Program Structures and Algorithms Spring 2024

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GITHUB LINK:https://github.com/Arthurccone123/info-6205/tree/main/RandomWalk

Task:

This task will implement and analyze random walk experiments, in which a drunk moves a specific number of steps in a two-dimensional space in a randomly selected direction, and finally calculates its Euclidean distance from the starting point. The relationship between the number of steps m and the distance d is derived by running experiments with different steps.

Relationship Conclusion:

In the random walk experiment, the average Euclidean distance d between the drunk and the starting point after moving m steps randomly on a two-dimensional plane increases with the increase of the number of steps m. But this increase is not linear, but increases with the square root of the number of steps.

Evidence to support that conclusion:

Here is the code:

```
* Copyright (c) 2017. Phasmid Software
 */

package edu.neu.coe.info6205.randomwalk;

import java.util.Random;

public class Randomwalk {

    private int x = 0;
    private int y = 0;

    private final Random random = new Random();

    /**
     * Private method to move the current position, that's to say the drunkard
moves
     *
     * @param dx the distance he moves in the x direction
     * @param dy the distance he moves in the y direction
     */
    private void move(int dx, int dy) {
```

```
        x += dx;
        y += dy;
    }

    /**
     * Perform a random walk of m steps
     *
     * @param m the number of steps the drunkard takes
     */
    private void randomWalk(int m) {
        for (int i = 0; i < m; i++) {
            randomMove();
        }
    }


    /**
     * Private method to generate a random move according to the rules of the
situation.
     * That's to say, moves can be (+-1, 0) or (0, +-1).
     */
    private void randomMove() {
        boolean ns = random.nextBoolean();
        int step = random.nextBoolean() ? 1 : -1;
        move(ns ? step : 0, ns ? 0 : step);
    }

    /**
     * Method to compute the distance from the origin (the lamp-post where the
drunkard starts) to his current position.
     *
     * @return the (Euclidean) distance from the origin to the current position.
     */
    public double distance() {
        return Math.sqrt(x * x + y * y);
    }


    /**
     * Perform multiple random walk experiments, returning the mean distance.
     *
     * @param m the number of steps for each experiment
     * @param n the number of experiments to run
     * @return the mean distance
     */
    public static double randomWalkMulti(int m, int n) {
        double totalDistance = 0;
        for (int i = 0; i < n; i++) {
            RandomWalk walk = new RandomWalk();
            walk.randomWalk(m);
            totalDistance = totalDistance + walk.distance();
        }
        return totalDistance / n;
    }

    // all unit test
```

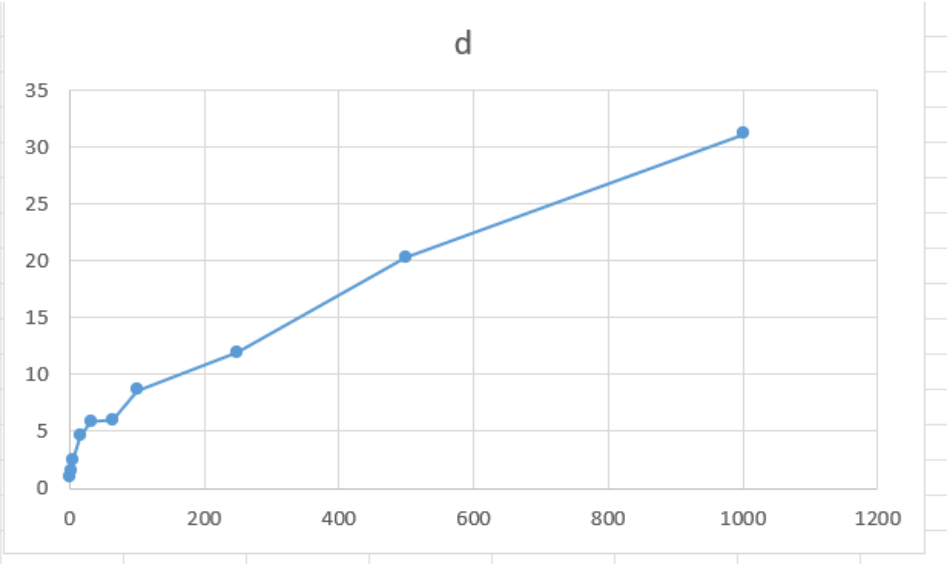
```
    /* public static void main(String[] args) {
         if (args.length == 0)
             throw new RuntimeException("Syntax: RandomWalk steps [experiments]");
         int m = Integer.parseInt(args[0]);
         int n = 30;
         if (args.length > 1) n = Integer.parseInt(args[1]);
         double meanDistance = randomWalkMulti(m, n);
         System.out.println(m + " steps: " + meanDistance + " over " + n + "
experiments");
     }*/

     // For particular assignment
    public static void main(String[] args) {
         int[] mValues = {1, 2, 4, 16, 32, 64, 100, 250, 500, 1000};
         int n = 10;
         for (int m : mValues) {
             double totalDistance = 0;
             for (int i = 0; i < n; i++) {
                 double distance = randomWalkMulti(m, 1);
                 totalDistance += distance;
             }
             double meanDistance = totalDistance / n;
             System.out.println(m + " steps: " + meanDistance + " over " + n + "
experiments");
         }
     }


}
```

Below is a scatterplot of the results of 10 runs:

m	d
1	1
2	1.44
4	2.48
16	4.62
32	5.81
64	6
100	8.63
250	11.87
500	20.25
1000	31.13



```java
    // For particular assignment
    public static void main(String[] args) {
        int[] mValues = {1, 2, 4, 16, 32, 64, 100, 250, 500, 1000};
        int n = 10;
        for (int m : mValues) {
            double totalDistance = 0;
            for (int i = 0; i < n; i++) {
                double distance = randomWalkMulti(m, 1);
```

Console

```
<terminated> RandomWalk [Java Application] C:\Users\Arthur\.p2\pool\plugins\org.eclipse.justj.openjdk.hotspot.jre.full.win32.x86_
1 steps: 1.0 over 10 experiments
2 steps: 1.4485281374238572 over 10 experiments
4 steps: 2.488245611270737 over 10 experiments
16 steps: 4.625454192648752 over 10 experiments
32 steps: 5.8169475976099205 over 10 experiments
64 steps: 6.001063767754602 over 10 experiments
100 steps: 8.63084971284923 over 10 experiments
250 steps: 11.87838109899681 over 10 experiments
500 steps: 20.255398550270577 over 10 experiments
1000 steps: 31.135377234642554 over 10 experiments
```

Unit Test Screenshots: