

## 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:

$$\begin{aligned}
 (3) \quad d^2 &= x_s^2 + y_s^2 \\
 &= x_1^2 + x_2^2 + \dots + x_m^2 + x_1x_2 + x_1x_3 + \dots + x_1x_m \\
 &\quad + y_1^2 + y_2^2 + \dots + y_l^2 + y_1y_2 + y_1y_3 + \dots + y_1y_l
 \end{aligned}$$

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:

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

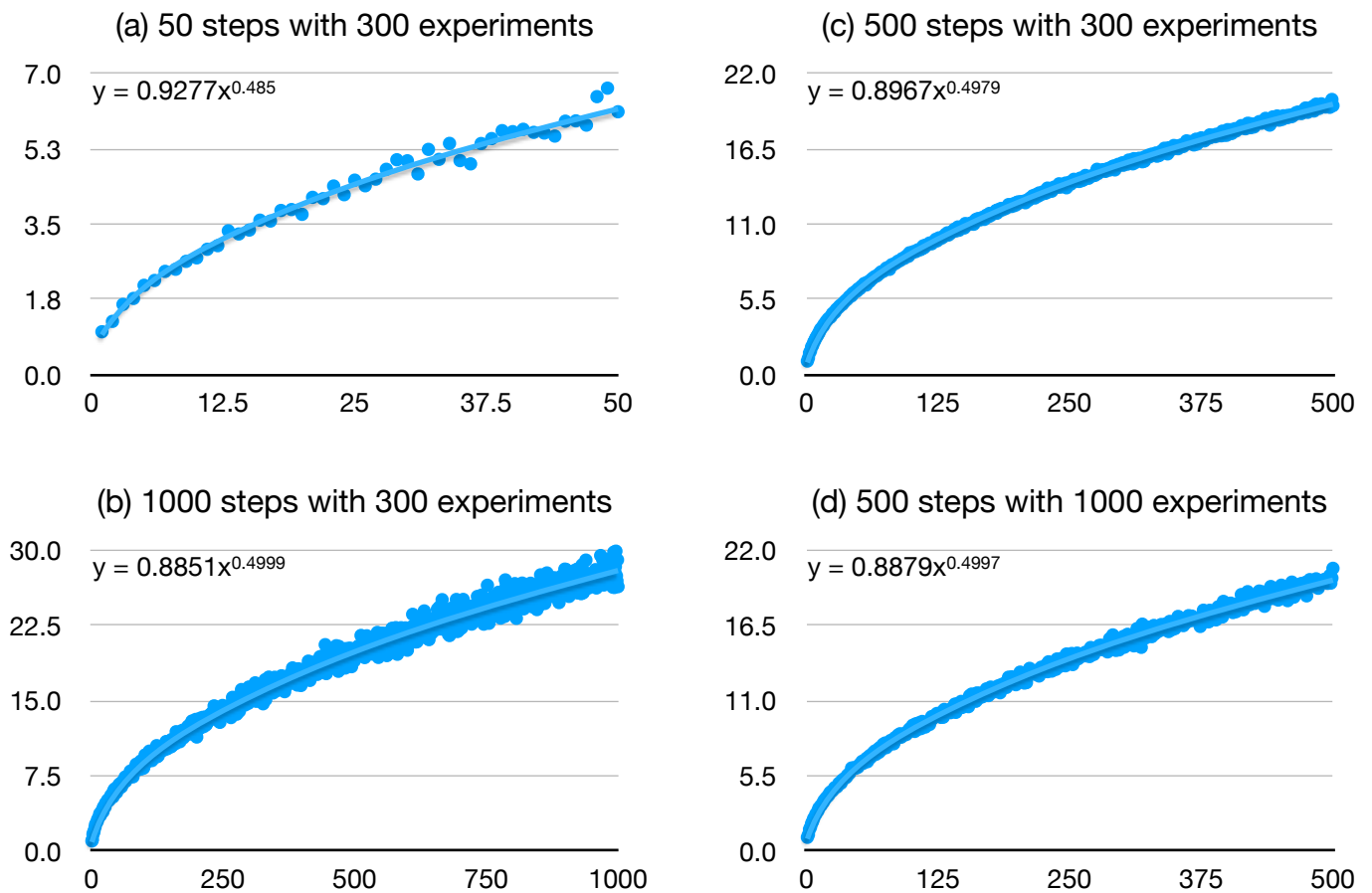
The  $m$  and  $l$  shared the same probability, 50% and the total steps are  $n$  steps.  
The result is

$$d^2 \approx n$$

Then

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

## 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 `RandomWalk.java` file with the following code:

```
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 left sidebar shows the project structure with the following folders:

- resources
- test
  - java
    - edu.neu.coe.info6205
      - bqs
      - dynamicProgramming.coins
      - functions
      - graphs
      - greedy
      - hashtable
      - lab\_1
      - life
      - pq
      - randomwalk
        - RandomWalkTest
      - reduction
      - sort
      - symbolTable
      - threesum
      - union\_find

The bottom panel shows the "Run" output for `RandomWalkTest`. It indicates 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

The bottom status bar shows "Tests passed: 6 (moments ago)" and "90:1 LF UTF-8 4 spaces Fall2021".