

# Random Walk

## Computational Techniques

C. Odhiambo<sup>1</sup>

<sup>1</sup>Institute of Mathematical Sciences  
Strathmore University

March 10th 2025

1 Random Walks

2 Types of Random Walks

3 Applications of Random Walks

# Random Walks

A random walk is a mathematical model that describes a path consisting of a series of random steps. It is widely used in physics, finance, biology, and computer science to model stochastic processes.

## Random Walk-Formal Definition

A random walk is a sequence of random steps in space or time. Mathematically, if  $X_n$  represents the position at step  $n$ , then:

$$X_n = X_{n-1} + S_n$$

where  $S_n$  is a random step, typically drawn from a probability distribution (e.g., uniform, normal, or Bernoulli).

# Types of Random Walks

## 1D Random Walk (One-Dimensional)

A 1D random walk occurs when movement is restricted to a single axis (e.g., left or right along a line). At each step:

The walker moves left  $(-1)$  or right  $(+1)$  with equal probability (if unbiased).

Example: Stock prices, genetic mutation models.

## 2D Random Walk (Two-Dimensional)

A 2D random walk allows movement in two perpendicular directions ( $x$  and  $y$ ). At each step:

The walker moves up, down, left, or right.

Example: Brownian motion, diffusion of molecules.

# Some Applications of Random Walks

- Finance & Stock Prices: Stock market fluctuations can be modeled as a random walk where prices change unpredictably. Example: The Efficient Market Hypothesis (EMH) assumes that stock prices follow a random walk.
- Physics & Chemistry: Brownian motion models particle movement in a fluid. Diffusion processes can be understood as 2D/3D random walks.
- Machine Learning & AI: Monte Carlo simulations rely on random walks to explore solution spaces. Reinforcement learning uses random exploration to learn optimal strategies.
- Biology & Ecology: Animal foraging patterns often resemble random walks. DNA sequence mutations follow stochastic processes similar to random walks.