Random numbers hit and miss

Maths pinpoints cause for faulty computer simulations.
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Flip a coin 100 times and you'll get roughly as many heads as tails. But computers often stumble at generating random numbers - and now researchers have figured out why.

Random-number generators are used in computer simulations for all areas of science, from high-energy physics to evolutionary biology. Almost all produce a sequence of supposedly haphazard numbers by calculating each one based on a subset of those that came before.

Random number generators can favour heads over tails. © GettyImages

Many random-number generators are intended effectively to generate a series of 1's and 0's just like a series of coin tosses. On average, the two digits should each appear with 50% probability.

The series of 1's and 0's will always repeat sooner or later. But the repeating pattern is often assumed not to crop up during the number of iterations performed in a typical simulation - so the series is effectively random, or 'pseudo-random'.

Yet as computers become more powerful, they will be used to carry out bigger simulations - and then the non-randomness will begin to show up. "In times of high precision there is no place for bad random-number generators," says Stephan Martens of the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy.

Martens and colleague Heiko Bauke of Otto von Guericke

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University in Magdeburg, Germany, have pinpointed the mathematical cause of this non-randomness. In a supposedly random sequence of 1's and 0's, a typical algorithm tends to cluster zeros together, they show, introducing a bias.

The answer, the researchers say, is to avoid the zeros. One could simulate coin flipping, for instance, with a random number generator that produced a sequence of 0's, 1's and 2's, and then ignored the 0's. But such an algorithm is more time-consuming, which is why only 1's and 0's are normally used.

The problem is more than academic. Studies have shown that computer simulations, such as one called the Monte Carlo procedure, are rendered faulty if their random-number generators are off-target. "The whole method is based on shaky grounds," say Martens and Bauke.

The Monte Carlo simulation can be compared to a hillwalker descending in the dark by taking a step in a random direction and seeing whether the gradient leads up or down. If it goes down, the walker takes another step; if up, the step is retraced and another one is attempted.

The moral for such simulations, Bauke and Mertens conclude, is not to trust a random-number generator unless the way it works is understood. Sometimes a quick, simple approach may be sufficiently random, they say, but sometimes it won't.

References


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