

What is...randomized mathematics?

Or: Subfields of mathematics 29

Deterministic \neq random !?

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True Random Number Service

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What's this fuss about *true* randomness?

Perhaps you have wondered how predictable machines like computers can generate randomness. In reality, most random numbers used in computer programs are *pseudo-random*, which means they are generated in a predictable fashion using a mathematical formula. This is fine for many purposes, but it may not be random in the way you expect if you're used to dice rolls and lottery drawings.

RANDOM.ORG offers *true* random numbers to anyone on the Internet. The randomness comes from atmospheric noise, which for many purposes is better than the pseudo-random number algorithms typically used in computer programs. People use RANDOM.ORG for holding drawings, lotteries and sweepstakes, to drive online games, for scientific applications and for art and music. The service has existed since 1998 and was built by [Dr Mads Haahr](#) of the [School of Computer Science and Statistics](#) at [Trinity College, Dublin](#) in Ireland. Today, RANDOM.ORG is operated by [Randomness and Integrity Services Ltd.](#)

True Random Number
Generator

Min:

Max:

Generate

Result:

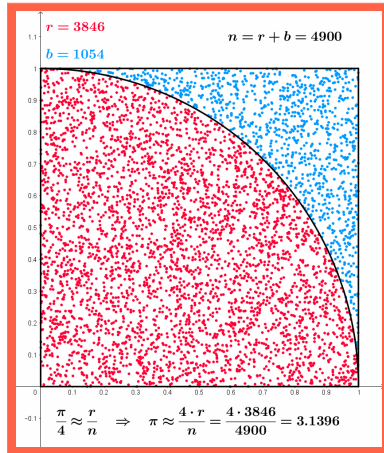
15

Min: 1, Max: 100
2024-12-13 22:08:03 UTC

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- ▶ One way Deterministic algorithms cannot create randomness
- ▶ Example Random numbers created by computers are pseudo random
- ▶ The other way Can randomness create deterministic results?

Red or blue?



- ▶ Imagine you want to know the value of π
- ▶ Monte Carlo approach Create random points in the square $[0, 1]^2$ and call them “red” if they have absolute value ≤ 1
- ▶ Doing the above often enough approximates π arbitrarily well

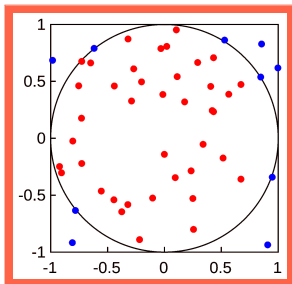
Monte Carlo methods



- ▶ Monte Carlo methods = a class of computational algorithms that rely on repeated random sampling to obtain deterministic results
- ▶ The name comes from the Monte Carlo Casino in Monaco (above) where Ulam (one of the pioneers of these methods) was inspired by gaming methods

Enter, the theorem

Monte Carlo integration does not suffer from the curse of dimensionality: quadrupling the sampled points halves the error in any dimension



- ▶ Monte Carlo integration = essentially as before
- ▶ Curse of dimensionality (for this video) = numeric integration gets exponentially worse when the dimension increases
- ▶ Non-numerical example The meat axe algorithm
- ▶ Randomized mathematics answers similar questions!

Algorithms of the century



- Metropolis Algorithm for Monte Carlo
- Simplex Method for Linear Programming
- Krylov Subspace Iteration Methods
- The Decompositional Approach to Matrix Computations
- The Fortran Optimizing Compiler
- QR Algorithm for Computing Eigenvalues
- Quicksort Algorithm for Sorting
- Fast Fourier Transform
- Integer Relation Detection
- Fast Multipole Method

▶ Above From the IEEE Computer Society Journal

▶ No such list can be perfect but Monte Carlo made it on it should tell us something 😊

Thank you for your attention!

I hope that was of some help.