IT314 LAB9

MUTATION TESTING

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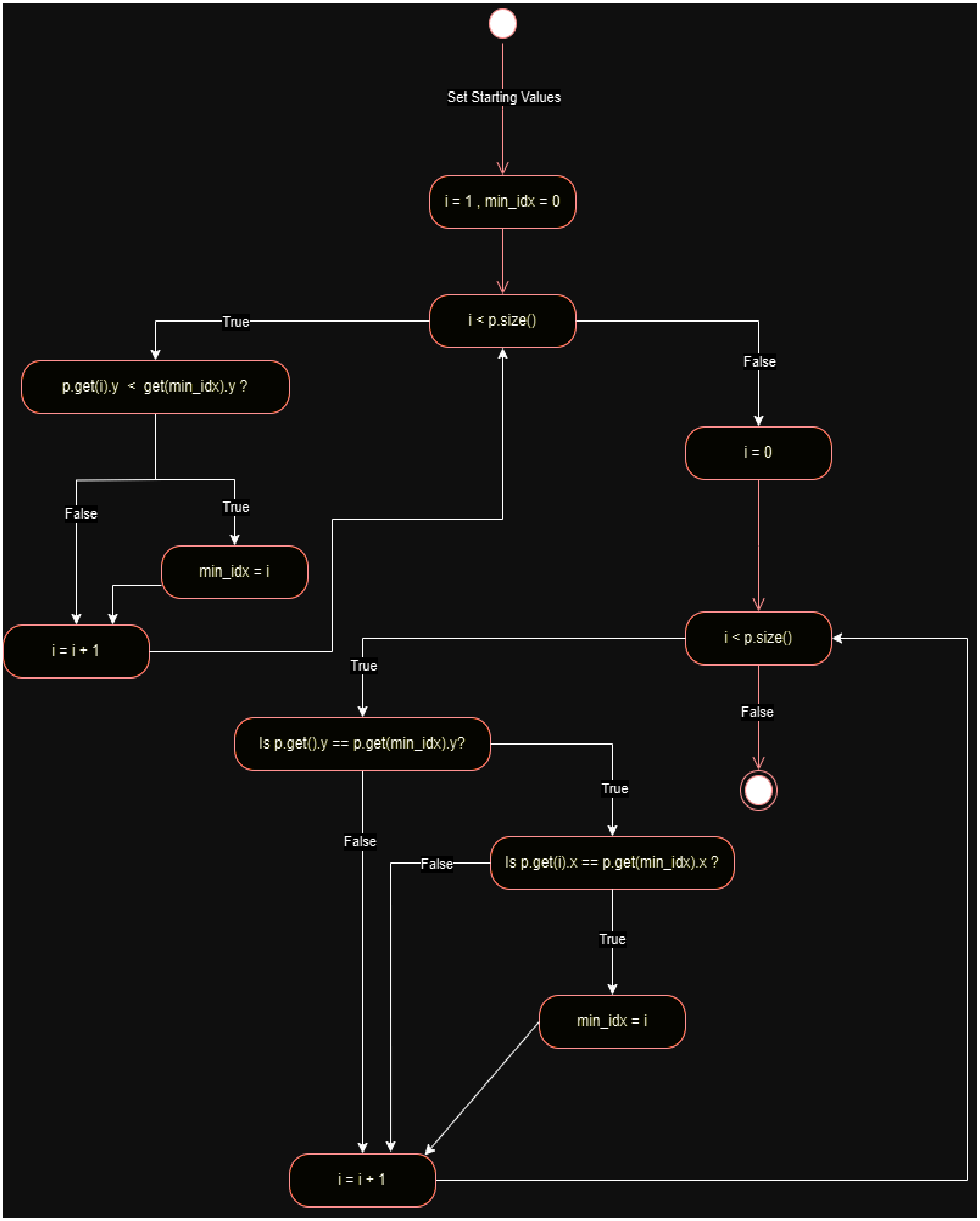
(1) Control Flow Graph :



(2) Java Code :

```java
import java.util.Vector;

class Point {
    int x, y;

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    @Override
    public String toString() {
        return "(" + x + ", " + y + ")";
    }
}

public class ConvexHull {
    public static void doGraham(Vector<Point> p) {
        int i, min;
        min = 0;

        System.out.println("Searching for the minimum y-coordinate...");
        for (i = 1; i < p.size(); ++i) {
            System.out.println("Comparing " + p.get(i) + " with " + p.get(min));
            if (p.get(i).y < p.get(min).y) {
                min = i;
                System.out.println("New minimum found: " + p.get(min));
            }
        }

        System.out.println("Searching for the leftmost point with the same
        minimum y-coordinate...");
        for (i = 1; i < p.size(); ++i) {
            if ((p.get(i).y == p.get(min).y) && (p.get(i).x > p.get(min).x)) {
                min = i;
            }
        }
        System.out.println("Leftmost point with minimum y-coordinate: " +
        p.get(min));
    }

    public static void main(String[] args) {
        Vector<Point> points = new Vector<>();
        points.add(new Point(1, 2));
        points.add(new Point(2, 1));
        points.add(new Point(0, 3));
        points.add(new Point(2, 0));

        doGraham(points);
    }
}
```

a) Statement Coverage:

Test Case 1:

- Input: p = [(0, 1), (1, 2), (2, 3)]
- Explanation: This input ensures we go through both loops and perform minimum checks in both y and x comparisons.
- Expected Outcome: index 2

b) Branch Coverage:

Test Case 2:

- Input: p = [(1, 3), (2, 1), (3, 3)]
- Explanation: This input allows the code to take both paths in p.get(i).y < p.get(min).y and p.get(i).y == p.get(min).y. The x-comparison will also be tested when y values are equal.
- Expected Outcome: index 2

Test Case 3:

- Input: p = [(0,3),(1,3),(2,3)]
- Explanation: Ensures the code covers cases where multiple points have the same y value and tests the branch where x values are compared.
- Expected Outcome: Index 2

c) Basic Condition Coverage:

Test Case 4:

- Input: p = [(2, 2), (1, 1), (0, 3)]
- Explanation: This set allows for basic condition testing where each part of p.get(i).y < p.get(min).y, p.get(i).y == p.get(min).y, and p.get(i).x > p.get(min).x evaluates as both true and false.
- Expected Outcome: index 2

Test Case 5:

- Input: p = [(1, 1), (1, 1), (2, 2)]
- Explanation: This input tests both true and false branches of each condition in isolation.
- Expected Outcome: Since the first two points are identical, the second loop tests the y equality and x comparison in a controlled manner. Min should be updated to reflect the highest x among points with the smallest y.

Identifying Undetected Code Mutations:

For the test suite you have recently analyzed, can you pinpoint a mutation in the code (such as a deletion, alteration, or addition) that would result in a failure but is not captured by your current tests? This task should be performed using a mutation testing tool

Types of Possible Mutations

Several common mutation types can be applied, including:

- Changes to Relational Operators: Modify <= to < or switch == to != in conditional statements.
- Logic Modifications: Remove or invert branches in if-statements.
- Statement Adjustments: Alter assignments or statements to see if the outcome goes unnoticed.

Potential Mutations and Their Consequences:

1. Modifying the Comparison for the Leftmost Point:

● **Mutation**: In the second loop, change p.get(i).x < p.get(min).x to p.get(i).x <= p.get(min).x.

● **Consequence**: This change could lead to the selection of points sharing the same x-coordinate as the leftmost point, undermining the uniqueness of the minimum point.

2. **Undetected by Current Tests**: The existing test cases do not address situations
where multiple points have identical x and y values, which would highlight if the function mistakenly includes such points as the leftmost.

3. **Changing the y-Coordinate Comparison to <= in the First Loop**:

● **Mutation**: Alter p.get(i).y < p.get(min).y to p.get(i).y <= p.get(min).y in the first loop.

● **Consequence**: This could allow points with the same y-coordinate but different x-coordinates to overwrite the minimum, potentially selecting a non-leftmost minimum point.

4. Undetected by Current Tests: The current test set lacks scenarios with multiple
points sharing the same y-coordinate, which could cause this mutation to remain undetected. To expose this issue, a test with points having the same y but different x values are necessary.

5. Eliminating the x-coordinate Check in the Second Loop:

● Mutation: Remove the condition p.get(i).x < p.get(min).x from the second loop.

● Consequence: This would permit the selection of any point with the minimum y-coordinate as the "leftmost," irrespective of its x-coordinate.

6. Undetected by Current Tests: The existing tests do not verify whether the correct leftmost point is selected when multiple points share the same y-coordinate but have different x values.

Additional Test Cases to Identify These Mutations:

To effectively detect these mutations, consider implementing the following test cases:

1. Test Case for Mutation 1:
- **Input:** [(0, 1), (0, 1), (1, 1)]
- **Expected Outcome:** The leftmost minimum should remain (0, 1) despite duplicates. This case will check if the x <= mutation incorrectly includes duplicate Points.

2. Test Case for Mutation 2:
- Input: [(1, 2), (0, 2), (3, 1)]
- **Expected Outcome:** The function should identify (3, 1) as the minimum point based on the y-coordinate. This test will confirm whether using <= for y comparisons erroneously overwrites the minimum point.

3. Test Case for Mutation 3:
- Input: [(2, 1), (1, 1), (0, 1)]
- **Expected Outcome:** The leftmost point should be (0, 1). This case will help determine if the x-coordinate check was incorrectly removed.

By adding these specific test cases, you can strengthen the test suite to ensure that these mutations are effectively caught.

Python Code For Mutation :

```
from math import atan2
class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def __repr__(self):
        return f"({self.x}, {self.y})"

def orientation(p, q, r):
    val = (q.y - p.y) * (r.x - q.x) - (q.x - p.x) * (r.y - q.y)
    if val == 0:
        return 0  # Collinear
    elif val > 0:
        return 1  # Clockwise
    else:
        return 2  # Counterclockwise

def distance_squared(p1, p2):
    return (p1.x - p2.x) ** 2 + (p1.y - p2.y) ** 2

def do_graham(points):
    n = len(points)
    min_y_index = 0

    for i in range(1, n):
        if points[i].y < points[min_y_index].y or \
           (points[i].y == points[min_y_index].y and points[i].x <
            points[min_y_index].x):
            min_y_index = i

    points[0], points[min_y_index] = points[min_y_index], points[0]
    p0 = points[0]

    sorted_points = sorted(points[1:], key=lambda p:
    (atan2(p.y - p0.y, p.x - p0.x), distance_squared(p0, p)))

    hull = [points[0], sorted_points[0], sorted_points[1]]

    for i in range(2, len(sorted_points)):
        while len(hull) > 1 and orientation(hull[-2], hull[-1],
        sorted_points[i]) != 2:
            hull.pop()
        hull.append(sorted_points[i])

    return hull
```

```python
# Sample test to observe behavior with the mutation
points = [Point(0, 3), Point(1, 1), Point(2, 2), Point(4, 4),
          Point(0, 0), Point(1, 2), Point(3, 1), Point(3, 3)]

hull = do_graham(points)

print("Convex Hull:", hull)
```