IT314 – Software Engineering Lab-09

Mutation Testing

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Question 1) doGraham Function ()

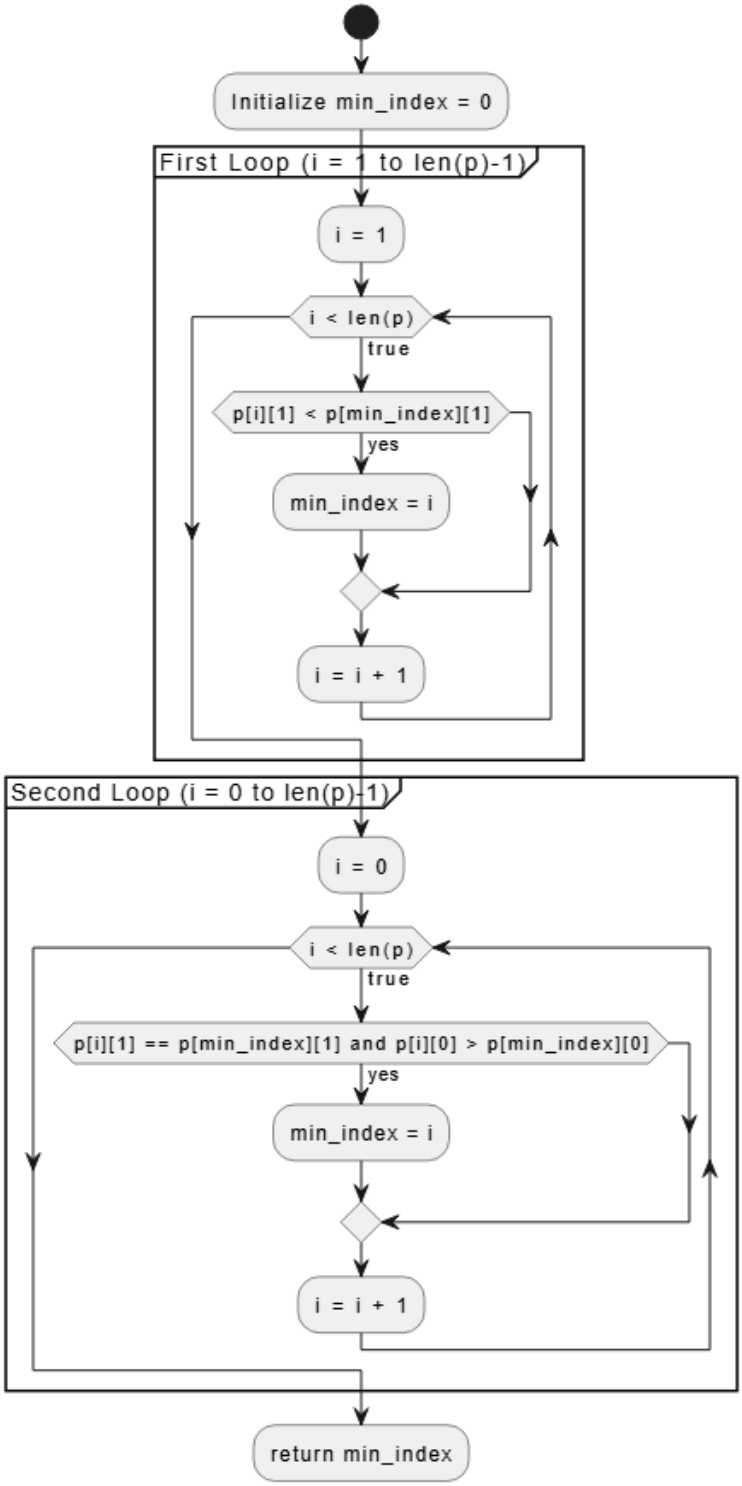
On converting code to python

```
def do_graham(p):
    min_index = 0

    # Search for minimum point for i in
    range(1, len(p)):
        if p[i][1] < p[min_index][1]:        # Compare y values min_index = i

    # Continue along the values with the same y component for i in range(len(p)):
        if p[i][1] == p[min_index][1] and p[i][0] > p[min_index][0]:
        # Compare x values
            min_index = i
    return min_index            # Return the index of the minimum point
```

Control Flow Graph (CFG): Yes,the logic of CFG generated matches with the one by tool using Eclipse flow graph generator



Test Sets

a. Statement Coverage

To achieve statement coverage, we need to ensure that each statement is executed at least once.

Minimum Test Cases:

1. **Test Case 1:** p = [(1, 2), (2, 3), (0, 1)]
    - Minimum point is (0, 1), index 2.
2. **Test Case 2:** p = [(1, 2), (2, 1), (0, 1)]
    - Minimum point is (0, 1), index 2.
3. **Test Case 3:** p = [(1, 2), (1, 2), (0, 1)]
    - Minimum point is (0, 1), index 2.

b. Branch Coverage

To achieve branch coverage, we need to ensure that both true and false outcomes for each condition are tested.

c. Minimum Test Cases:

1. **Test Case 1:** p = [(1, 2), (2, 3), (0, 1)] (Covers first condition True)
2. **Test Case 2:** p = [(1, 2), (1, 3), (0, 1)] (Covers first condition False)
3. **Test Case 3:** p = [(1, 1), (2, 1), (0, 1)] (Covers second condition True)
4. **Test Case 4:** p = [(1, 1), (0, 1), (0, 2)] (Covers second condition False)

d. Basic Condition Coverage

This requires that each atomic condition in the program has been evaluated to be both true and false.

Minimum Test Cases:

1. **Test Case 1:** p = [(1, 2), (2, 3), (0, 1)] (First condition True)
2. **Test Case 2:** p = [(1, 2), (1, 3), (0, 1)] (First condition False)
3. **Test Case 3:** p = [(1, 1), (2, 1), (0, 1)] (Second condition True for both)
4. **Test Case 4:** p = [(1, 1), (0, 1), (0, 2)] (Second condition False for both)

To achieve basic condition coverage, we can reuse the four cases from branch coverage since they effectively cover all atomic conditions.

Mutation Testing

```
C:\Users\Admin>pip install MutPy==0.3.0
Collecting MutPy==0.3.0
  Downloading MutPy-0.3.0.tar.gz (14 kB)
  Preparing metadata (setup.py) ... done
Collecting PyYAML>=3.1
  Downloading PyYAML-6.0.2-cp311-cp311-win_amd64.whl (161 kB)
     ---------------------------------------- 162.0/162.0 kB 966.5 kB/s eta 0:00:00
Installing collected packages: PyYAML, MutPy
  DEPRECATION: MutPy is being installed using the legacy 'setup.py install' method, because it does not have a 'pyproject
t.toml' and the 'wheel' package is not installed. pip 23.1 will enforce this behaviour change. A possible replacement is
 to enable the '--use-pep517' option. Discussion can be found at https://github.com/pypa/pip/issues/8559
  Running setup.py install for MutPy ... done
Successfully installed MutPy-0.3.0 PyYAML-6.0.2
```

```
C:\Users\Admin\Documents\project>python test_convex_hull.py
.F..
======================================================================
FAIL: test_y_value_different (__main__.TestDoGraham.test_y_value_different)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 12, in test_y_value_different
    self.assertEqual(do_graham(p), 1)
AssertionError: 2 != 1

----------------------------------------------------------------------
Ran 4 tests in 0.002s

FAILED (failures=1)
```

Corrected Code:

convex_hull.py - C:/Users/Admin/Documents/convex_hull.py (3.10.5)

File Edit Format Run Options Window Help

```
def do_graham(p):
    min_index = 0


    for i in range(len(p)):

        if p[i][1] < p[min_index][1]:
            min_index = i

        elif p[i][1] == p[min_index][1] and p[i][0] < p[min_index][0]:
            min_index = i

    return min_index
```

Test cases:

test_convex_hull.py - C:\Users\Admin\Documents\project\test_convex_hull.py (3.1

File Edit Format Run Options Window Help

```
import unittest
from convex_hull import do_graham

class TestDoGraham(unittest.TestCase):
    def test_basic_case(self):
        p = [[0, 0], [1, 1]]
        self.assertEqual(do_graham(p), 0)

    def test_y_value_different(self):
        p = [[0, 0], [1, -1]]
        self.assertEqual(do_graham(p), 1)

    def test_y_value_same_x_different(self):
        p = [[0, 0], [0, 0], [1, 0]]
        self.assertEqual(do_graham(p), 2)

    def test_y_value_edge_case(self):
        p = [[1, 1], [1, 1], [2, 0]]
        self.assertEqual(do_graham(p), 2)

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

```
C:\Users\Admin\Documents\project>python test_convex_hull.py
....
----------------------------------------------------------------------
Ran 4 tests in 0.001s

OK
```

Mutation 1: Deleting a line of code

```
def do_graham(p):
    min_index = 0

    for i in range(len(p)):
        if p[i][1] < p[min_index][1]:
            min_index = i


    return min_index
```

```
C:\Users\Admin\Documents\project>python test_convex_hull.py
...F
======================================================================
FAIL: test_y_value_same_x_different (__main__.TestDoGraham.test_y_value_same_x_different)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 16, in test_y_value_same_x_different
    self.assertEqual(do_graham(p), 2)
AssertionError: 0 != 2

----------------------------------------------------------------------
Ran 4 tests in 0.001s

FAILED (failures=1)
```

Mutation 2: Inserting a line of code

```
def do_graham(p):
    min_index = 0
    min_index = 1

    for i in range(len(p)):
        if p[i][1] < p[min_index][1]:
            min_index = i
        elif p[i][1] == p[min_index][1] and p[i][0] < p[min_index][0]:
            min_index = i

    return min_index
```

```
C:\Users\Admin\Documents\project>python test_convex_hull.py
...F
======================================================================
FAIL: test_y_value_same_x_different (__main__.TestDoGraham.test_y_value_same_x_different)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 16, in test_y_value_same_x_different
    self.assertEqual(do_graham(p), 2)
AssertionError: 1 != 2

----------------------------------------------------------------------
Ran 4 tests in 0.001s

FAILED (failures=1)
```

Mutation 3: Modifying a line of code

```
def do_graham(p):
    min_index = 0

    for i in range(len(p)):
        if p[i][1] > p[min_index][1]:
            min_index = i
        elif p[i][1] == p[min_index][1] and p[i][0] < p[min_index][0]:
            min_index = i

    return min_index
```

```
C:\Users\Admin\Documents\project>python test_convex_hull.py
FFFF
======================================================================
FAIL: test_basic_case (__main__.TestDoGraham.test_basic_case)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 8, in test_basic_case
    self.assertEqual(do_graham(p), 0)
AssertionError: 1 != 0

======================================================================
FAIL: test_y_value_different (__main__.TestDoGraham.test_y_value_different)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 12, in test_y_value_different
    self.assertEqual(do_graham(p), 1)
AssertionError: 0 != 1

======================================================================
FAIL: test_y_value_edge_case (__main__.TestDoGraham.test_y_value_edge_case)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 20, in test_y_value_edge_case
    self.assertEqual(do_graham(p), 2)
AssertionError: 0 != 2

======================================================================
FAIL: test_y_value_same_x_different (__main__.TestDoGraham.test_y_value_same_x_different)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "C:\Users\Admin\Documents\project\test_convex_hull.py", line 16, in test_y_value_same_x_different
    self.assertEqual(do_graham(p), 2)
AssertionError: 0 != 2

----------------------------------------------------------------------
Ran 4 tests in 0.002s

FAILED (failures=4)
```

Path Coverage

To ensure path coverage where every loop is explored at least zero, one, or two times, we can create the following test cases:

Derived Test Cases:

1. Test Case 1: p = [] (0 iterations of both loops)
2. Test Case 2: p = [(1, 1)] (0 iterations of the second loop)
3. Test Case 3: p = [(1, 1), (1, 1), (1, 1)] (1 iteration of the first loop, 0 of the second)
4. Test Case 4: p = [(1, 2), (2, 1), (0, 1)] (1 iteration of both loops)
5. Test Case 5: p = [(1, 2), (0, 1), (0, 1)] (2 iterations of the second loop)