Software Testing Project

Testing Numpy

Group 22
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OUTLINE

Numpy

NumPy is the fundamental package for scientific computing with Python. It contains among other things:

- a powerful N-dimensional array object
- sophisticated (broadcasting) functions
- tools for integrating C/C++ and Fortran code
- useful linear algebra, Fourier transform, and random number capabilities

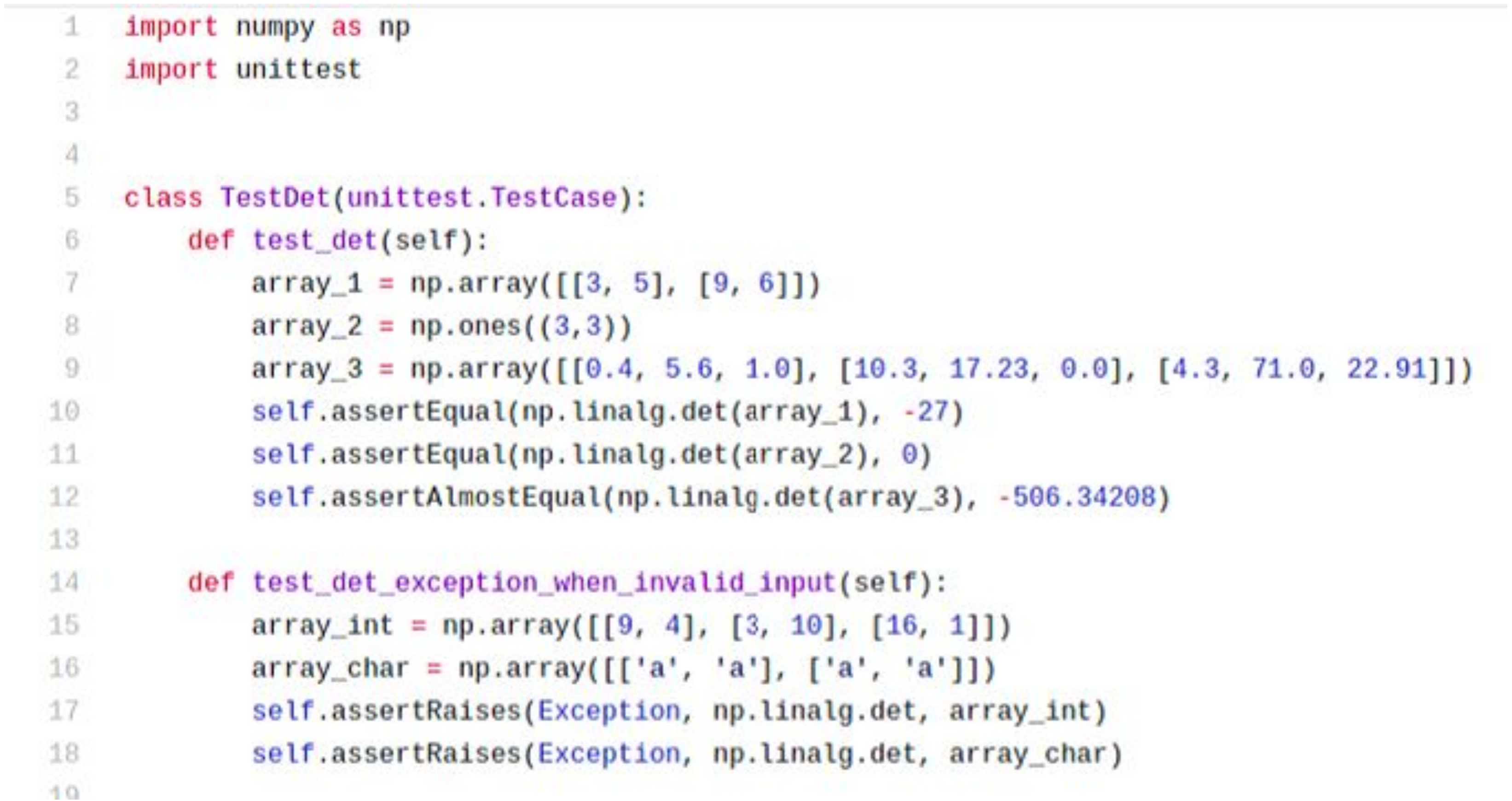
BLACK BOX TESTING

- **Searching:** argmax, argmin, where
- **Linear Algebra:** det, dot, norm
- **Ndarray:** dtype, shape, indexing
- **Sorting:** heap, quick, merge, stable
- **Statistics:** median, average, std, var

For example:

- The **det** function of the Linear Algebra submodule takes a matrix and returns it's determinant
- The **median** function of the Statistics submodule takes an array and returns the median value of that array
- The **shape** function of the Ndarray submodule returns the dimensions of a matrix

TEST CASES



```python
import numpy as np
import unittest


class TestDet(unittest.TestCase):
    def test_det(self):
        array_1 = np.array([[3, 5], [9, 6]])
        array_2 = np.ones((3,3))
        array_3 = np.array([[0.4, 5.6, 1.0], [10.3, 17.23, 0.0], [4.3, 71.0, 22.91]])
        self.assertEqual(np.linalg.det(array_1), -27)
        self.assertEqual(np.linalg.det(array_2), 0)
        self.assertAlmostEqual(np.linalg.det(array_3), -506.34208)

    def test_det_exception_when_invalid_input(self):
        array_int = np.array([[9, 4], [3, 10], [16, 1]])
        array_char = np.array([['a', 'a'], ['a', 'a']])
        self.assertRaises(Exception, np.linalg.det, array_int)
        self.assertRaises(Exception, np.linalg.det, array_char)
```

WHITE BOX TESTING

- We are testing the *polynomial* submodule which provides functions for dealing with polynomial series
- One function in the polynomial submodule is the **polyval** function, which evaluates a polynomial for a given value of *x*:

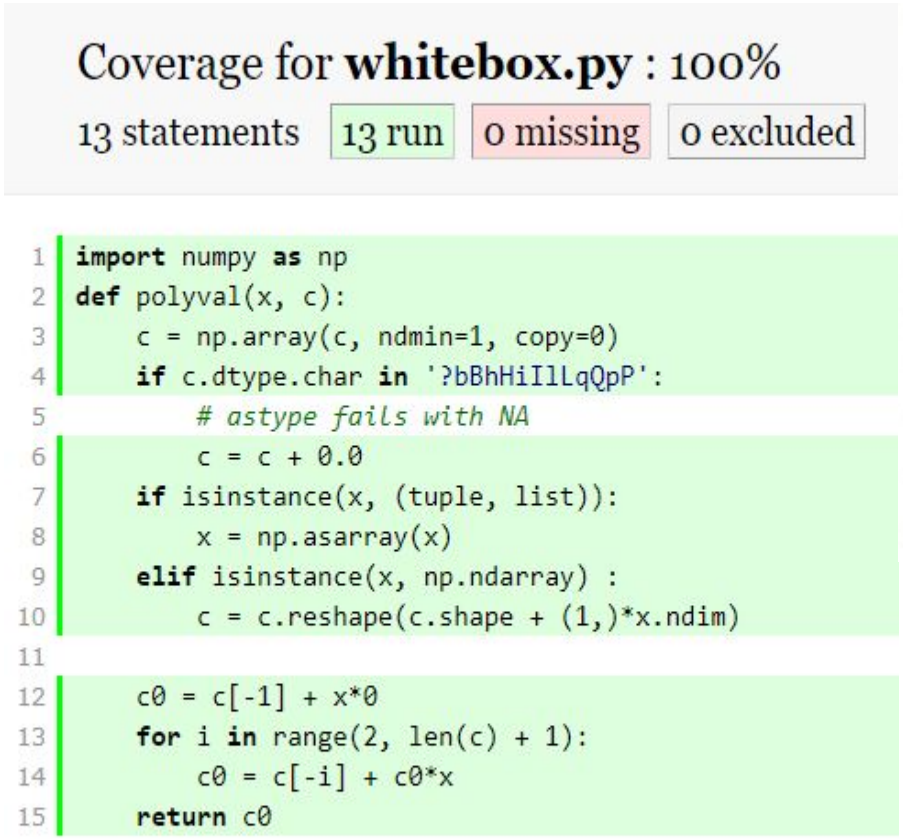
```python
import numpy as np

print('(3x^2 + 2x + 1)(2)= ' + str(np.polyval(2,[1, 2, 3])))
#prints (3x^2 + 2x + 1)(2)= 17
```

- Interesting piece of code found in the implementation of **polyval**:

```python
    if c.dtype.char in '?bBhHiIlLqQpP':
        # astype fails with NA
        c = c + 0.0
```

TEST CASES

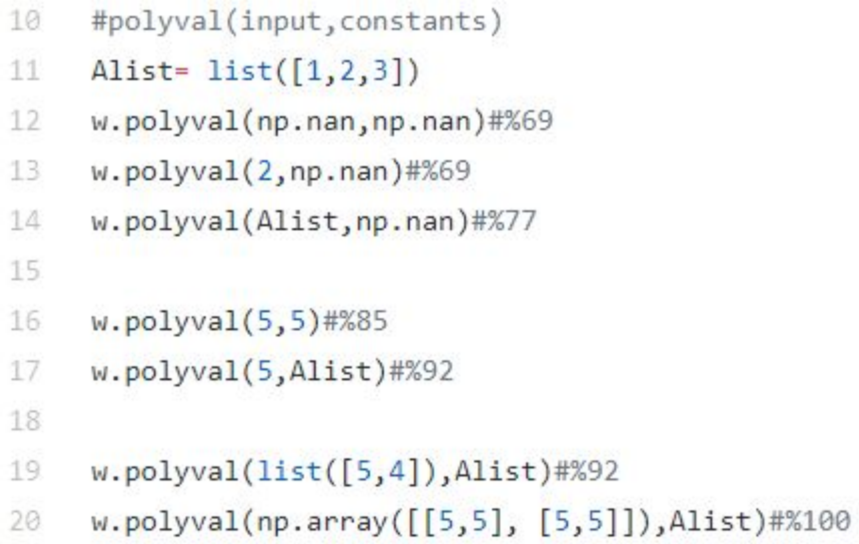


Coverage for **whitebox.py** : 100%

13 statements | 13 run | 0 missing | 0 excluded

```python
import numpy as np
def polyval(x, c):
    c = np.array(c, ndmin=1, copy=0)
    if c.dtype.char in '?bBhHiIlLqQpP':
        # astype fails with NA
        c = c + 0.0
    if isinstance(x, (tuple, list)):
        x = np.asarray(x)
    elif isinstance(x, np.ndarray) :
        c = c.reshape(c.shape + (1,)*x.ndim)

    c0 = c[-1] + x*0
    for i in range(2, len(c) + 1):
        c0 = c[-i] + c0*x
    return c0
```



```python
#polyval(input,constants)
Alist= list([1,2,3])
w.polyval(np.nan,np.nan)#%69
w.polyval(2,np.nan)#%69
w.polyval(Alist,np.nan)#%77

w.polyval(5,5)#%85
w.polyval(5,Alist)#%92

w.polyval(list([5,4]),Alist)#%92
w.polyval(np.array([[5,5], [5,5]]),Alist)#%100
```

CONCLUSION

- NumPy: Explore the capabilities of NumPy through software testing
- Black box testing: Opportunity to expand our knowledge of Unit testing framework
- White box testing: Opportunity to deal with Coverage API

FUTURE WORK

- Implement white box testing:
  - **Polyval** function with expansion of other polyval related functions
  - A more complicated function
- Construct a control flow graph using methods of the white box testing field

REFERENCE

[1] N. developers, "NumPy," 2019. [Online]. Available: https://numpy.org/. [Accessed 4 November 2019].

THANK YOU FOR LISTENING

Any questions?