


Springer Optimization and Its Applications 191

Ashkan Nikeghbali  
Panos M. Pardalos  
Andrei M. Raigorodskii  
Michael Th. Rassias *Editors*

# High-Dimensional Optimization and Probability

With a View Towards Data Science

 Springer

# Springer Optimization and Its Applications

Volume 191

## Series Editors

Panos M. Pardalos , *University of Florida*

My T. Thai , *University of Florida*

## Honorary Editor

Ding-Zhu Du, *University of Texas at Dallas*

## Advisory Editors

Roman V. Belavkin, *Middlesex University*

John R. Birge, *University of Chicago*

Sergiy Butenko, *Texas A&M University*

Vipin Kumar, *University of Minnesota*

Anna Nagurney, *University of Massachusetts Amherst*

Jun Pei, *Hefei University of Technology*

Oleg Prokopyev, *University of Pittsburgh*

Steffen Rebennack, *Karlsruhe Institute of Technology*

Mauricio Resende, *Amazon*

Tamás Terlaky, *Lehigh University*

Van Vu, *Yale University*

Michael N. Vrahatis, *University of Patras*

Guoliang Xue, *Arizona State University*

Yinyu Ye, *Stanford University*

## **Aims and Scope**

Optimization has continued to expand in all directions at an astonishing rate. New algorithmic and theoretical techniques are continually developing and the diffusion into other disciplines is proceeding at a rapid pace, with a spot light on machine learning, artificial intelligence, and quantum computing. Our knowledge of all aspects of the field has grown even more profound. At the same time, one of the most striking trends in optimization is the constantly increasing emphasis on the interdisciplinary nature of the field. Optimization has been a basic tool in areas not limited to applied mathematics, engineering, medicine, economics, computer science, operations research, and other sciences.

The series **Springer Optimization and Its Applications (SOIA)** aims to publish state-of-the-art expository works (monographs, contributed volumes, textbooks, handbooks) that focus on theory, methods, and applications of optimization. Topics covered include, but are not limited to, nonlinear optimization, combinatorial optimization, continuous optimization, stochastic optimization, Bayesian optimization, optimal control, discrete optimization, multi-objective optimization, and more. New to the series portfolio include Works at the intersection of optimization and machine learning, artificial intelligence, and quantum computing.

*Volumes from this series are indexed by Web of Science, zbMATH, Mathematical Reviews, and SCOPUS.*

Ashkan Nikeghbali • Panos M. Pardalos •  
Andrei M. Raigorodskii • Michael Th. Rassias  
Editors

# High-Dimensional Optimization and Probability

With a View Towards Data Science

 Springer

*Editors*

Ashkan Nikeghbali  
Institut für Mathematik  
Universität Zürich  
Zürich, Switzerland

Panos M. Pardalos   
Dept. of Industrial & Systems Eng.  
University of Florida  
Gainesville, FL, USA

Andrei M. Raigorodskii  
Moscow Institute of Physics & Technology  
Dolgoprudny, Russia

Michael Th. Rassias  
Department of Mathematics and  
Engineering Sciences  
Hellenic Military Academy  
Athens, Greece

ISSN 1931-6828                      ISSN 1931-6836 (electronic)  
Springer Optimization and Its Applications  
ISBN 978-3-031-00831-3              ISBN 978-3-031-00832-0 (eBook)  
<https://doi.org/10.1007/978-3-031-00832-0>

Mathematics Subject Classification: 05C85, 47N10, 65K10, 90C26, 91A40

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2022

**Open Access** Chapter “Efficient Location-Based Tracking for IoT Devices Using Compressive Sensing and Machine Learning Techniques” is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>). For further details see license information in the chapter.

This work is subject to copyright. All rights are solely and exclusively licensed 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

# Preface

*High Dimensional Optimization and Probability: With a view towards Data Science* presents a collection of high-quality research as well as survey papers under the broad banner of Optimization and Probability as well as their interconnections with a wide spectrum of areas, such as machine learning. The goal of the present book is to publish essential developments in various areas in which Optimization and Probability are applied. More specifically, the contributions within the book discuss advances in non-convex optimization, advances in decentralized distributed convex optimization, and topics on surrogate-based reduced dimension global optimization in process systems engineering, the projection of a point onto a convex set, optimal sampling for learning sparse approximations in high dimensions, the split feasibility problem, higher order embeddings, codifferentials and quasidifferentials of the expectation of nonsmooth random integrands, adjoint circuit chains associated with a random walk, analysis of the trade-off between sample size and precision in truncated ordinary least squares, spatial deep learning, efficient location-based tracking for IoT devices using compressive sensing and machine learning techniques, nonsmooth mathematical programs with vanishing constraints in Banach spaces.

Effort has been made for the papers within this publication to represent a broad variety of topics, presenting the state of the art for the corresponding problems treated. Our aspiration is that the content of the book will constitute a valuable source for graduate students as well as advanced researchers working on Optimization, Probability and their various interconnections with a variety of other areas.

We would like to express our sincere thanks to the contributors of papers for their valuable participation in this collective effort. Last but not least, we would like to express our appreciation to the staff of Springer for their valuable help throughout the publication process of this book.

Zürich, Switzerland  
Gainesville, FL, USA  
Moscow, Russia  
Athens, Greece

Ashkan Nikeghbali  
Panos M. Pardalos  
Andrei M. Raigorodskii  
Michael Th. Rassias

# Contents

<b>Projection of a Point onto a Convex Set via Charged Balls Method</b> .....	1
Majid E. Abbasov	
<b>Towards Optimal Sampling for Learning Sparse Approximations in High Dimensions</b> .....	9
Ben Adcock, Juan M. Cardenas, Nick Dexter, and Sebastian Moraga	
<b>Recent Theoretical Advances in Non-Convex Optimization</b> .....	79
Marina Danilova, Pavel Dvurechensky, Alexander Gasnikov, Eduard Gorbunov, Sergey Guminov, Dmitry Kamzolov, and Innokentiy Shibaev	
<b>Higher Order Embeddings for the Composition of the Harmonic Projection and Homotopy Operators</b> .....	165
Shusen Ding, Guannan Shi, and Donna Sylvester	
<b>Codifferentials and Quasidifferentials of the Expectation of Nonsmooth Random Integrands and Two-Stage Stochastic Programming</b> .....	185
M. V. Dolgopolik	
<b>On the Expected Extinction Time for the Adjoint Circuit Chains Associated with a Random Walk with Jumps in Random Environments</b> .....	219
Chrysoula Ganatsiou	
<b>A Statistical Learning Theory Approach for the Analysis of the Trade-off Between Sample Size and Precision in Truncated Ordinary Least Squares</b> .....	241
Giorgio Gnecco, Fabio Raciti, and Daniela Selvi	

**Recent Theoretical Advances in Decentralized Distributed Convex Optimization** ..... 253  
Eduard Gorbunov, Alexander Rogozin, Aleksandr Beznosikov, Darina Dvinskikh, and Alexander Gasnikov

**On Training Set Selection in Spatial Deep Learning** ..... 327  
Eligius M. T. Hendrix, Mercedes Paoletti, and Juan Mario Haut

**Surrogate-Based Reduced-Dimension Global Optimization in Process Systems Engineering** ..... 341  
Kody Kazda and Xiang Li

**A Viscosity Iterative Method with Alternated Inertial Terms for Solving the Split Feasibility Problem** ..... 359  
Lulu Liu, Qiao-Li Dong, Shen Wang, and Michael Th. Rassias

**Efficient Location-Based Tracking for IoT Devices Using Compressive Sensing and Machine Learning Techniques** ..... 373  
Ramy Aboushelbaya, Taimir Aguacil, Qiuting Huang, and Peter A. Norreys

**Nonsmooth Mathematical Programs with Vanishing Constraints in Banach Spaces** ..... 395  
Vivek Laha, Vinay Singh, Yogendra Pandey, and S. K. Mishra