Journal of
Applied & Computational Mathematics

Sowa, J Applied Computat Mathemat 2012, 1:6
DOI: 10.4172/2168-9679.1000e120

Editorial Open Access

Applied and Computational Mathematics May Largely Be In the Pre-Synthesis Stage-Let Us Enjoy the Process of Co-Creating Its Future

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Doing mathematics from an applied and computational perspective emphasizes construction over speculation. For a mathematician who assumes such a stance, even if temporarily, the process of scientific enquiry often looks like this:

• Construct a *model* for some fragment of extrinsic "reality" that is of interest.

• Develop *algorithms* that use the model to generate new data; interpret the data to make predictions about the properties of the extrinsic reality.

• Develop the underlying mathematics to improve the process, e.g. make the model more accurate or the algorithms faster; potentially discover interesting new mathematical structures.

When practicing mathematics from this perspective, i.e. with an eye towards applications, one takes a keen interest in the specific and individual properties of particular mathematical objects. It defies the naïve way of treating mathematics as a deductive system of general statements about the generic properties of large classes of objects. Of course, unique and beautiful examples have always been at the heart of successful mathematical theories, even if they needn't have been their highlight. Nevertheless, the computing machinery has made it possible for us to touch and hold examples of increasing complexity, to see mathematical objects from up close and to discern their texture-rich individuality.

The applicable mindset is universal, portable, and can be used to explore all sorts of scientific problems, including the problems of pure mathematics! And, indeed, why not? It is often natural and sometimes quite fruitful to scrutinize an abstract object from a point of view that is outside the framework of pure mathematics. Examples of such work include that of Berry and Keating [1], wherein the zeros of the Riemann's zeta function, see e.g. [2], are probed with the semi-classical apparatus of quantum physics. Other interpretations of the zeta function suggest that it may be possible, at least in principle, to engineer a quantum measurement that will evaluate the function for a range of real arguments, [3].

The comingling streams of the classical mathematics on one hand and the applicable and computational methodologies on the other seem to create a very fertile delta. The computationally efficient digital realization of the classical method of expanding a function into a Fourier series, which is the Fast Fourier Transform introduced in the 1960s by J.W. Cooley and J.W. Tukey, is arguably the most fundamental tool of the computational harmonic analysis. I have recently observed that the classical Dirichlet series-i.e. objects that were put on the mathematical map centuries ago by Euler, Dirichlet, and Riemann, mainly to ponder questions about prime numbers-also lead to a class of fast transforms, [4,5]. I have found those latter transforms to be useful in the analysis of signals generated in memristive circuits, as well as in the analysis of matrices.

It is the classical 18-19 century mathematics that seems especially akin in spirit to the modern computational mathematics. That was mathematics before the advent of Topology; it was largely algorithmic and to an extent calculable, advancing through closed-form formulas. The XX century infused mathematics with the abstract topology. In particular, there was that brilliant vision of S. Banach to deploy the methods of topology in the study of linear operations. Modern applied mathematics still immensely benefits from those developments. Thanks to the FFT, and thanks to the theoretical concepts of S. L. Sobolev, we can probe the regularity of a discrete representation of a function by observing the behavior of its Fourier coefficients. There are known ties between the continuity of an operator and the numerical stability of its discrete representation. However, even though numerical analysis is obviously sensitive to the topological properties of operations, it may eventually lead to a nonequivalent, not entirely topological concept of a good operation. I. M. Gelfand was quoted as saying "We still do not have a good definition of *space*, nor do we yet have a good definition of *operator*", see the Editor's Foreword in [6]. Perhaps the development of computational methods will lead us toward a revised concept of operators that will be more firmly rooted in the algorithmic and constructive way of thinking. For the time being, we can revel in explorations of the individual objects. While the information we gather is not always strictly rigorous, and not the most general, it is often very compelling and inspiring, not to mention practically useful. In time this will bring new syntheses, hopefully some of them as elegant as the great Euclid's *Elements*, [7].

The creation of an open source journal for publication of mathematical results and numerical experimental results addressing the modern day challenges will help accelerate progress in applied and computational mathematics. This particular journal from OMICS creates an excellent opportunity for mathematicians and scientists to share discoveries that employ innovative methodologies. It is an opportunity to co-create the future of a multidisciplinary field that is largely in a pre-synthesis stage.

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Received September 25, 2012; **Accepted** September 28, 2012; **Published** October 01, 2012

Citation: Sowa A (2012) Applied and Computational Mathematics May Largely Be In the Pre-Synthesis Stage-Let Us Enjoy the Process of Co-Creating Its Future. J Applied Computat Mathemat 1:e120. doi:10.4172/2168-9679.1000e120

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