What is the Monte Carlo Simulation?

The Monte Carlo simulation is a mathematical technique that predicts possible outcomes of an uncertain event. Computer programs use this method to analyze past data and predict a range of future outcomes based on a choice of action. For example, if you want to estimate the first month’s sales of a new product, you can give the Monte Carlo simulation program your historical sales data. The program will estimate different sales values based on factors such as general market conditions, product price, and advertising budget.

## Why is the Monte Carlo simulation important?

The Monte Carlo simulation is a probabilistic model that can include an element of uncertainty or randomness in its prediction. When you use a probabilistic model to simulate an outcome, you will get different results each time. For example, the distance between your home and office is fixed. However, a probabilistic simulation might predict different travel times by considering factors such as congestion, bad weather, and vehicle breakdowns.

In contrast, conventional forecasting methods are more deterministic. They provide a definite answer to the prediction and cannot factor in uncertainty. For instance, they might tell you the minimum and maximum travel time, but both answers are less accurate.

### **Benefits of the Monte Carlo simulation**

The Monte Carlo simulation provides multiple possible outcomes and the probability of each from a large pool of random data samples. It offers a clearer picture than a deterministic forecast. For instance, forecasting financial risks requires analyzing dozens or hundreds of risk factors. Financial analysts use the Monte Carlo simulation to produce the probability of every possible outcome.

## What are the Monte Carlo simulation use cases?

Companies use Monte Carlo methods to assess risks and make accurate long-term predictions. The following are some examples of use cases.

### **Business**

Business leaders use Monte Carlo methods to project realistic scenarios when making decisions. For example, a marketer needs to decide whether it's feasible to increase the advertising budget for an online yoga course. They could use the Monte Carlo mathematical model on uncertain factors or variables such as the following:

* Subscription fee
* Advertising cost
* Sign-up rate
* Retention

The simulation would then predict the impact of changes on these factors to indicate whether the decision is profitable.

### **Finance**

Financial analysts often make long-term forecasts on stock prices and then advise their clients of appropriate strategies. While doing so, they must consider market factors that could cause drastic changes to the investment value. As a result, they use the Monte Carlo simulation to predict probable outcomes to support their strategies.

### **Online gaming**

Strict regulations govern the online gaming and betting industry. Customers expect gaming software to be fair and mimic the characteristics of its physical counterpart. Therefore, game programmers use the Monte Carlo method to simulate results and ensure a fair-play experience.

### **Engineering**

Engineers must ensure the reliability and robustness of every product and system they create before making it available to the public. They use Monte Carlo methods to simulate a product’s probable failure rate based on existing variables. For example, mechanical engineers use the Monte Carlo simulation to estimate the durability of an engine when it operates in various conditions.

## What are the components of a Monte Carlo simulation?

A Monte Carlo analysis consists of input variables, output variables, and a mathematical model. The computer system feeds independent variables into a mathematical model, simulates them, and produces dependent variables.

### **Input variables**

Input variables are random values that affect the outcome of the Monte Carlo simulation. For example, manufacturing quality and temperature are input variables that influence a smartphone's durability. You can express input variables as a range of random value samples so Monte Carlo methods can simulate the results with random input values.

### **Output variable**

The output variable is the result of the Monte Carlo analysis. For example, an electronic device’s life expectancy is an output variable, with its value being a time such as 6 months or 2 years. The Monte Carlo simulation software shows the output variable in a histogram or graph that distributes the result in a continuous range on the horizontal axis.

### **Mathematical model**

A mathematical model is an equation that describes the relationship between output and input variables in mathematical form. For example, the mathematical model for profitability is Profit = Revenue − Expenses.

**How to use Monte Carlo methods**

Regardless of what tool you use, Monte Carlo techniques involves three basic steps:

1. Set up the predictive model, identifying both the dependent variable to be predicted and the independent variables (also known as the input, risk or predictor variables) that will drive the prediction.
2. Specify probability distributions of the independent variables. Use historical data and/or the analyst’s subjective judgment to define a range of likely values and assign probability weights for each.
3. Run simulations repeatedly, generating random values of the independent variables. Do this until enough results are gathered to make up a representative sample of the near infinite number of possible combinations.

**The Algorithm**

1. Initialize circle\_points, square\_points and interval to 0.

2. Generate random point x.

3. Generate random point y.

4. Calculate d = x\*x + y\*y.

5. If d <= 1, increment circle\_points.

6. Increment square\_points.

7. Increment interval.

8. If increment < NO\_OF\_ITERATIONS, repeat from 2.

9. Calculate pi = 4\*(circle\_points/square\_points).

10. Terminate.