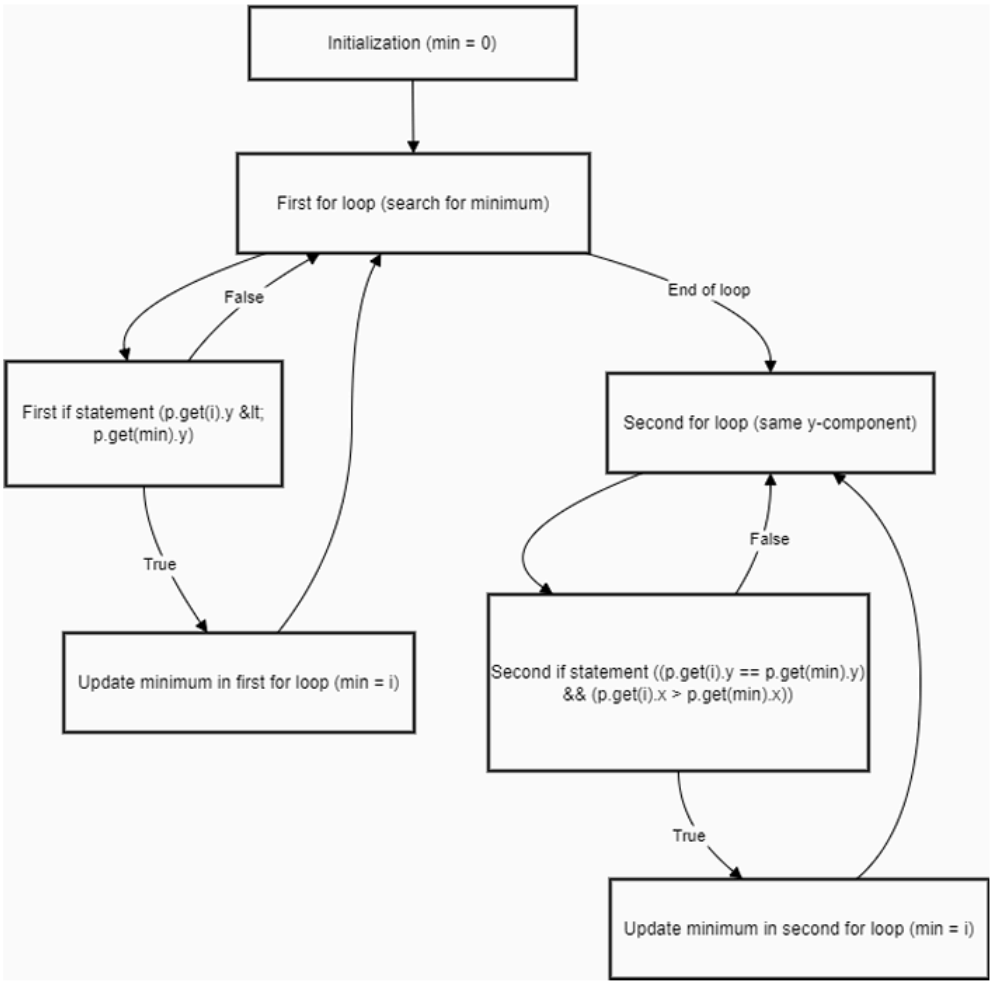
Lab09

Mutation Testing

Ramya Shah

202201409

1. **Convert the code comprising the beginning of the doGraham method into a control flow graph (CFG). You are free to write the code in any programming language.**



2. **Construct test sets for your flow graph that are adequate for the following criteria:**
    a. **Statement Coverage:-** Statement coverage requires that each statement in the code is executed at least once. We need to ensure that all lines (1 to 7 in the code) are executed in at least one of the test cases.

    Test Set for Statement Coverage:
    ● TestCase1: Input vector with only one point (e.g., [(0, 0)])
    ● TestCase2: Input vector with two points, one lower y value (e.g., [(1, 1), (2, 0)])
    ● TestCase3: Input vector with points having the same y value but different x values (e.g., [(1, 1), (2, 1), (3, 1)]

b. **Branch Coverage:-** Branch coverage requires that each branch in the code (True/False paths for each decision) is taken at least once.

Test Set for Branch Coverage:

● TestCase1: Input vector with only one point (e.g., [(0, 0)])
    ○ True branch: The first loop exits immediately, covering the loop without changes.
● TestCase2: Input vector with two points, one lower y value (e.g., [(1, 1), (2, 0)])
    ○ True branch: The minimum is updated to the second point.
● TestCase3: Input vector with points having the same y but different x values (e.g., [(1, 1), (3, 1), (2, 1)])
    ○ True branch for the second condition.
● TestCase4: Input vector with all points having the same y value (e.g., [(1, 1), (1, 1), (1, 1)])
    ○ False branch: Ensure the second loop is executed without changing the minimum.

c. **Basic Condition Coverage:-** Basic Condition Coverage requires that each individual condition within every decision is evaluated as both True and False at least once.

Test Set for Basic Condition Coverage:

● TestCase1: Input vector with only one point (e.g., [(0, 0)])
    ○ Covers the first condition p.get(i).y < p.get(min).y as false since no comparisons can be made.
● TestCase2: Input vector with two points with the second point having a lower y value (e.g.,
[(1, 1), (2, 0)])
    ○ Coverst he first condition true and the second condition false.
● TestCase3: Input vector with points that have the same y but different x values (e.g., [(1, 1),
(3, 1), (2, 1)])
    ○ Covers the second condition as true.
● TestCase4: Input vector with points that have the same y and x values (e.g., [(1, 1), (1,
1), (1, 1)])
    ○ Covers both conditions as false

3. For the test set you have just checked can you find a mutation of the code (i.e. the deletion, change or insertion of some code) that will result in failure but is not detected by your test set. You have to use the mutation testing tool.

```
[*] Start mutation process:
   - targets: point
   - tests: test_points
[*] 4 tests passed:
   - test_points [0.36220 s]
[*] Start mutants generation and execution:
   - [#   1] COI point:
--------------------------------------------------------------------------------
   6:
   7: def find_min_point(points):
   8:     min_index = 0
   9:     for i in range(1, len(points)):
- 10:         if points[i].y < points[min_index].y:
+ 10:         if not (points[i].y < points[min_index].y):
  11:             min_index = i
  12:     for i in range(len(points)):
  13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
  14:             min_index = i
--------------------------------------------------------------------------------
[0.23355 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_ties
   - [#   2] COI point:
--------------------------------------------------------------------------------
   9:     for i in range(1, len(points)):
```

```
--------------------------------------------------------------------------------
[0.23355 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_ties
   - [#   2] COI point:
--------------------------------------------------------------------------------
   9:     for i in range(1, len(points)):
  10:         if points[i].y < points[min_index].y:
  11:             min_index = i
  12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if not ((points[i].y == points[min_index].y and points[i].x > points[min_index].x))
  14:             min_index = i
  15:     return points[min_index]
--------------------------------------------------------------------------------
[0.27441 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_same_y
   - [#   3] LCR point:
--------------------------------------------------------------------------------
   9:     for i in range(1, len(points)):
  10:         if points[i].y < points[min_index].y:
  11:             min_index = i
  12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y == points[min_index].y or points[i].x > points[min_index].x):
  14:             min_index = i
  15:     return points[min_index]
```

```
--------------------------------------------------------------------------------
[0.18323 s] survived
   - [#   6] ROR point:
--------------------------------------------------------------------------------
   9:     for i in range(1, len(points)):
  10:         if points[i].y < points[min_index].y:
  11:             min_index = i
  12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y != points[min_index].y and points[i].x > points[min_index].x):
  14:             min_index = i
  15:     return points[min_index]
--------------------------------------------------------------------------------
[0.18059 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_same_y
   - [#   7] ROR point:
--------------------------------------------------------------------------------
   9:     for i in range(1, len(points)):
  10:         if points[i].y < points[min_index].y:
  11:             min_index = i
  12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y == points[min_index].y and points[i].x < points[min_index].x):
  14:             min_index = i
  15:     return points[min_index]
--------------------------------------------------------------------------------
   [0.13933 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_same_y
      - [#   8] ROR point:
   ----------------------------------------------------------------------------
      9:     for i in range(1, len(points)):
     10:         if points[i].y < points[min_index].y:
     11:             min_index = i
     12:     for i in range(len(points)):
   - 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
   + 13:         if (points[i].y == points[min_index].y and points[i].x >= points[min_index].x):
     14:             min_index = i
     15:     return points[min_index]
   ----------------------------------------------------------------------------
   [0.11494 s] survived
   [*] Mutation score [2.22089 s]: 75.0%
      - all: 8
      - killed: 6 (75.0%)
      - survived: 2 (25.0%)
      - incompetent: 0 (0.0%)
      - timeout: 0 (0.0%)
```

4. Create a test set that satisfies the path coverage criterion where every loop is explored at least zero, one or two times.

Test Case	Input	Description	Expected Output
Test Case 1	An empty vector `p`	Ensures no iterations of either loop occur.	Handle gracefully (e.g., return an empty result or a specific value indicating no points).
Test Case 2	`[(3, 4)]`	Ensures the first loop runs exactly once (the minimum point is the only point).	Return the only point in `p`: `(3, 4)`.
Test Case 3	`[(1, 2), (3, 2)]`	Ensures the first loop finds the minimum point, and the second loop runs once to compare x-coordinates.	Return the point with the maximum x-coordinate: `(3, 2)`.
Test Case 4	`[(3, 1), (2, 2), (5, 1)]`	Ensures the first loop finds the minimum y-coordinate and continues to the second loop.	Return `(5, 1)`, as it has the maximum x-coordinate among points with the same y.
Test Case 5	`[(1, 1), (4, 1), (3, 2)]`	Ensures the first loop finds `(1, 1)`, and the second loop runs twice to check other points with y = 1.	Return `(4, 1)`, as it has the maximum x-coordinate.