

Editorial Board Members

Joaquim Filipe 

Polytechnic Institute of Setúbal, Setúbal, Portugal

Ashish Ghosh

Indian Statistical Institute, Kolkata, India

Raquel Oliveira Prates 

Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil

Lizhu Zhou

Tsinghua University, Beijing, China

More information about this series at <http://www.springer.com/series/7899>

Robert M. Corless · Jürgen Gerhard ·
Ilias S. Kotsireas (Eds.)

Maple in Mathematics Education and Research

4th Maple Conference, MC 2020
Waterloo, Ontario, Canada, November 2–6, 2020
Revised Selected Papers

Editors

Robert M. Corless
Western University
London, ON, Canada

Jürgen Gerhard
Maplesoft
Waterloo, ON, Canada

Ilias S. Kotsireas
Wilfrid Laurier University
Waterloo, ON, Canada

ISSN 1865-0929 ISSN 1865-0937 (electronic)
Communications in Computer and Information Science
ISBN 978-3-030-81697-1 ISBN 978-3-030-81698-8 (eBook)
<https://doi.org/10.1007/978-3-030-81698-8>

© Springer Nature Switzerland AG 2021

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

As a global pandemic has been gripping the world for over a year now, many aspects of our lives have changed: The way we work; the way we play; the way we meet friends and family. And so the way the Maple community gathered on November 2–6, 2020 was very different as well. We met virtually. And so there was no conference dinner, no coffee breaks, no handshakes or hugs with friends that we had not seen in a while.

But we coped. Our social event was a virtual tour of the Tom Thomson Art Gallery. We met at informal breakfast and lunch “tables” to chat with old and new members of the community. We were fortunate to have some brilliant keynote speakers like Dr. Gabor Domokos who took us behind the scenes of the discovery of the Gömböc and Dr. Juana Sendra Pons who introduced us to the magic of Bohemian matrices.

And indeed, despite the difficult circumstances that the world finds itself in, some things were better. With no constraints from travel budget and week-long scheduling conflicts, an unprecedented proportion of the Maple community was able to participate, making the event more engaging and inspiring than ever with a large number of excellent contributions drawn from research to education to interesting and novel applications of Maple. In addition, the new format of combining pre-recorded talks with live Q&A sessions allowed participants to watch presentations at their own pace and to have the time to absorb the material before bringing thoughtful questions and comments to the authors during the live session.

What is driving us at Maplesoft is the belief that Math Matters, stemming from the realization that mathematics drives the world around us. Our mission is to build engaging tools that help gain insight into mathematical concepts and that not just provide solutions but also provide the inspiration to dig deeper and discover not only the usefulness but also the beauty of mathematics. With this in mind, it was great to see another first for a Maple Conference: We hosted a very lively and interesting panel discussion with a group of social media influencers that share our vision of making math accessible and enjoyable. Sneak peeks at our Maple Calculator Mobile App as well as our new online solution for learning and teaching math, Maple Learn, rounded out this part of the program.

The virtual format also allowed a record number of Maplesoft staff from around the world to attend the conference and share their expertise with all attendees. There is always something new to discover in the world of Maple and I would go out on a limb and say that every participant learned something new in the course of this week.

Overall, we had an exceptional event and it was great to see the Maple community come together. I was able to greet many familiar faces and introduce myself to an even larger number of people that attended for the first time.

Finally, I would like to express a huge thank you to the Program Chairs Rob Corless and Jürgen Gerhard and the rest of the Program Committee as well as to the countless people at Maplesoft who made the event a resounding success.

Laurent Bernardin

Preface

The Maple Conference 2020 happened under stressful circumstances, mostly to do with the global COVID-19 pandemic, but important political events (all over the world) also happened during the conference. Political events are not usually explicitly acknowledged in the proceedings of any scientific conference, on the basis that science is above politics, or else on the basis that mathematics and science are apolitical. The truth of a mathematical theorem or the functioning of a piece of software is indeed normally independent of what any given group of humans has decided to do.

As always, the truth is more complex. The science and engineering that gets accomplished by a community depends strongly on how that community is organized. It depends in a long-term way—on a cycle of decades at least—on how the members of the society are educated, and on the intellectual infrastructure and social capital available to thinkers, educators, and doers—who may or may not be the same people.

The Maple Conference 2020 happened at a time of severe crisis. Millions of people were being struck down, and many dying, of an infectious disease. The personal impact of this crisis was of course huge, and continues to be huge: we swim in grief for family, friends, loved ones, even for people we do not know. To protect vulnerable people and medical institutions, many governments imposed Non-Pharmaceutical Interventions (NPIs) which, among other impacts, forbade or reduced travel and in-person interactions.

In spite of the impact of this crisis and of the NPIs taken to mitigate the impact, not all of these impositions seem to have been wholly bad for science in general, or for the Maple conference in particular. Perhaps as a side effect of going virtual, the Maple Conference 2020 had over 700 registrants, the most of any Maple conference to date. On any given day of the conference, which took place during November 2–6, 2020, we might have had 400 people actively participating. By all normal measures, the conference was a resounding success. For this we have to thank the efforts of many working behind the scenes: specifically Kathleen McNichol, Eithne Murray, Jen Iorgulescu, and Rochelle Angyal. Their very hard work and adaptability made the virtual conference a success, both by long preparation ahead of time and by putting out the inevitable “last-minute” fires with the software platform we were using. As a result, the conference ran very smoothly.

One concludes in general that the impact of the crisis on science is as yet unclear, because people have worked so hard to adapt. Because of these efforts, we now know that remote collaboration and conferencing are not only possible but have some advantages, as this conference proved. New tools for remote learning—such as Maple Learn, perhaps—may help even more in the future.

This proceedings provides a tangible archive of that success. In this volume you will find a selection of papers based on work presented at the conference: on mathematical research, applications of Maple, and on mathematics education. There is another archive: all the talks were recorded and they are, at the time of writing, still available on

the original website; after November 2021 they will move to a YouTube channel. We encourage you to watch the videos of the talks, not just read the papers in these proceedings.

In particular, the invited talks by Professor Gabor Domokos, Professor Juana Sendra Pons, and Dr. Laurent Bernardin all remain available, and we highly recommend watching them. We thank all of them for their discussions of fascinating work. Professor Sendra Pons also contributed a paper to the proceedings, for which we also thank her.

The “Meet the Developers” panel, consisting of Laurent Bernardin, Paulina Chin, Paul DeMarco, Jürgen Gerhard, Erik Postma, Karishma Punwani, and Andrew Smith, was lively and engaging, and we thank them all for their time and expertise.

The rise of YouTube “influencers”, among them Online Kyne, Bobby Seagull, and Tom Crawford (The Naked Mathematician), was possibly predictable but the reality is so amazing—they have not contributed to the proceedings but we urge you to watch the panel discussion in the video on the conference website—that we would actually be shocked had anyone predicted it, or predicted just how popular math and science videos would turn out to be. We thank these influencers for their very entertaining and thought-provoking panel discussion.

The three workshops, presented by Paulina Chin, Erik Postma, and Stephen Forrest, were well-attended and extremely valuable. These workshops are not part of the formal proceedings, and are not attached to the video record of the conference, but we thank the presenters for their contributions to the conference at the time.

Several Maplesoft personnel gave presentations at the conference and these are part of the video record: Dr. Robert Lopez, “Analytic Approximation for the Dirichlet Problem;” Thomas Richard, “Application of the Identify Command to Special Functions;” Valery McKay-Crites, “Generate Captivating Visualizations with Maple;” Karishma Punwani, “Introducing Maple Calculator and Maple Learn;” Dr. Stephen Forrest, “Machine Learning in Maple;” Samir Khan, “Maple Whiteboard - tactile, responsive calculations for science, engineering and technical analysis;” and Samir Khan and Karishma Punwani, “Our Favorite Things: Maple 2020 Gems You May Have Missed.” These presentations were extremely useful and enlightening, and are still available; we hope that at least some of them will be reprised at the Maple Conference 2021!

We thank our Program Committee and all the reviewers for all their hard work, especially during this time of the COVID-19 pandemic. Refereeing is one of the most critical, but thankless, jobs of an academic. Everyone is just expected to do it. Our referees put in a very significant amount of work, providing feedback to our authors and presenters, going well above the norm which made a significant difference to the quality of the papers.

Of course, we also thank all our presenters and authors. They, too, worked hard; in preparing their videos (sometimes for the first time ever for a conference), in taking questions, in writing their papers, and in taking the constructive criticism of the referees and using it to improve their papers.

Science takes time, and social stability, and education, and other things. That the Maple 2020 Conference went so well, with participants from 70 countries, from Australia to Zambia, is a mark of hard work and persistence, and of the resilience of the

supporting institutions and personal resilience of the participants. We believe that these proceedings show evidence of this high-water mark, and we hope that all the participants feel justified pride in their achievements in the face of the truly difficult circumstances that they faced.

May 2021

Robert M. Corless
Jürgen Gerhard
Ilias S. Kotsireas

Organization

Program Chairs

Rob Corless
Jürgen Gerhard

Western University, Canada
Maplesoft, Canada

Program Committee

Andrew Arnold
David Bailey
Michel Beaudin
Murray Bremner
Curtis Bright
Neil Calkin
Eunice Chan
Bruce Char
Shaoshi Chen
Paulina Chin
Jean-Guillaume Dumas
Matthew England
Laureano Gonzalez-Vega
Jonathan Hauenstein
Silvana Ilie
David Jeffrey
Jeremy Johnson
Manuel Kauers
Ilias Kotsireas
George Labahn
Gilbert Labelle
Wen-shin Lee
David Linder
Austin Lobo
Robert Martin
John May
Douglas B. Meade
Michael Monagan
Guillaume Moroz
Judy-anne Osborn
Veronika Pillwein
Erik Postma
Alban Quadrat
Georg Regensburger

Google, USA
University of California, Davis, USA
ETS Montreal, Canada
University of Saskatoon, Canada
Carleton University, Canada
Clemson University, USA
Western University, Canada
Drexel University, USA
Chinese Academy of Sciences, China
Maplesoft, Canada
Université Grenoble Alpes, France
University of Coventry, UK
CUNEF, Spain
University of Notre Dame, USA
Ryerson University, Canada
Western University, Canada
Drexel University, USA
Johannes Kepler University Linz, Austria
Wilfrid Laurier University, Canada
University of Waterloo, Canada
Université du Québec à Montréal, Canada
University of Antwerp, Belgium
Maplesoft, Canada
Washington College, USA
University of Manitoba, Canada
Maplesoft, USA
University of South Carolina, USA
Simon Fraser University, Canada
Inria, France
University of Newcastle, Australia
Johannes Kepler University Linz, Austria
Maplesoft, Canada
Inria, France
Johannes Kepler University Linz, Austria

Thomas Richard	Maplesoft, Canada
Rafael Sendra	University of Alcala, Spain
Brandilyn Stigler	Southern Methodist University, USA
M. Pilar Velez	Nebrija University, Spain
Thomas Wolf	Brock University, Canada
Lihong Zhi	Chinese Academy of Sciences, China

Local Organizing Committee

Rob Corless	Western University, Canada
Jürgen Gerhard	Maplesoft, Canada
Kathleen McNichol	Maplesoft, Canada
Eithne Murray	Maplesoft, Canada
Jennifer Iorgulescu	Maplesoft, Canada
Rochelle Angyal	Maplesoft, Canada

Proceedings Editors

Rob Corless	Western University, Canada
Jürgen Gerhard	Maplesoft, Canada
Ilias Kotsireas	Wilfrid Laurier University, Canada

Contents

Keynote Presentation

Bohemian Matrices: Past, Present and Future	3
<i>Juana Sendra</i>	

Accepted Papers Alphabetically by Author

The TruncatedSeries Package for Solving Linear Ordinary Differential Equations Having Truncated Series Coefficients.	19
<i>S. A. Abramov, D. E. Khmelnov, and A. A. Ryabenko</i>	
Computation of the Observed Spectral Sequence Spectrum for Nucleotide Sequence Alignments	34
<i>Ernesto Álvarez González and Ricardo Balam-Narváez</i>	
Multivariate Power Series in Maple.	48
<i>Mohammadali Asadi, Alexander Brandt, Mahsa Kazemi, Marc Moreno Maza, and Erik J. Postma</i>	
Bernoulli's Problem $x^y = y^x$ and Maple	67
<i>T. J. Ayoub, K. Basu, and D. J. Jeffrey</i>	
Student Satisfaction Determinants in Hybrid Learning Environments Based on MAPLE.	77
<i>Lisa Binkowski, Marcel Dux, and Tilo Wendler</i>	
Puiseux Series and Algebraic Solutions of First Order Autonomous AODEs – A MAPLE Package	89
<i>François Boulrier, José Cano, Sebastian Falkensteiner, and J. Rafael Sendra</i>	
Algebraic Aspects of a Rank Factorization Problem Arising in Vibration Analysis.	104
<i>Yacine Bouzidi, Roudy Dagher, Elisa Hubert, and Alban Quadrat</i>	
Computation of the \mathcal{L}_∞ -norm of Finite-Dimensional Linear Systems.	119
<i>Yacine Bouzidi, Alban Quadrat, Fabrice Rouillier, and Grace Younes</i>	
A Maple Package to Deal with the Birationality of Curves and Surfaces Parametrizations.	137
<i>Jorge Caravantes, Sonia Pérez-Díaz, and J. Rafael Sendra</i>	

A Maple Implementation of the Finite Element Method for Solving Boundary-Value Problems for Systems of Second-Order Ordinary Differential Equations	152
<i>Galmandakh Chuluunbaatar, Alexander Gusev, Vladimir Derbov, Sergue Vinitsky, Ochbadrakh Chuluunbaatar, Luong Le Hai, and Vladimir Gerdt</i>	
Blends in MAPLE	167
<i>Robert M. Corless and Erik J. Postma</i>	
Certified Evaluations of Hölder Continuous Functions at Roots of Polynomials	185
<i>Parker B. Edwards, Jonathan D. Hauenstein, and Clifford D. Smyth</i>	
Maple for Distance Education in Secondary Schools During the COVID-19 Emergency	204
<i>Cecilia Fissore, Francesco Floris, Marina Marchisio, and Matteo Sacchet</i>	
Development of Problem Solving Skills with Maple in Higher Education.	219
<i>Cecilia Fissore, Marina Marchisio, Fabio Roman, and Matteo Sacchet</i>	
Modelling and Sensitivity Analysis of Nonlinear Firefighting Systems Using Maple.	234
<i>Flóra Hajdu, Győző Molnárka, and Rajmund Kuti</i>	
Merging Maple and GeoGebra Automated Reasoning Tools	252
<i>Zoltán Kovács, Tomás Recio, and M. Pilar Vélez</i>	
AGADE—A Maple Package for Computing Rational General Solutions of Parametrizable First-Order Algebraic ODEs	268
<i>Johann J. Mitteramskogler</i>	
Estimation of Travel Time for Additional Metrobus Route	288
<i>V. Nieves-Cruz and P. E. Balderas-Cañas</i>	
Understanding Math Concepts in Music and Vice-Versa	304
<i>Gabriel Picioroaga</i>	
Numerical Solution for Radial Distortion Rectification in Optical Systems	319
<i>Obed I. Rios-Orellana, Rigoberto Juarez-Salazar, and Victor H. Diaz-Ramirez</i>	
A Simplified Introduction to Virus Propagation Using Maple’s Turtle Graphics Package Suitable for Children.	334
<i>Eugenio Roanes-Lozano and Eugenio Roanes-Macías</i>	

A Maple Toolchain for Rigid Body Dynamics of Serial, Hybrid and Parallel Robots	350
<i>Moritz Schappler, Tim-David Job, and Tobias Ortmaier</i>	
Rational Trigonometry Using Maple	365
<i>Thomas Schramm</i>	
Power Series Representations of Hypergeometric Type Functions	376
<i>Bertrand Teguia Tabuguia and Wolfram Koepf</i>	
Rational Cone of Norm-Invariant Vectors Under a Matrix Action	394
<i>Juan Tolosa</i>	
Branching Out into Structural Identifiability Analysis with Maple: Interactive Exploration of Uncontrolled Linear Time-Invariant Structures	410
<i>Jason M. Whyte</i>	
A Maple Exploration of Problem 6 of the IMO 88	429
<i>Zhenbing Zeng, Xiang Sun, Yong Huang, Yaochen Xu, Xiaoru Chen, and Lu Yang</i>	
An Isometric Embedding of the Impossible Triangle into the Euclidean Space of Lowest Dimension	438
<i>Zhenbing Zeng, Yaochen Xu, Zhengfeng Yang, and Zhi-bin Li</i>	
Errata for Maple Conference 2019 Proceedings	
“A Poly-algorithmic Quantifier Elimination Package in Maple” Erratum	461
<i>Zak Tonks</i>	
Author Index	463