

The Computational Scientist: But does Nature calculate anything at all ?

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Is our Universe a mathematical construction ? Are natural processes controlled by some algorithms ? Does Nature calculate ?

Such questions are arising at some point in the mind of any scientist busy with doing calculations according to mathematical models, which were created to cope with some natural phenomena. Mathematics seems to be "unreasonably effective in natural sciences" [1], even so effective that one could be tempted to assume that reality *is* actually a mathematical structure, something to be uncovered bit-by-bit in the process of scientific exploration [2].

Calculations are prevalent nowadays in all disciplines, with increasingly complex algorithms running on more and more powerful computers, and modern computers are very distant relatives to the Turing Universal Computing Machine model [3]. A problem is declared as being computable if there is an algorithm for solving it effectively. Unfortunately enough, for Turing-like computers most real life problems are way too hard to deal with. There are known limits to what we could compute efficiently, according to the particular model of computations [4]. The real processes that happen in nature are usually evolving in parallel, are highly nondeterministic, but quite often they are also at the same time coordinated and stable.

Are these uncomputability, undecidability or unpredictability issues, lurking in our formal models of reality, influencing somehow our understanding of the physical world ? Not really, because in physical and natural sciences there is always an experimental factor accompanying any calculations or simulations. All theoretically made predictions have to be confirmed experimentally to become credible. The discrepancies noticed between the theoretical predictions and the experiment could also help in the model refinements or indicate the necessity of introduction of more profound changes, enhancing our knowledge.

Recently, a come-back of analog computing has been observed, bringing the models closer to the way they are realized in nature [5]. Analog computations provide the possibility of solving problems numerically but without performing mathematical calculations, by measurements of relevant physical quantities. The results are then available immediately after the measurement act, in a relatively short time, so even real-time simulations are becoming possible in many cases. Analog computations are performed simply by harnessing the natural behavior of model physical systems, by performing measurements, not calculations.

In summary, it is argued that the undecidability, uncomputability and unpredictability issues are relevant to the formal models of reality only, rather than to the physical world itself. Scientists are the ones who model and calculate, but Nature does not calculate anything at all.

References

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