Mathematical and Computational Applications

MDPI

Editorial

Preface to Numerical and Symbolic Computation: Developments and Applications—2021

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This is the Special Issue "Numerical and Symbolic Computation: Developments and Applications—2021", also available at the Special Issue website https://www.mdpi.com/journal/mca/special_issues/SYMCOMP2021, of the *Mathematical and Computational Applications* international scientific journal (*MCA*) and comprehends a collection of extended works presented and/or developed upon the 5th International Conference in Numerical and Symbolic Computation—SYMCOMP 2021.

This conference was organized and held during the COVID-19 pandemic, in a period where confinement and several restrictions to dislocations were more severe. This pandemic brought diversified and profound impacts on professional activities, in general, and in higher education and research, more particularly, leading to the need to adopt different working research and communication paradigms, which was also extended to scientific and technical events. Only the future will tell, but some significant changes will probably remain.

Therefore, it was in this context that SYMCOMP 2021 was held fully online on 25–26 March 2021, featuring the University of Évora as its virtual host. Nevertheless, the objective of bringing together researchers from very different scientific areas, aiming at sharing different experiences, in a cross-fertilization perspective was preserved as a major goal.

The articles selected for this book, organized in reverse chronological order, are the best illustrations of the transversal and multidisciplinary character of the conference. The first article in this Special Issue has the title "Increased Material Density within a New Biomechanism" and was authored by Andreucci et al. [1]. In their work, a Bioactive Kinetic Screw (BKS) for screws and bone implants developed by the first author is presented using a bone dental implant screw, in which the bone particles, blood, cells, and protein molecules removed during bone drilling are used as a homogeneous autogenous transplant in the same implant site, to obtain primary and secondary bone stability, simplifying the surgical procedure and improving the healing process. In vitro tests validated the mathematical results obtained, describing that in two different materials, the same compact factor was determined with the new biomechanical device.

The second article in the book, "Comparison of Symbolic Computations for Solving Linear Delay Differential Equations Using the Laplace Transform Method", is authored by Sherman et al. [2] and the goal is the performance investigation of the mathematical software program Maple and the programming language MATLAB when using these respective platforms to compute the method of steps (MoSs) and the Laplace transform (LT) solutions for neutral and retarded linear delay differential equations (DDEs). Conclusions were taken regarding the influence of the complexity of the history function, the number of terms used in the LT solution, the number of intervals used in the MoS solution, and the parameters of the DDE.

Citation: Loja, M.A.R. Preface to Numerical and Symbolic Computation: Developments and Applications—2021. *Math. Comput. Appl.* **2022**, *27*, 107. https://doi.org/10.3390/mca27060107

Received: 9 December 2022
Accepted: 9 December 2022
Published: 12 December 2022

Conceição et al. presented new operator theory algorithms related to Cauchy-type singular integrals, defined in the unit circle in the third article, entitled "Symbolic Computation Applied to Cauchy Type Singular Integrals" [3]. The methods developed and implemented in *Mathematica* rely on innovative techniques of operator theory and have a great potential for extension to more complex and general problems.

The fourth article, "Dynamic and Interactive Tools to Support Teaching and Learning", is authored by Conceição [4] and aims at showing how some new dynamic and interactive tools, created with Wolfram Mathematica and available in the Computable Document Format, can be used as active learning tools to promote better student activity and engagement in the learning process, either in a remote or classroom learning environment.

"Modelling Forest Fires Using Complex Networks" constitutes the fifth article in this Special Issue and the authors are Perestrelo et al. [5]. In this work, a mathematical model is proposed to predict fire spreading in each land portion divided into patches, considering the area and the rate of spread of each patch as inputs. The rate of spread can be estimated from previous knowledge of fuel availability, weather, and terrain conditions. The authors estimate the time duration of the spreading process in a land patch to construct and parametrize a landscape network, using cellular automata simulations. We use the multilayer network model to propose a network of networks at the landscape scale, where the nodes are the local patches, each with spreading dynamics.

The article "Using the Evolution Operator to Classify Evolution Algebras" is the next work in this Special Issue and it is authored by Fernández-Ternero et al. [6]. In this study, the authors consider evolution algebras, currently widely studied due to their importance for their many applications to different scientific disciplines, and propose a criterion for classifying those satisfying certain conditions and an algorithm to obtain degenerate evolution algebras starting from those of smaller dimensions, which is also analyzed and constructed.

Following this work, one encounters the article "Analytical Equations Applied to the Study of Steel Profiles under Fire According to Different Nominal Temperature-Time Curves" by Oliveira et al. [7]. The main goal of this work is the temperature calculation in different cross-sections of structural hot-rolled steel profiles (IPE, HEM, L, and UAP) using the lumped capacitance method and the simplified equation from Eurocode 3. Those profiles were analyzed, considering them as submitted to the fire action according to the nominal temperature–time curves (standard temperature–time curve ISO 834, external fire curve, and hydrocarbon fire curve). The obtained results allow for verifying the agreement between the used methodologies and the influence in the temperature field due to the use of different nominal fire curves.

The eighth article is titled "Effectiveness of Floating-Point Precision on the Numerical Approximation by Spectral Methods" [8] and the authors are Matos and Vasconcelos. In this work, experimental results on the computation of approximate solutions of differential problems via spectral methods are detailed with recourse to quadruple-precision arithmetic. Variable precision arithmetic was used in Tau Toolbox, a mathematical software package to solve integro-differential problems via the spectral Tau method. The results obtained allow one to draw conclusions about the efficiency of the use of quadruple precision on the computation of approximate solutions of differential problems via the spectral Tau method, in terms of accuracy of the solution. Nevertheless, the authors mention a time penalty that must be paid.

Mitic addresses the problem of selecting a suitable method to solve a black-box optimization problem that uses noisy data in the article "Operational Risk Reverse Stress Testing: Optimal Solutions" [9]. A targeted stop condition for the function to be optimized, implemented as a stochastic algorithm, makes established Bayesian methods inadmissible. Hence, the author proposes a simple modification that considerably improves the efficiency of the process. The optimization effectiveness was measured in terms of the mean and standard deviation of the number of function evaluations required to achieve the target. Comparisons with alternative methods showed that the modified Bayesian method and binary search were both performant but in different ways. In a sequence of identical runs, the former had a lower expected value for the number of runs needed to find an optimal value. The latter had a lower standard deviation for the same sequence of runs. The author also suggests a way to find an approximate solution to the same problem using symbolic computation.

The tenth article, “A Sequential Approach for Aerodynamic Shape Optimization with Topology Optimization of Airfoils”, by Martinez et al. [10], studies the coupling of two efficient optimization techniques, Aerodynamic Shape Optimization (ASO) and Topology Optimization (TO), in 2D airfoils. To achieve this objective, two open-source codes, SU2 and Calculix, are used for ASO and TO, respectively, using Sequential Least-Squares Programming (SLSQP) and Bi-directional Evolutionary Structural Optimization (BESO) algorithms; the latter is well-known for allowing for the addition of material in the TO, which constitutes, as far as the authors’ knowledge, a novelty for this kind of application. The codes are linked using a script capable of reading the geometry and pressure distribution obtained from the ASO and defining the boundary conditions to be applied in the TO. The Free-Form Deformation technique is chosen for the definition of the design variables to be used in the ASO, while the densities of the inner elements are defined as design variables of the TO. As a test case, a widely used benchmark transonic airfoil, the RAE2822, is chosen here with an internal geometric constraint to simulate the wing-box of a transonic wing. Improvements in both aerodynamic and structural performances are found, as expected: the ASO reduced the total pressure on the airfoil surface to minimize drag, which resulted in lower stress values experienced by the structure.

The eleventh article in this Special Issue has the title “A Framework for Analysis and Prediction of Operational Risk Stress” [11] and was written by Mitic. In this work, the author presents a model for financial stress testing and stability analysis. Given operational risk loss data within a time window, short-term projections are made using Loess fits to sequences of lognormal parameters. The projections can be scaled by a sequence of risk factors, derived from economic data in response to international regulatory requirements. Historic and projected loss data are combined using a lengthy nonlinear algorithm to calculate a capital reserve for the upcoming year. The model is embedded in a general framework, in which arrays of risk factors can be swapped in and out to assess their effect on the projected losses. Risk factor scaling is varied to assess the resilience and stability of financial institutions to economic shock. Symbolic analysis of projected losses shows that they are well-conditioned with respect to risk factors. Specific reference is made to the effect of the 2020 COVID-19 pandemic. For a 1-year projection, the framework indicates a requirement for an increase in regulatory capital of approximately 3% for mild stress, 8% for moderate stress, and 32% for extreme stress. The proposed framework is significant because it is the first formal methodology to link financial risk with economic factors in an objective way without recourse to correlations.

At this point, I would like to thank the valuable contribution of all the authors that kindly contributed their works to this Special Issue, well illustrating the diversity of science and engineering application areas of symbolic and numerical computation.

Last, but not least, I would like to express my deep gratitude for the opportunity to publish with MDPI. This acknowledgment is deservedly extensive to the *MCA* Editorial Office and, more particularly, to editor, who has permanently supported me in this process. It was a great pleasure to work in such conditions and I look forward to collaborating with *MCA* in the future.

Conflicts of Interest: The author declares no conflict of interest.

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