Springer Proceedings in Mathematics & Statistics

D. Marc Kilgour · Herb Kunze ·
Roman Makarov · Roderick Melnik ·
Xu Wang *Editors*

# Recent Developments in Mathematical, Statistical and Computational Sciences

## The V AMMCS International Conference, Waterloo, Canada, August 18–23, 2019

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**Springer Proceedings in Mathematics & Statistics**

Volume 343

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*Editors*
D. Marc Kilgour
Department of Mathematics
Wilfrid Laurier University
Waterloo, ON, Canada

Herb Kunze
Department of Mathematics and Statistics
University of Guelph
Guelph, ON, Canada

Roman Makarov
Department of Mathematics
Wilfrid Laurier University
Waterloo, ON, Canada

Roderick Melnik
Department of Mathematics
Wilfrid Laurier University
Waterloo, ON, Canada

Xu Wang
Department of Mathematics
Wilfrid Laurier University
Waterloo, ON, Canada

ISSN 2194-1009 ISSN 2194-1017 (electronic)
Springer Proceedings in Mathematics & Statistics
ISBN 978-3-030-63590-9 ISBN 978-3-030-63591-6 (eBook)
https://doi.org/10.1007/978-3-030-63591-6

Mathematics Subject Classification: 15-XX, 34-XX, 35-XX, 37-XX, 60-XX, 45-XX, 49-XX, 62-XX, 65-XX, 68-XX, 74-XX, 76-XX, 91-XX, 92-XX



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

# Preface

This volume contains a selection of papers originally prepared for presentations at AMMCS-2019, an international conference held in Waterloo, Ontario, Canada from 18 to 23 August 2019. It was the fifth in the series of AMMCS meetings, held biennially at Wilfrid Laurier University beginning in 2011. The 2019 event continued the tradition of promoting interdisciplinary research and collaboration involving mathematical, statistical and computational sciences within the broader international community, highlighting recent advances in Applied Mathematics, Modeling and Computational Science (AMMCS).

The interdisciplinary focus of the AMMCS conferences has been crucial to their success. The primary aim of AMMCS-2019 was to promote research and collaboration involving new applications of mathematical, statistical and computational sciences to many fields, for the benefit of international communities of researchers, practitioners, and students.

For millennia, mathematical methods have been fundamental tools for the development of human knowledge. Now sophisticated mathematical and statistical tools are making essential contributions to progress in an amazing range of application areas—in the natural and social sciences, engineering, finance, and even the arts. Mathematics, statistics, and associated computational and data science techniques are playing a fundamental role in the modern world, throwing new light on problems, both ancient and contemporary, thereby contributing to human well-being.

Today's most challenging problems arise not only in the physical sciences and engineering, where mathematics is traditionally applied, but also in the life sciences, the social sciences, and finance. Stunning advances in these areas have resulted from the great subtlety and power of mathematical techniques and reasoning, augmented by data collection and analysis on a scale more massive than could be imagined only a few years ago, and by computational studies that not only support analysis but also explore new combinations and structures. These developments have forged new connections among disciplines that were once widely separated, as the horizons of mathematical and computational modeling expand at an increasing rate.

AMMCS-2019 was a major international forum for the exchange of ideas in an interdisciplinary setting, with a focus on applications of mathematical and

computational sciences, modeling and simulation to the natural and social sciences, engineering and technology, industry and finance. It proudly followed the traditions of previous AMMCS events, particularly in its emphasis on discussion, comparison, and synthesis across disciplines. We believe that only through interdisciplinary collaboration will it be possible to meet the complex challenges facing humanity today.

This book consists of a representative selection of current research presented at AMMCS-2019. It illustrates how mathematics, statistics, and modeling are contributing to a range of disciplines. The 68 selected contributions are organized into six parts, as follows:

I. Advances in Mathematical Modelling and Theory;
II. Advances in Statistical Modelling and Data Analysis;
III. Computational Methods for Differential Equations;
IV. Mathematical Modelling in Engineering, Physical and Chemical Sciences;
V. Mathematical and Statistical Modelling in Life Sciences;
VI. Mathematics and Computation in Finance, Economics, and Social Sciences.

The titles of the parts make the breadth of the topics clear. This wide-ranging selection shows clearly how mathematical, statistical, and computational sciences are now emerging as fundamental tools in a wide range of disciplines.

The editors of this volume extend their thanks to all of the contributors to AMMCS-2019, to all of the attendees, to the Organizing, Scientific, and Technical Committees, and to all of the volunteers, without whom the conference could not have taken place. We are grateful to our sponsors and to Wilfrid Laurier University. We give special thanks to the contributors who prepared papers for this volume, and to the referees whose guidance was essential to us as we evaluated proposed contributions. We also thank Leonie Kunz of Springer, who assisted us with the documents and editorial work, and Banu Dhayalan of Springer, who handled the technical aspects of production and publishing. We are proud of this volume, and pleased to acknowledge all those who helped bring it to fruition.

Group photo of participants in the AMMCS-2019 International Conference: Applied Mathematics, Modeling and Computational Science

Waterloo, ON, Canada
October 2020

D. Marc Kilgour
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