

Program Structures & Algorithms

Fall 2021 Assignment No. 1

Tasks

* Relationship Conclusion:

The relationship conclusion by mathematical deduction is: $d \approx \sqrt{n}$

However, the program simulation result is: $d \approx 0.89\sqrt{n}$

Here the n is the step, and the d , specifically is the root-mean-square of the distance, because of the d actually is a probability density function, but we are no need to calculate it.

* Evidence to support the conclusion:

1. Mathematical deduction

First come to my mind is to divide the calculation of x and y , which they are independent. The distance of the x and y are probability distributions, however, I found that the average distance is enough, which are also in the code.

Assume that there are totally n steps, and x moved m steps and y moved l steps.

The sum of the x and y , let's say x_s and y_s , which is the final coordinates of the drunken man.

The two equations show the sum of the x and y :

$$(1) x_s = x_1 + x_2 + \dots x_m$$

$$(2) y_s = y_1 + y_2 + \dots y_l$$

And the distance is:

$$d = \sqrt{x_s^2 + y_s^2}$$

Then replace the x_s and y_s with the (1) and (2) respectively:

$$(3) d^2 = x_s^2 + y_s^2$$

$$= x_1^2 + x_2^2 + \dots + x_m^2 + x_1x_2 + x_1x_3 + \dots + x_1x_m$$

$$+y_1^2 + y_2^2 + \dots + y_l^2 + y_1y_2 + y_1y_3 + \dots + y_1y_l$$

Assume that n is a really big number, and the x_n and y_n are probably become positive or negative, the terms in the (3) $x_1x_2 + x_1x_3 + \dots + x_1x_m$ and $y_1y_2 + y_1y_3 + \dots + y_1y_l$ can be ignored.

Then an approximation can be showed:

$$d^2 \approx \underbrace{[x_1^2 + y_1^2] + [x_2^2 + y_2^2] \dots + [x_m^2 + y_l^2]}_{n \text{ steps}}$$

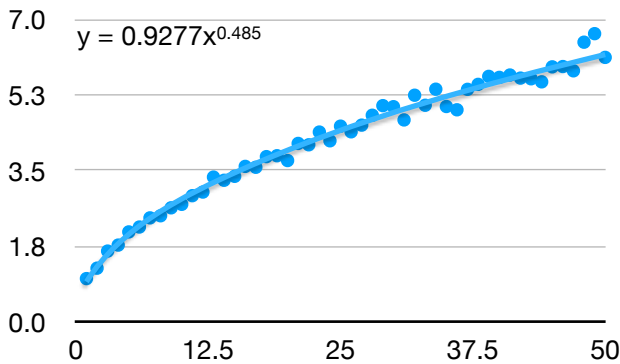
The m and l shared the same probability, 50% and the total steps are n steps.
The result is

$$d^2 \approx n$$

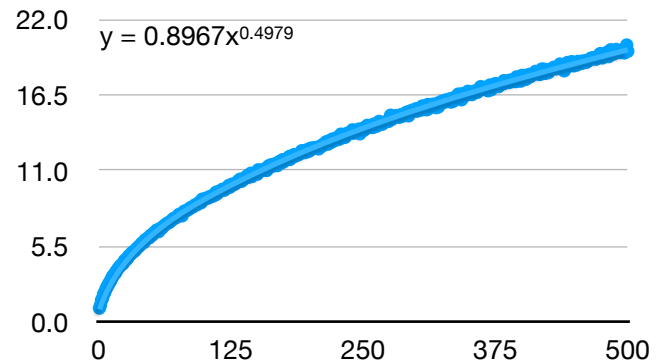
Then

$$d \approx \sqrt{n}$$

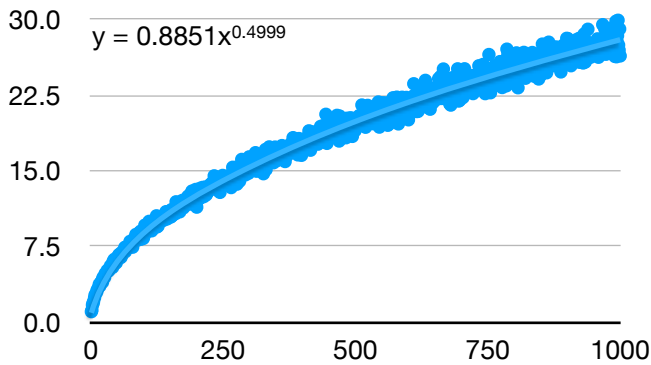
(a) 50 steps with 300 experiments



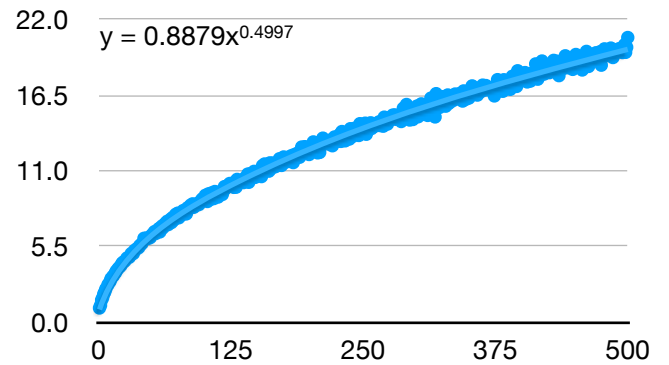
(c) 500 steps with 300 experiments



(b) 1000 steps with 300 experiments



(d) 500 steps with 1000 experiments



2. Graphical Representation from program simulation

The y axis represent the output of the program, which is the mean distance of the experiments.

The x axis means the steps of the drunk man moved.

Some observations:

- * Under the same experiments(plot a, b, and c), the increase of the steps can improve the precision of the power of x, but not the coefficient of the x.
- * Under the same steps, the increase of the experiments can also improve the precision of the power of x, but not the coefficient of the x.
- * The average of the coefficient of the x is approximately 8.99.

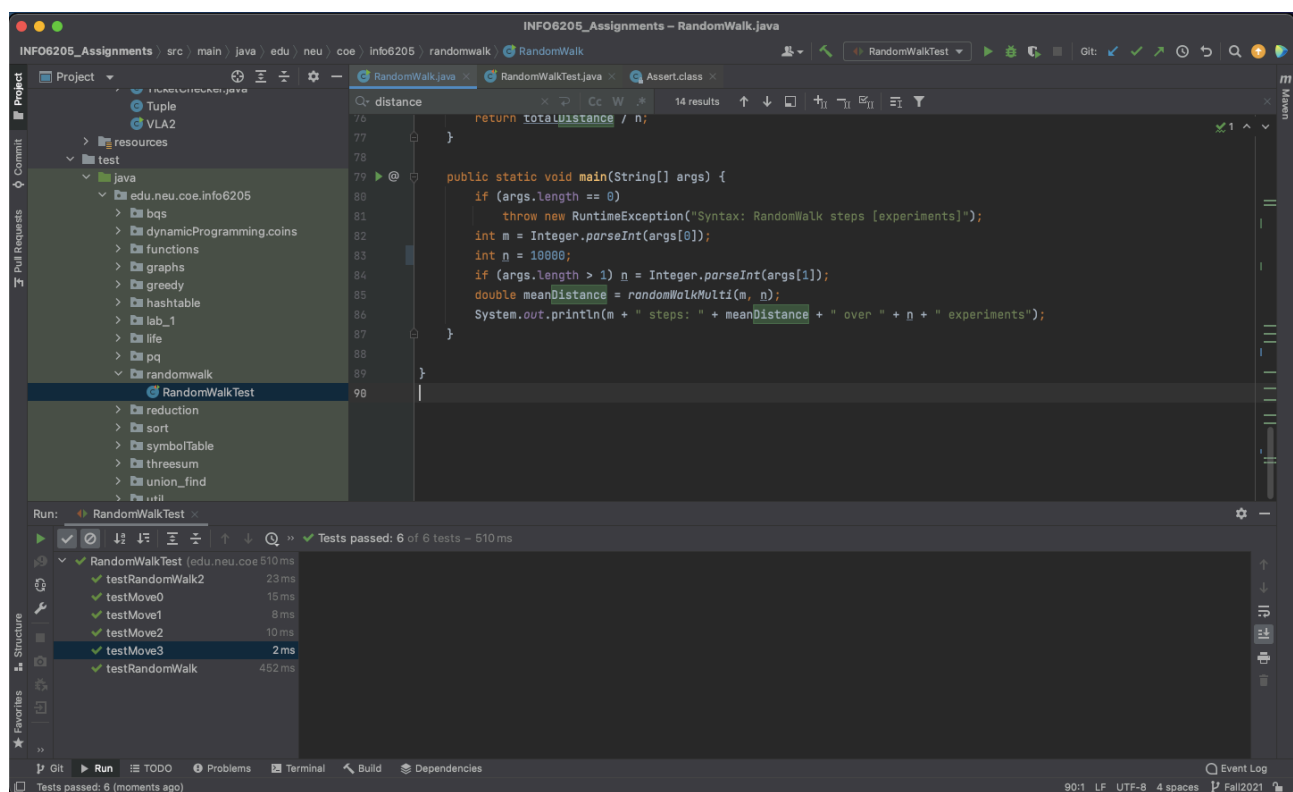
3. Reproduction the experiments

The Bash script I ran to generate the statistics, which located with RandomWalk.java:

run_experiments.sh

A file “results.csv” will be generated, then it can be plotted.

* Unit tests result:



The screenshot shows an IDE window titled "INFO6205_Assignments - RandomWalk.java". The main editor displays the code for `RandomWalk.java`, which includes a `main` method that takes command-line arguments and calls `randomWalkMulti` to calculate the mean distance. The code is as follows:

```
76 return totalDistance / n;
77 }
78
79 public static void main(String[] args) {
80     if (args.length == 0)
81         throw new RuntimeException("Syntax: RandomWalk steps [experiments]");
82     int m = Integer.parseInt(args[0]);
83     int n = 10000;
84     if (args.length > 1) n = Integer.parseInt(args[1]);
85     double meanDistance = randomWalkMulti(m, n);
86     System.out.println(m + " steps: " + meanDistance + " over " + n + " experiments");
87 }
88
89 }
```

The bottom panel shows the "Run" output, indicating that 6 tests passed out of 6 tests in 510 ms. The test results are as follows:

Test Name	Duration (ms)
testRandomWalk2	23
testMove0	15
testMove1	8
testMove2	10
testMove3	2
testRandomWalk	452