

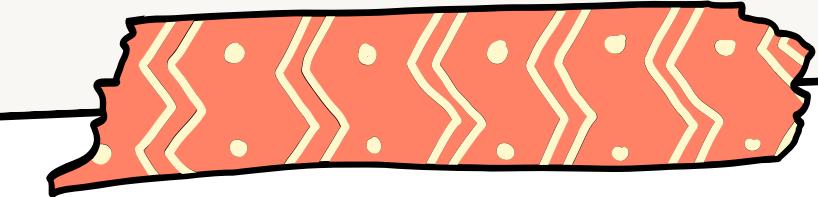
Monte Carlo Simulation

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Introduction

What is Monte Carlo simulation?

Monte Carlo simulation is a computational technique used to model and analyze uncertain systems or processes by random sampling.

- It involves using random sampling and statistical analysis to simulate and estimate the behavior of complex systems.

The name "Monte Carlo" comes from the famous casino in Monaco, which is known for its games of chance.



Why Monte Carlo?

Complex problems

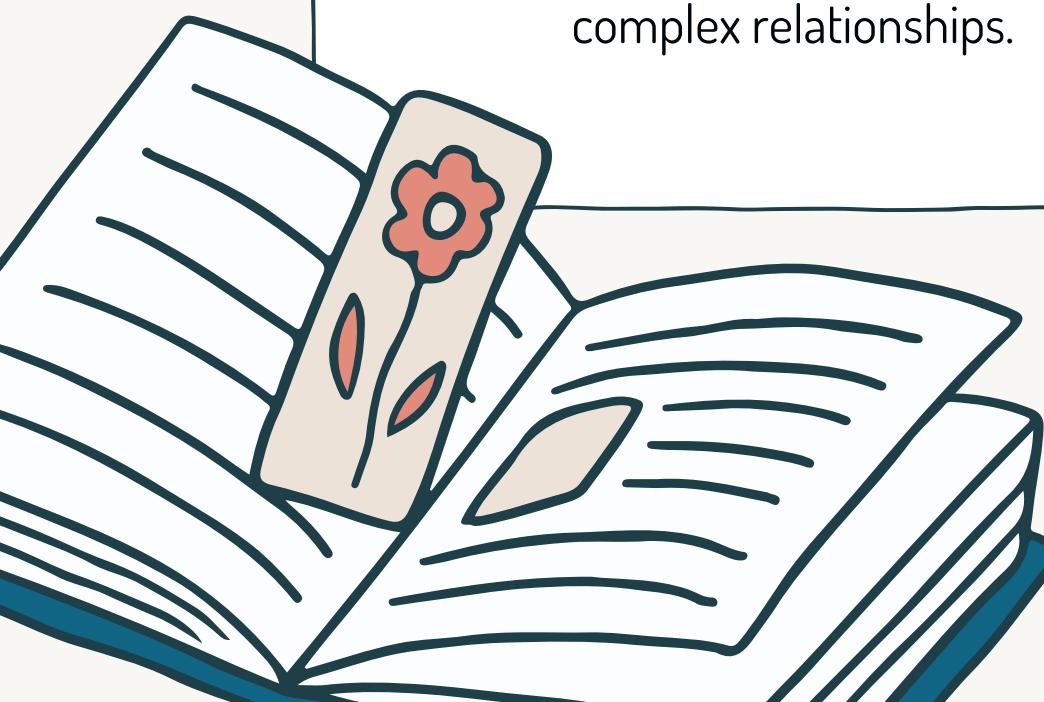
Monte Carlo Simulation is particularly useful when dealing with problems that have multiple variables or complex relationships.

Uncertainty and randomness

It allows us to model and analyze situations where uncertainty and randomness play a significant role.

Flexibility

Monte Carlo Simulation can be applied to a wide range of problem types, making it a versatile tool.



Limitations

Computationally intensive

Running simulations can be time-consuming, especially for large-scale problems.

Approximation

The accuracy of Monte Carlo results depends on the number of simulations performed, so a higher number is usually required for better accuracy.

Simplifying assumptions

Some simulations may involve assumptions that simplify the problem, which can affect the accuracy of results.





Monte Carlo Application in the Real World



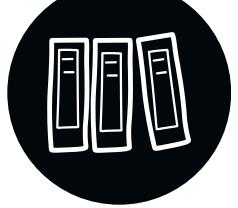
Finance

- Monte Carlo Simulation is used for portfolio optimization, options pricing, and risk analysis.



Healthcare

- It aids in modeling the spread of diseases, optimizing treatment strategies, and assessing health risks.



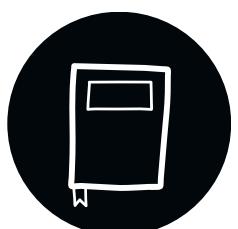
Engineering

- It helps evaluate the reliability and safety of structures, such as bridges and buildings.



Manufacturing

- It assists in process optimization, quality control, and supply chain management.



Energy

- It supports decision-making in energy trading, production planning, and resource allocation.



e.J Drawback of Monte Carlo Algorithm

- `Slow Convergence`: Monte Carlo methods typically rely on generating a large number of random samples to obtain accurate results. As a result, the convergence rate can be slow, especially for high-dimensional problems. The computational time required to achieve a desired level of precision can be significant, making Monte Carlo methods inefficient in certain scenarios.
- `High Variance`: Monte Carlo methods are known for their potential high variance, particularly when the integrand function exhibits large fluctuations or has a complex behavior. This high variance can lead to imprecise estimations and the need for a larger number of samples to reduce the uncertainty.
- `Difficulties in Rare Event Estimation`: Monte Carlo methods can encounter challenges when estimating rare events with extremely low probabilities. Due to the random nature of the sampling process, it may take an extensive number of samples to capture such rare events accurately. This issue is often referred to as the "rare event problem."
- `Dependence on Randomness`: Monte Carlo methods heavily rely on the generation of random numbers to produce the samples for estimation. The quality of the random number generator used can impact the accuracy and reliability of the results. Moreover, the randomness introduced can make the Monte Carlo estimates less reproducible.
- `Curse of Dimensionality`: Monte Carlo methods can suffer from the curse of dimensionality, especially when dealing with high-dimensional integration problems. As the dimensionality increases, the number of samples required to achieve a certain level of accuracy grows exponentially, which poses a computational challenge.
- `Need for Special Techniques`: In some cases, Monte Carlo methods may require additional techniques to improve efficiency or accuracy. Variance reduction techniques such as importance sampling, control variates, or stratified sampling may need to be applied to mitigate high variance issues. Implementing and optimizing these techniques can add complexity to the Monte Carlo process.

Despite these drawbacks, Monte Carlo methods remain valuable and widely used due to their versatility, applicability to complex problems, and the ability to handle problems with limited analytical solutions. Researchers continue to develop and refine Monte Carlo techniques, as well as hybrid approaches, to address these limitations and enhance the efficiency and accuracy of Monte Carlo simulations.

Thank's For Watching

