as the result object. unittest provides the **TextTestRunner** as an example test runner which reports test results on the standard error stream by default. Alternate runners can be implemented for other environments (such as graphical environments) without any need to derive from a specific class.

A Basic Example of Unittest

```python
import unittest

class TestStringMethods(unittest.TestCase):

    def test_upper(self):
        self.assertEqual('foo'.upper(), 'FOO')

    def test_isupper(self):
        self.assertTrue('FOO'.isupper())
        self.assertFalse('Foo'.isupper())

    def test_split(self):
        s = 'hello world'
        self.assertEqual(s.split(), ['hello', 'world'])
        # check that s.split fails when the separator is not a string
        with self.assertRaises(TypeError):
            s.split(2)

suite = unittest.TestLoader().loadTestsFromTestCase(TestStringMethods)
unittest.TextTestRunner(verbosity=2).run(suite)
```

A Basic Example of Unittest

The final block shows the creation of a **TestSuite** that contains all the defined test methods and how those tests can be executed using a **TestRunner**.

The script produces an output that looks like this:

```
test_isupper (__main__.TestStringMethods) ... ok
test_split (__main__.TestStringMethods) ... ok
test_upper (__main__.TestStringMethods) ... ok

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

OK
```

A Basic Example of Unittest

```
suite = unittest.TestLoader().loadTestsFromTestCase(TestStringMethods)
```

This adds to the suite all the methods which are called with a name that starts with the word “test”.

We can add just some of them creating a **TestSuite** class and adding only the methods that we would like to have runned by the test:

```
suite = unittest.TestSuite()
suite.addTest(TestStringMethods('test_upper'))
suite.addTest(TestStringMethods('test_isupper'))
```

Command-Line Interface

The unittest module can be used from the command line to run tests from modules, classes or even individual test methods:

```
python -m unittest test_module1 test_module2
python -m unittest test_module.TestClass
python -m unittest test_module.TestClass.test_method
```

It is possible to find and run all the test in the sub-directory of a folder:

```
python -m unittest discover -s project_directory -p "test*.py"
```

Test Fixture

Such test cases can be numerous, and their set-up can be repetitive.

Luckily, the set-up code can be implemented in the **setUp()** which will be automatically call by the framework when we run the test before running each test function. Similarly, we can provide a **tearDown()** method that tidies up after the **runTest()** method has been run.

The operations that are performed during the set-up and cleanup are called test fixture.

Test Fixture

```
import unittest

def fib(n):
   return 1 if n<=2 else fib(n-1)+fib(n-2)

class TestFib(unittest.TestCase):

   def setUp(self):
       self.n = 10
   def tearDown(self):
       del self.n

   def test_fib_assert_equal(self):
       self.assertEqual(fib(self.n), 55)
   def test_fib_assert_true(self):
       self.assertTrue(fib(self.n) == 55)

suite = unittest.TestLoader().loadTestsFromTestCase(TestFib)
unittest.TextTestRunner(verbosity=2).run(suite)
```

Skipping Tests

Unittest supports skipping individual test methods and even whole classes of tests. In addition, it supports marking a test as an “expected failure,” a test that is broken and will fail, but shouldn’t be counted as a failure on a **TestResult**.

You can skip an entire test class adding an apposite decorator:

```
@unittest.skip("showing class skipping")
class MySkippedTestCase(unittest.TestCase):
    def test_not_run(self):
        pass
```

Or only some specified function as in the following example.

Skipping Tests

```python
import numpy
import unittest
import sys

class MyTestCase(unittest.TestCase):

   @unittest.skip("demonstrating skipping")
   def test_nothing(self):
       self.fail("shouldn't happen")

   @unittest.skipIf(numpy.__version__ < "1.17",
                    "not supported in this library version")
   def test_format(self):
       # Tests that work for only a certain version of the library.
       pass

   @unittest.skipUnless(sys.platform.startswith("win"), "requires Windows")
   def test_windows_support(self):
       # windows specific testing code
       Pass

suite = unittest.TestLoader().loadTestsFromTestCase(MyTestCase)
unittest.TextTestRunner(verbosity=2).run(suite)
```

Skipping Tests

The output of this test is:

```
test_format (__main__.MyTestCase) ... skipped 'not supported in this library version'
test_nothing (__main__.MyTestCase) ... skipped 'demonstrating skipping'
test_windows_support (__main__.MyTestCase) ... skipped 'requires Windows'

----------------------------------------------------------------------
Ran 3 tests in 0.005s

OK (skipped=3)
```

Expected Failure

It is possible to mark a test as an "expected failure," a test that is broken and will fail, but shouldn't be counted as a failure on a **TestResult**. It is sufficient using the apposite decorator.

```
import unittest

class ExpectedFailureTestCase(unittest.TestCase):
   @unittest.expectedFailure
   def test_fail(self):
       self.assertEqual(1, 0, "broken")

suite = unittest.TestLoader().loadTestsFromTestCase(ExpectedFailureTestCase)
unittest.TextTestRunner(verbosity=2).run(suite)
```

Git Testing with Continuous Integration

Continuous Integration (CI)

CI allows automating the execution of tests on different platforms/installations

GitLab and Github offer built-in continuous integration and delivery tools

When a new commit is pushed to the repository, GitLab/GitHub will use their CI runners to execute the test suite against the code in an isolated Docker container

Gitlab CI

Setting Up CI/CD on GitLab

To have a working CI you need to:

- add .gitlab-ci.yml to the root directory of your repository
- configure a *runner*

The .gitlab-ci.yml file tells the GitLab runner what to do. By default, it runs a pipeline with three stages: build, test, and deploy.

The Runner is the process that will trigger the CI pipeline after each commit or push.

A green (if all the test are passed) or red checkmarker will be associated to the given commit. It is then possible to explore the test reports from the GitLab interface

Creating the *.gitlab-ci.yml* Configuration File

```
image: python:3.5

variables:
  PIP_CACHE_DIR: "$CI_PROJECT_DIR/.cache/pip"

cache:
  paths:
    - .cache/pip
    - venv/

before_script:
  - python -V               # Print out python version for debugging
  - pip install virtualenv
  - virtualenv venv
  - source venv/bin/activate
  - pip install -r requirements.txt

test:
  only:
    - master
  script:
    - python -m unittest discover -s tests
```

Configure a Runner

If you use GitLab.com you can use the **Shared Runners** provided by GitLab Inc.

These are special virtual machines that run on GitLab's infrastructure and can build any project.

To enable the Shared Runners you have to go to your project's

Settings ➔ CI/CD and click Enable shared runners.

The Requirements File

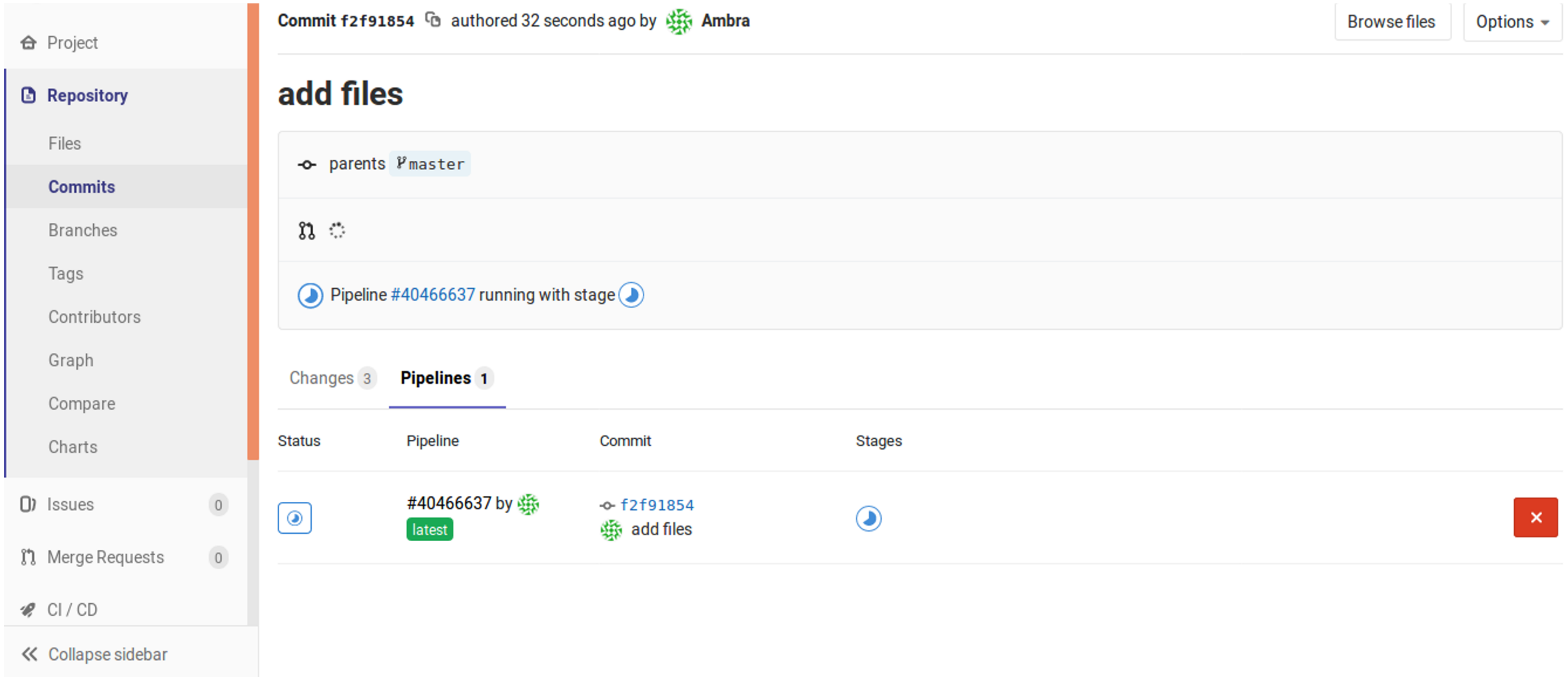
The requirements file contains the number (and eventually the version) of the libraries that are needed to execute the code.

For example, to run the code in the examples of this lecture, the only required library that has to be installed is numpy.

Therefore, we have to have a file called “requirements.txt” which will contain just a single row:

numpy

Check the Test Results


Commit f2f91854 authored 32 seconds ago by Ambra

add files

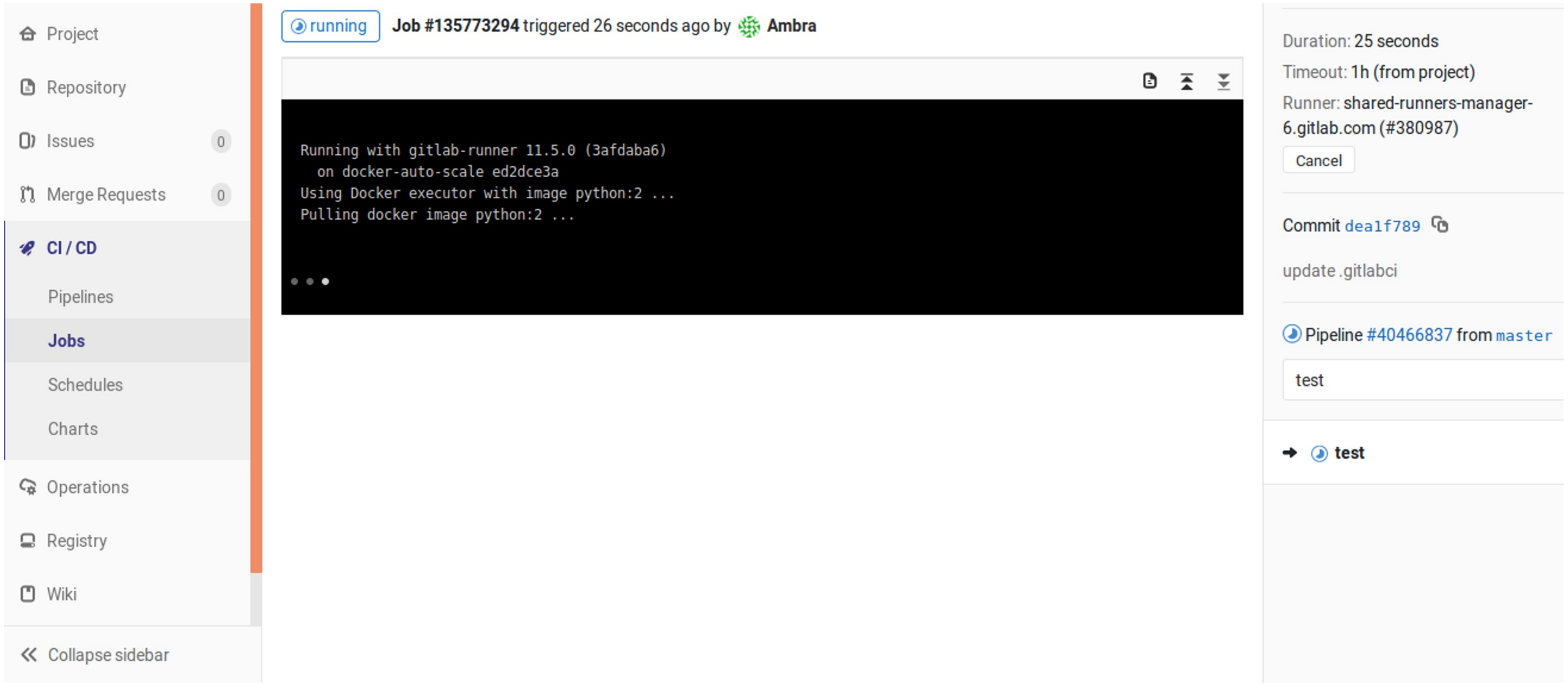
parents master

Pipeline #40466637 running with stage

Changes 3 Pipelines 1

Status	Pipeline	Commit	Stages
	#40466637 by latest	f2f91854 add files	

Check the Test Results



Job #135773294 triggered 26 seconds ago by Ambra

```
Running with gitlab-runner 11.5.0 (3afdaba6)
  on docker-auto-scale ed2dce3a
Using Docker executor with image python:2 ...
Pulling docker image python:2 ...
```

Duration: 25 seconds
Timeout: 1h (from project)
Runner: shared-runners-manager-6.gitlab.com (#380987)

Commit dea1f789

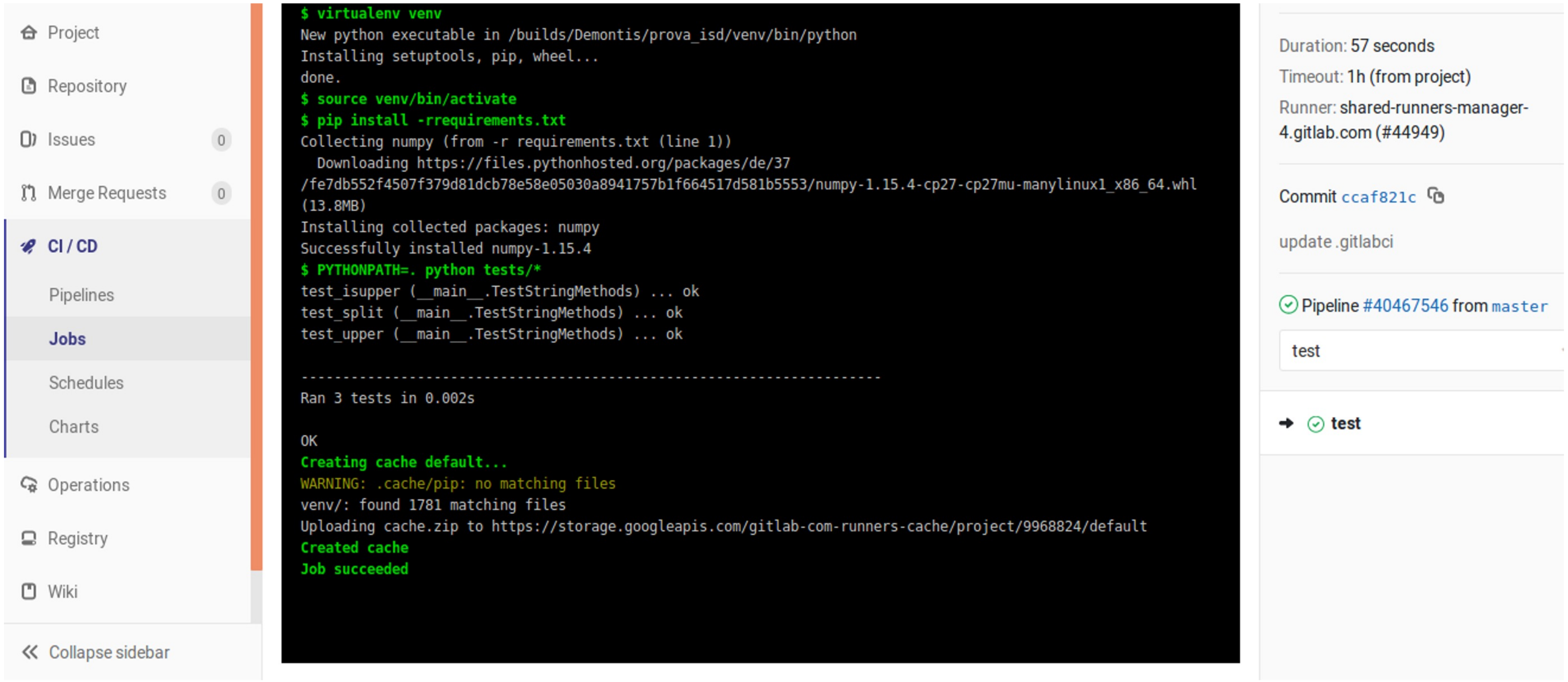
update .gitlabci

Pipeline #40466837 from master

test

→ test

Check the Test Results



```
$ virtualenv venv
New python executable in /builds/Demontis/prova_isd/venv/bin/python
Installing setuptools, pip, wheel...
done.
$ source venv/bin/activate
$ pip install -rrequirements.txt
Collecting numpy (from -r requirements.txt (line 1))
  Downloading https://files.pythonhosted.org/packages/de/37
/fe7db552f4507f379d81dcb78e58e05030a8941757b1f664517d581b5553/numpy-1.15.4-cp27-cp27mu-manylinux1_x86_64.whl
(13.8MB)
Installing collected packages: numpy
Successfully installed numpy-1.15.4
$ PYTHONPATH=. python tests/*
test_isupper (__main__.TestStringMethods) ... ok
test_split (__main__.TestStringMethods) ... ok
test_upper (__main__.TestStringMethods) ... ok

----------------------------------------------------------------------
Ran 3 tests in 0.002s

OK
Creating cache default...
WARNING: .cache/pip: no matching files
venv/: found 1781 matching files
Uploading cache.zip to https://storage.googleapis.com/gitlab-com-runners-cache/project/9968824/default
Created cache
Job succeeded
```

Duration: 57 seconds
Timeout: 1h (from project)
Runner: shared-runners-manager-4.gitlab.com (#44949)

Commit ccaf821c

update .gitlabci

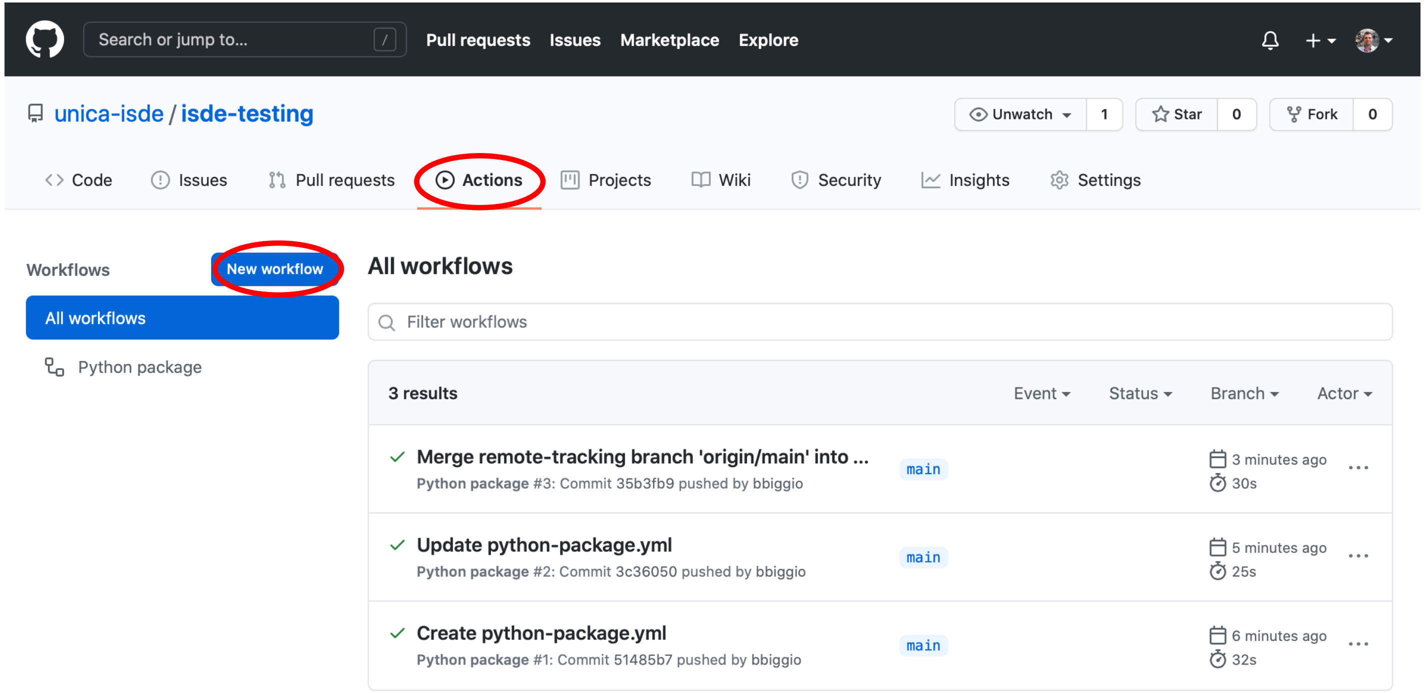
Pipeline #40467546 from master

test

test

GitHub CI

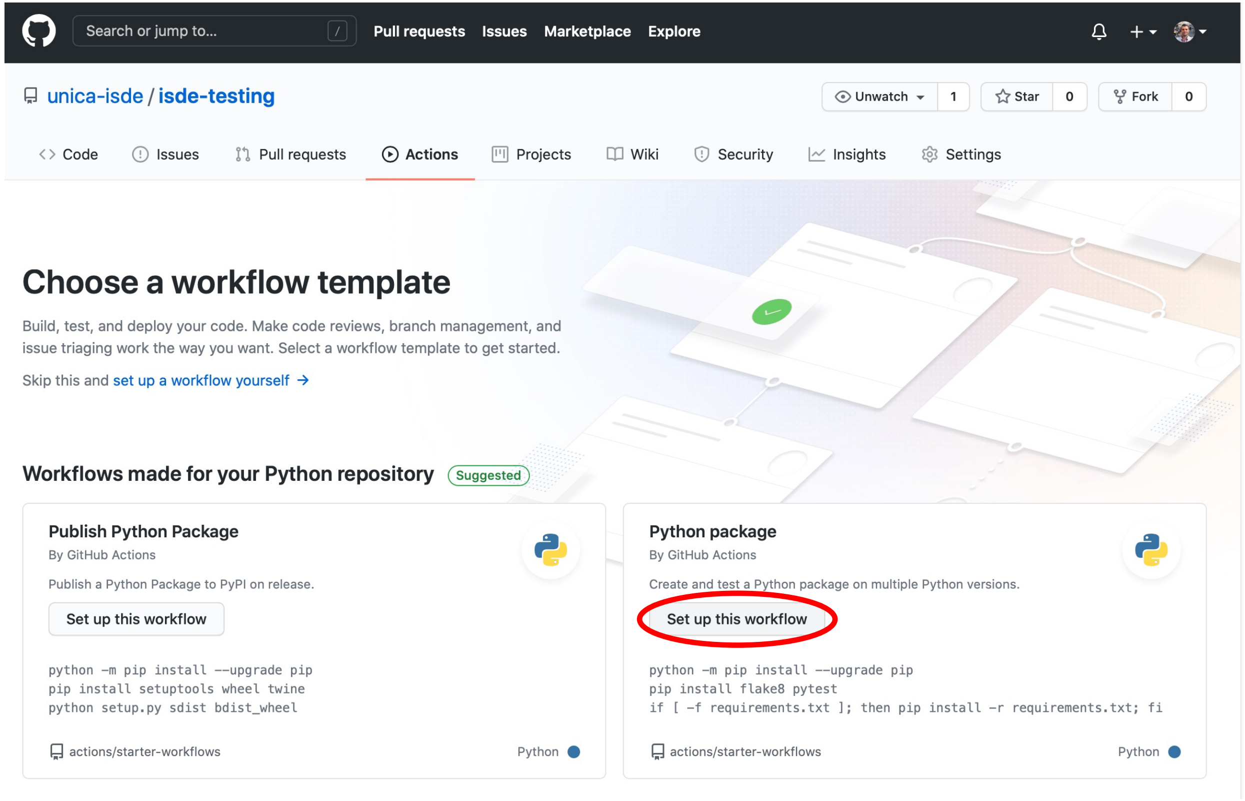
In Two Clicks...



3 results

✓ Merge remote-tracking branch 'origin/main' into ... — Python package #3: Commit 35b3fb9 pushed by bbiggio	main	3 minutes ago	30s
✓ Update python-package.yml — Python package #2: Commit 3c36050 pushed by bbiggio	main	5 minutes ago	25s
✓ Create python-package.yml — Python package #1: Commit 51485b7 pushed by bbiggio	main	6 minutes ago	32s

In Two Clicks...



Choose a workflow template

Build, test, and deploy your code. Make code reviews, branch management, and issue triaging work the way you want. Select a workflow template to get started.

Skip this and set up a workflow yourself →

Workflows made for your Python repository Suggested

Publish Python Package
By GitHub Actions
Publish a Python Package to PyPI on release.
Set up this workflow

```
python -m pip install --upgrade pip
pip install setuptools wheel twine
python setup.py sdist bdist_wheel
```

actions/starter-workflows Python

Python package
By GitHub Actions
Create and test a Python package on multiple Python versions.
Set up this workflow

```
python -m pip install --upgrade pip
pip install flake8 pytest
if [ -f requirements.txt ]; then pip install -r requirements.txt; fi
```

actions/starter-workflows Python

References

Unittest:
https://docs.python.org/3/library/unittest.html

GitLab CI:
https://gitlab.com/help/ci/quick_start/README

GitHub *Building and Testing Python*:
https://docs.github.com/en/free-pro-team@latest/actions/guides/building-and-testing-python#starting-with-the-python-workflow-template

Python Unittest Coverage

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Coverage

- **Test coverage** is a percentage measure of the degree to which the source code of a program is executed *when a particular test suite is run*

- Different coverage measures exist
  - **Function coverage** (fraction of functions called by the tests)
  - **Statement coverage** (fraction of statements correctly executed when running the tests)
  - **Branch coverage** (fraction of branches explored, e.g., in *if/case* control statements)
  - …

- We'll measure **code coverage** as *the fraction of code lines that are executed when running the tests*

Measuring Code Coverage in Python

- Two packages are available
  - Coverage.py
  - Pytest-cov

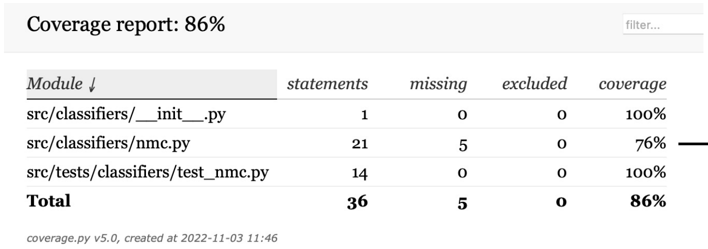
- We will use coverage.py
  - pip install coverage

- You can run it along with pytest. Coverage.py will “monitor” the test runner and log results
  - python -m coverage run -m pytest

- Then you can check the report (both in the terminal or storing results in html)
  - python -m coverage report
  - python -m coverage html

Example of Report

- The report highlights coverage for each file…
- … and which lines in your program are not tested

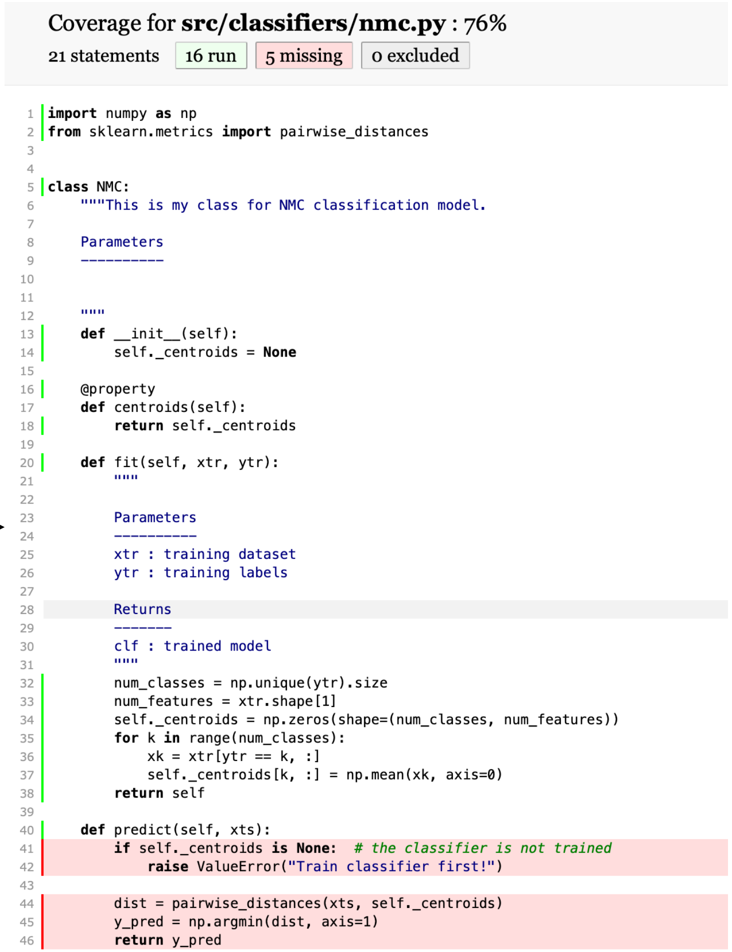


Coverage report: 86%

filter...

Module ↓	*statements*	*missing*	*excluded*	*coverage*
src/classifiers/__init__.py	1	0	0	100%
src/classifiers/nmc.py	21	5	0	76%
src/tests/classifiers/test_nmc.py	14	0	0	100%
Total	**36**	**5**	**0**	**86%**

coverage.py v5.0, created at 2022-11-03 11:46



Coverage for **src/classifiers/nmc.py** : 76%

21 statements | 16 run | 5 missing | 0 excluded

```python
import numpy as np
from sklearn.metrics import pairwise_distances


class NMC:
    """This is my class for NMC classification model.

    Parameters
    ----------


    """
    def __init__(self):
        self._centroids = None

    @property
    def centroids(self):
        return self._centroids

    def fit(self, xtr, ytr):
        """

        Parameters
        ----------
        xtr : training dataset
        ytr : training labels

        Returns
        -------
        clf : trained model
        """
        num_classes = np.unique(ytr).size
        num_features = xtr.shape[1]
        self._centroids = np.zeros(shape=(num_classes, num_features))
        for k in range(num_classes):
            xk = xtr[ytr == k, :]
            self._centroids[k, :] = np.mean(xk, axis=0)
        return self

    def predict(self, xts):
        if self._centroids is None:  # the classifier is not trained
            raise ValueError("Train classifier first!")

        dist = pairwise_distances(xts, self._centroids)
        y_pred = np.argmin(dist, axis=1)
        return y_pred
```