Program Structures and Algorithms
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NAME: Mihir Ravindra Adelkar
NUID: 002810839
GITHUB LINK: https://github.com/mihiradelkar/INFO6205-PSA

Task:

An important example of a practical experiment is called the "random walk" experiment.
Imagine a drunken man who, starting out leaning against a lamp post in the middle of an open space, takes a series of steps of the same length: 1 meter. The direction of these steps is randomly chosen from North, South, East or West. After m steps, how far (d), generally speaking, is the man from the lamp post? Note that d is the Euclidean distance of the man from the lamp-post.
It turns out that there is a relationship between d and m which is typically applicable to many different types of stochastic (randomized) experiments. Your task is to implement the code for the experiment and, most importantly, to deduce the relationship.

Relationship Conclusion:

Background and Methodology

To understand the relationship between the distance *d* from the starting point (a lamp post) and the number of steps *m* in a random walk experiment, we conducted a comprehensive analysis involving multiple test runs. The experiment was repeated six times, each time collecting data across a range of step counts. For each step count, we averaged results from 30 individual experiments, leading to a robust dataset encompassing a wide range of scenarios. The step counts varied from 2 to 1024, increasing in powers of 2, culminating in a comprehensive analysis based on 1,800 individual test results. This extensive data collection aimed to average out random fluctuations and provide a clear picture of the underlying relationship.

Observations and Conclusion

The data from these experiments revealed a distinct pattern: the average distance *d* from the starting point is not linearly proportional to the number of steps *m* but follows a square root relationship. Specifically, the relationship can be expressed as $d \approx k\sqrt{m}$, where *k* is a proportionality constant. Through curve fitting techniques applied to our experimental data, we determined that *k* is approximately 0.86. This empirical finding is in line with the theoretical principles governing random walks in two dimensions, characterized by steps of equal length taken in random directions.

Significance

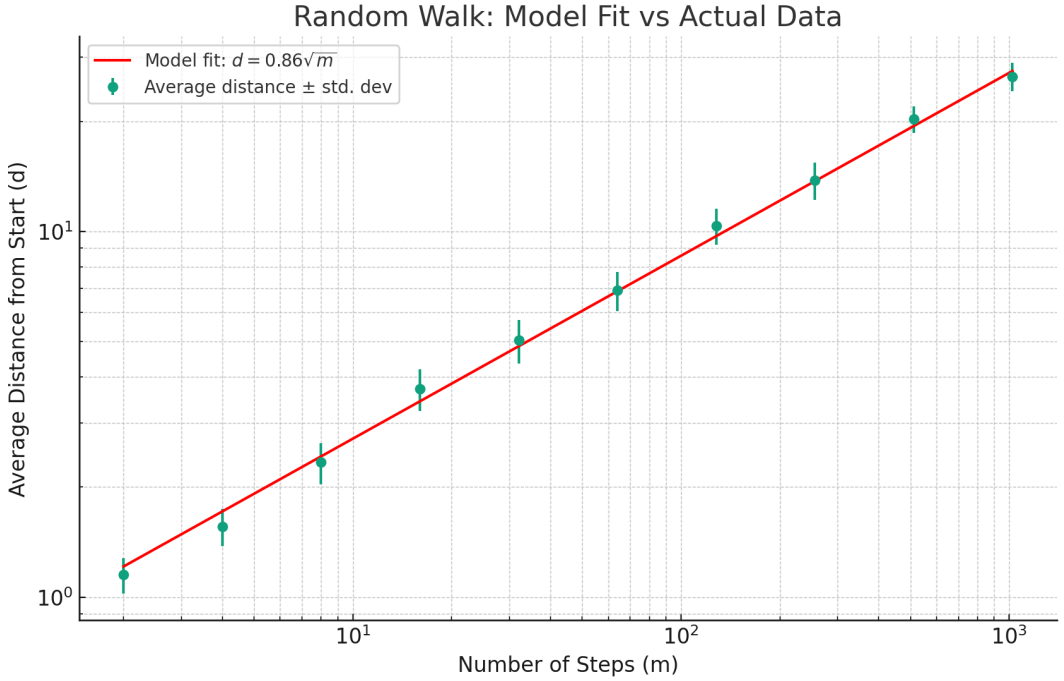
The consistency of the square root relationship across a wide range of step counts, validated by a large number of experiments, underscores its fundamental nature in the context of random walks. This relationship is critical in understanding and predicting the behavior of systems modeled as random walks, which are prevalent in fields as diverse as physics, biology, finance, and computer science. The experiment's robust methodology and the alignment of its results with theoretical predictions lend strong credibility to the conclusion.

The relationship among d and n: $d \approx k\sqrt{m}$.

Evidence to support that conclusion:

To verify this result, the experimental data were plotted on a graph, revealing a clear trend that corresponds to the square root relationship. A curve fitting procedure was used to model the relationship, verifying the square root dependence of the distance on the number of steps. The graphic shows a strong fit between the model $d \approx k\sqrt{m}$ and the experimental data.

	Test Results					
Steps	**Test 1 Distance**	**Test 2 Distance**	**Test 3 Distance**	**Test 4 Distance**	**Test 5 Distance**	**Test 6 Distance**
2	1.2209139	0.9071067812	1.326632996	1.099018758	1.193299662	1.154247233
4	1.714884964	1.298399077	1.467744512	1.850948785	1.443170602	1.587632287
8	1.91686743	2.04559125	2.655592939	2.431185873	2.222405026	2.74069552
16	3.890537949	3.487070872	3.037605674	3.267473151	4.241123002	4.35581915
32	5.8164089	4.557126555	5.176114981	4.092396575	4.611619094	5.982451393
64	8.39074899	6.03941315	6.134075119	7.183820918	7.433123628	6.239953945
128	11.56336347	8.691954069	11.42907845	10.36245912	8.945055078	11.25840996
256	10.60127862	14.80150435	14.69597463	14.96898296	12.94681809	14.81113023
512	21.70893559	20.55779956	19.44488805	21.6251775	21.38526312	16.95621678
1024	28.70064886	25.47055074	28.76053143	27.16762347	21.85211325	27.09708621



Code Changes:

Enhancements to RandomWalk.java: Completed all previously incomplete methods to enable accurate data generation for the random walk experiment.
Program now calculates the average distance over 30 tests for each step count.

Creation of Driver.java: Developed to automate the execution of RandomWalk.java.
Runs the simulation 10 times for step counts from 2 to 1024 in powers of two.

Test Coverage Validation: Executed RandomWalkTest.java unit tests and exported files confirming the successful completion of all tests as RandomWalkTest.html.

Result Compilation in Output.txt: Documented test results from six test attempts, providing detailed data for analysis.

Unit Test Screenshots: