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Monte Carlo Simulation and Its application to STEM

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ABSTRACT: Monte Carlo simulation is one of the noteworthy methods in the field of STEM. The Monte Carlo method is most famous for its use during the Second World War in the design of the atomic bomb. It has also been used in diverse applications, such as the analysis semiconductors devices, the development of models for the evolution of stars, and attempts to predict fluctuations of physical quantities in the statistical physics. The scheme also finds applications in quantum computation, integrated circuit (IC) and communications engineering.

KEYWORDS: Monte Carlo, STEM, Defence Strategies, Simulation.

I. INTRODUCTION

Monte Carlo sampling became far more well-known in the 1940s and early 1950s. It was used to solve problems in physics associated to atomic weapons. The name itself is from this era, taken from the renowned casino located in Monte Carlo. Many of the problems considered had a deterministic origin. Currently it is standard to use random sampling on problems stated deterministically but in the beginning it was a major innovation, and was even well thought-out to be part of the definition of a Monte Carlo method. There is now extensive research work on Monte Carlo method [1-6]. To study the phenomenon like planning of traffic flow on superhighways, the development of models for the evolution of stars, and attempts for planning of Defence Strategies for International armed forces are done by various research groups [7]. In this paper we attempt to explain the application of Monte Carlo simulation to science, technology, engineering and Mathematics (STEM) disciplines by explaining evaluation of π.

II. MONTE CARLO METHOD AND APPLICATION

A familiar use of the Monte Carlo method is to carry out numerical integration on a function that may be difficult to integrate analytically. This may look crazy at first, but the intuition is rather straight forward. The trick is to think about the problem geometrically and correlate this with probability. The $n^{-1/2}$ convergence properties of the Monte Carlo methods give them vast advantage over systematic procedures when applied to the very high-dimensional integrals come across in statistical mechanics.

Modern form of Monte Carlo method originated with Ulam and Segre in Los Alamos and Eniac computer. Before that "sampling" was used a method for integration of functions. Π is Mathematical constant used in various functions of science, technology, engineering and Mathematics (STEM) disciplines. Let us now discuss a problem of calculation of value of π from Monte Carlo Method i.e. Monte Carlo simulation as illustrated in figure 1.

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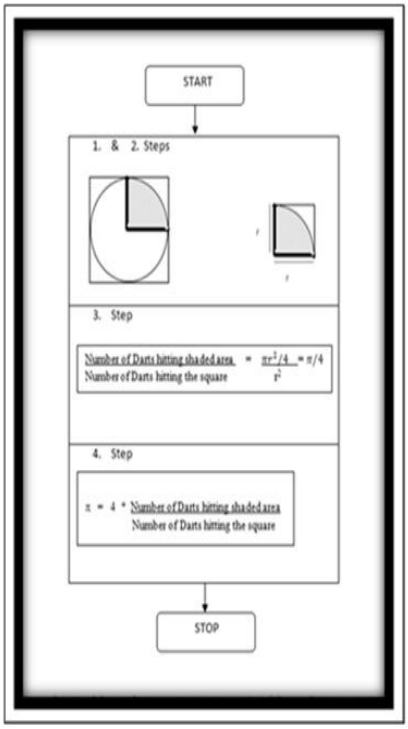


```
/ generate 452 numbers for π=
3.141592920354

x = 0

/ 14 pairs of random numbers for Pi

y=14

for i = 1, y

do

a=math.random()

b=math. random()

if (a^2+b^2<1 ) then x=x+1 end

end

print(4*x/y)
```

Figure 1: Evaluation of π by Monte Carlo Method

Let us consider a circle inscribed in an r cm square. Given that the circle and the square have a ratio of areas that is π/4, the value of π can be approximated using a Monte Carlo analysis.

1. Draw a square on the paper, and then inscribe a circle within it.
2. Uniformly scatter some objects of uniform size over the square.
3. Count the number of objects inside the circle and the total number of objects.
4. The ratio of the two counts is an estimate of the ratio of the two areas, which is π/4. Multiply the result by 4 to estimate π.

So the Monte Carlo method, also called Monte Carlo analysis, is a means of statistical evaluation of mathematical functions using random samples. This requires a good source of random numbers. The Monte Carlo method was used in internationally for the development of an Integrated Effectiveness Model for Aerial Targets like FGFA, UAV.

III. RESULTS AND DISCUSSION

In its mathematical formulation, the Monte Carlo method consists of evaluating the definite integral of a function by selecting a large number of independent-variable samples at random from within an region or interval , averaging the resulting dependent-variable values, and then dividing by the size of the region or the span of the interval over which the random samples were selected. This diverges from the traditional method of approximating a definite integral, in which independent-variable samples are chosen at equally-spaced points within a region or interval. There is constantly some error involved with these scheme, but the larger the number of random samples taken, the more accurate the result.

IV. CONCLUSION

Monte Carlo method is a means of statistical evaluation of mathematical functions using random samples. This requires a good source of random numbers. There is constantly some error involved with these scheme, but the larger the number of random samples taken, the more precise the result. Although the Monte Carlo Method is often useful for solving STEM problems which cannot be solved by analytical means but they are critical tool for analysis of

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reliability of systems. Monte Carlo Simulation has application in smart/functional material, advanced polymer material, composite & Nano-composite material & fluids, wide range of artificial and strategically space/defence material. Hence Monte Carlo is useful Simulation adding a new dimension to analytical analysis of STEM.

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REFERENCES

1. Kroese, D. P., Taimre, T., Botev, Z. I., & Rubinstein, R. Y. (2007). Simulation and the Monte Carlo Method. Wiley Series in Probability and Statistics. Doi: 10.1002/9780470285312.
2. Kroese, Dirk P., Tim Brereton, Thomas Taimre, and Zdravko I. Botev. "Why the Monte Carlo Method Is so Important Today." Wiley Interdisciplinary Reviews: Computational Statistics WIREs Comput Stat 6.6 (2014): 386-92. Web.
3. "Stanislaw Ulam." Wikipedia. Wikimedia Foundation, n.d. Web. 25 June 2016.
4. Estimating Cost Uncertainty using Monte Carlo Techniques, Paul F. Dienemann, Memorandum, RM-4854-PR, Jan 1966.
5. "Monte Carlo Simulation." Springer Reference (n.d.): n. pag. Web.
6. "Markov Chain Monte Carlo Methods for Eigenvalue Problems." Monte Carlo Methods for Applied Scientists (2007): 101-32. Web.
7. Alexander, Dennis. Application of Monte Carlo simulations to system reliability analysis (n.d.): n. pag. Web.

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