Lecture Notes in Computer Science

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison
Lancaster University, Lancaster, UK

Takeo Kanade
Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler
University of Surrey, Guildford, UK

Jon M. Kleinberg
Cornell University, Ithaca, NY, USA

Friedemann Mattern
ETH Zurich, Zurich, Switzerland

John C. Mitchell
Stanford University, Stanford, CA, USA

Momi Naor
Weizmann Institute of Science, Rehovot, Israel

C. Pandu Rangan
Indian Institute of Technology, Madras, India

Bermhard Steffen
TU Dortmund University, Dortmund, Germany

Demetri Terzopoulos
University of California, Los Angeles, CA, USA

Doug Tygar
University of California, Berkeley, CA, USA

Gerhard Weikum
Max Planck Institute for Informatics, Saarbrücken, Germany
More information about this series at http://www.springer.com/series/7407
Numerical Analysis and Its Applications

6th International Conference, NAA 2016
Lozenetz, Bulgaria, June 15–22, 2016
Revised Selected Papers
Preface

This volume of the 6th International Conference on Numerical Analysis and Applications was held at the hotel Sunset Beach, Lozenetz, Bulgaria, June 15–22, 2016. The conference was organized by the Division of Numerical Analysis and Statistics, University of Rousse Angel Kanchev, Bulgaria, in cooperation with the Department of Parallel Algorithms, Institute of Information and Communication Technologies, Bulgarian Academy of Sciences, Sofia.

The conference continued the tradition of the five previous meetings (1996, 2000, 2004 in Ruse and 2008, 2012 in Lozenetz) as a forum where scientists from leading research groups from the “East” and “West” are provided with the opportunity to meet and exchange ideas and establish research cooperations. More than 120 scientists from all over the world participated in the conference.

The main tracks comprised: Numerical Modeling; Numerical Stochastics; Numerical Approximation and Computational Geometry; Numerical Linear Algebra and Numerical Solution of Transcendental Equations; Numerical Methods for Differential Equations; High-Performance Scientific Computing;

The special topics covered at the conference were: Novel methods in computational finance based on the FP7 Marie Curie Action, project Multi-ITN STRIKE—Novel Methods in Computational Finance (grant agreement number 304617); and advanced numerical and applied studies of fractional differential equations.

A wide range of problems concerning recent achievements in numerical analysis and its applications in physics, chemistry, engineering, and economics were discussed. An extensive exchange of ideas between scientists who develop and study numerical methods and researchers who use them to solve real-life problems took place during the conference.

The keynote lectures reviewed some of the advanced achievements in the field of numerical methods and their efficient applications. The conference lectures were presented by university researchers and industry engineers including applied mathematicians as well as numerical analysis and computer experts.

The success of the conference and the present volume are due to the joint efforts of the Scientific Committee, to the local organizers, and to many colleagues from various institutions and organizations. We thank to our colleagues for their help in the organization of this conference. We especially thank to M. Koleva for her help in the preparation of this volume. We are also grateful to the organizers of the minisymposia.

The 7th International Conference on Numerical Analysis and Its Applications will be held in June 2020.

January 2017

Ivan Dimov
István Faragó
Lubin Vulkov

faragois@cs.elte.hu
Organization

NAA 2016 was organized by the Division of Numerical Analysis and Statistics, University of Ruse Angel Kanchev, Bulgaria, in cooperation with the Department of Parallel Algorithms, Institute of Information and Communication Technologies, Bulgarian Academy of Sciences, Sofia.

Scientific Committee

Ivan Dimov IICT, Bulgarian Academy of Sciences, Bulgaria
Matthias Ehrhardt Bergische Universität Wuppertal, Germany
István Faragó Eötvös Loránd University, Hungary
Martin Gander Université de Genève, Switzerland
Francisco Gaspar University of Zaragoza, Spain
Abdul Khalilq Middle Tennessee State University, USA
Ryotcho Lazarov Texas A&M University, USA
Piotr Matus Institute of Mathematics, NAS, Belarus
Nikolai Nefedov Lomonosov Moscow State University, Russia
Vladimir Shtaidurov Institute of Computational Modelling SB RAS, Russia
Martin Stynes Beijing Computational Science Research Center, China
Petr Vabishchevich Russian Academy of Sciences, Russia
Song Wang Curtin University, Australia

Local Organizers

Luben Vulkov (Chair) Ruse University “Angel Kanchev”, Bulgaria
Tatiana Chernogorova Sofia University “St. Kliment Ohridski”, Bulgaria
Juri Dimitrov Ruse University “Angel Kanchev”, Bulgaria
Miglena Koleva Ruse University “Angel Kanchev”, Bulgaria
Walter Mudzimbabwe Ruse University “Angel Kanchev”, Bulgaria
Radoslav Valkov University of Antwerp, Belgium

faragois@cs.elte.hu
## Contents

### Invited Papers

Behavior of Weak Solutions to the Boundary Value Problems for Second Order Elliptic Quasi-Linear Equation with Constant and Variable Nonlinearity Exponent in a Neighborhood of a Conical Boundary Point... 3  
*Yury Alkhutov, Mikhail Borsuk, and Sebastian Jankowski*

CVA Computing by PDE Models ................................. 15  
*Iñigo Arregui, Beatriz Salvador, and Carlos Vázquez*

Chaotic Dynamics of Structural Members Under Regular Periodic and White Noise Excitations .......................... 25  
*J. Awrejcewicz, A.V. Krysko, I.V. Papkova, N.P. Erofeev, and V.A. Krysko*

Convergence Order of a Finite Volume Scheme for the Time-Fractional Diffusion Equation .............................. 33  
*Abdallah Bradji and Jürgen Fuhrmann*

A 2nd-Order FDM for a 2D Fractional Black-Scholes Equation .......... 46  
*W. Chen and S. Wang*

Convergence of Alternant Theta-Method with Applications ........... 58  
*István Faragó and Zénó Farkas*

A Numerical Study on the Compressibility of Subblocks of Schur Complement Matrices Obtained from Discretized Helmholtz Equations ... 70  
*Martin J. Gander and Sergey Solovyev*

Convergence Outside the Initial Layer for a Numerical Method for the Time-Fractional Heat Equation ........................ 82  
*José Luis Gracia, Eugene O’ Riordan, and Martin Styne*

Multi-preconditioned Domain Decomposition Methods in the Krylov Subspaces ........................................... 95  
*Valery P. Il’in*

Use of Asymptotics for New Dynamic Adapted Mesh Construction for Periodic Solutions with an Interior Layer of Reaction-Diffusion-Advection Equations .......................... 107  
*Dmitry Lukyanenko, Nikolay Nefedov, Egor Nikulin, and Vladimir Volkov*
A Mathematical Model and a Numerical Algorithm
for an Asteroid-Comet Body in the Earth’s Atmosphere. 119
V. Shaydurov, G. Shchepanovskaya, and M. Yakubovich

On Stochastic Representation of Blow-Ups for Distributed
Parameter Systems  132
Milan Stehlík and Jozef Kiselák

A Singularly Perturbed Boundary Value Problems with Fractional
Powers of Elliptic Operators  141
Petr N. Vabishchevich

Contributed Papers

Simulation of Surface Heating Process with Laser  155
Tatiana Akimenko, Olga Gorbunova, and Valery Dunaev

A Higher Order Difference Scheme for the Time Fractional Diffusion
Equation with the Steklov Nonlocal Boundary Value Problem
of the Second Kind  164
Anatoly A. Alikhanov and Inna Z. Kozokova

Local Discontinuous Galerkin Methods for Reaction-Diffusion Systems
on Unstructured Triangular Meshes  172
Na An, Xijun Yu, Chaobao Huang, and Maochang Duan

A Method for Linearization of a Beam Problem  180
A.B. Andreev and M.R. Racheva

Numerical Modeling of Fluid Flow in Liver Lobule Using Double
Porosity Model  187
M. Yu. Antonov, A.V. Grigorev, and A.E. Kolesov

Numerical Modelling of Ion Transport in 5-HT3 Serotonin Receptor
Using Molecular Dynamics  195

Induced Dimension Reduction Method to Solve the Quadratic
Eigenvalue Problem  203
R. Astudillo and M.B. van Gijzen

Algorithms for Numerical Simulation of Non-stationary Neutron
Diffusion Problems  212
A.V. Avvakumov, V.F. Strizhov, P.N. Vabishchevich, and A.O. Vasilev

Regularization Methods of the Continuation Problem
for the Parabolic Equation  220
Andrey Belonosov and Maxim Shishlenin

faragois@cs.elte.hu
Computer Simulation of Plasma Dynamics in Open Plasma Trap ............... 227
   Evgeny Berendaev, Galina Dudnikova, Anna Efimova, and Vitaly Vshikov

Note on a New High Order Piecewise Linear Finite Element Approximation
for the Wave Equation in One Dimensional Space ........................... 235
   Abdallah Bradji

Short Rate as a Sum of Two CKLS-Type Processes ............................ 243
   Zuzana Buckova, Jana Halgasova, and Beata Stehlikova

Improving the Convergence of Differential Evolution ....................... 252
   Petr Bujok

The Service-Oriented Multiagent Approach to High-Performance
Scientific Computing ............................................................... 261
   Igor Bychkov, Gennady Oparin, Alexander Feoktistov, Vera Bogdanova,
   and Ivan Sidorov

Innovative Integrators for Computing the Optimal State in LQR Problems ...
   Petra Csomos and Hermann Menz

Existence and Stability of Contrast Structures in Multidimensional
Singularly Perturbed Reaction-Diffusion-Advection Problems ................ 277
   M.A. Davydova and N.N. Nefedov

A Comparison of Numerical Techniques for the FEM for the Stokes
Problem for Incompressible Flow .............................................. 286
   Ekaterina Dementyeva and Evgeniya Karepova

Numerical Modeling of Coupled Problems of External
Aerothermodynamics and Internal Heat-and-Mass Transfer
in High-Speed Vehicle Composite Constructions ................................ 294
   Yury Dimitrienko, Mikhail Koryakov, and Andrey Zakharov

Latin Hypercube Sampling and Fibonacci Based Lattice Method
Comparison for Computation of Multidimensional Integrals ................. 302
   Stoyan Dimitrov, Ivan Dimov, and Venelin Todorov

Non-singular Model for Evaporating Sessile Droplets ....................... 311
   Stanislav Z. Dunin and Oleg V. Nagornov

Combinatorial Modeling Approach to Find Rational Ways of Energy
Development with Regard to Energy Security Requirements .................. 317
   Alexey Edelev and Ivan Sidorov

A Conservative Semi-Lagrangian Method for the Advection Problem ....... 325
   Alexandr Efremov, Evgeniya Karepova, and Vladimir Shaidurov
Contents

Fast Meshless Techniques Based on the Regularized Method of Fundamental Solutions ........................................... 334
Csaba Gáspár

Parallel Computations for Solving 3D Helmholtz Problem by Using Direct Solver with Low-Rank Approximation and HSS Technique .................................................. 342
Boris Glinskiy, Nikolay Kuchin, Victor Kostin, and Sergey Solovyev

ADI Schemes for 2D Subdiffusion Equation ................................................... 350
Sandra Živanović and Boško S. Jovanović

Evolution of Copulas in Discrete Processes with Application to a Numerical Modeling of Dependence Relation Between Exchange Rates .................................................. 359
Naoyuki Ishimura and Yasukazu Yoshizawa

Using \( \epsilon \)-nets for Solving the Classification Problem ................................................... 367
Maria A. Ivanchuk and Igor V. Malýk

Convergence of a Factorized Finite Difference Scheme for a Parabolic Transmission Problem ................................................... 375
Zorica Milovanović Jeknić and Boško Jovanović

Compound Log-Series Distribution with Negative Multinomial Summands . . 383
Pavlina Jordanova, Monika P. Petkova, and Milan Stehlík

Inverse Problems of Determination of the Right-Hand Side Term in the Degenerate Higher-Order Parabolic Equation on a Plane ................................................... 391
Vitaly L. Kamynin and Tatiana I. Bukharova

Numerical Methods of Solution of the Dirichlet Boundary Value Problem for the Fractional Allers’ Equation ................................................... 398
Fatimat A. Karova

Slot Machine Base Game Evolutionary RTP Optimization ................................................... 406
Delyan Keremedchiev, Petar Tomov, and Maria Barova

Numerical Analysis of Reinforced Concrete Deep Beams ................................................... 414
Aleksandr E. Kolesov, Petr V. Sivtsev, Piotr Smarzewski, and Petr N. Vabishchevich

Numerical Solution of Thermoporoelasticity Problems ................................................... 422
Alexandr E. Kolesov and Petr N. Vabishchevich

Computation of Delta Greek for Non-linear Models in Mathematical Finance ................................................... 430
Miglena N. Koleva and Lubin G. Valkov

faragois@cs.elte.hu
New Grid Approach for Solution of Boundary Problems for Convection-Diffusion Equations ................................................. 550
  Sergey V. Polyakov, Yuri N. Karamzin, Tatiana A. Kudryashova, and Viktoria O. Podryga

Finite-Difference Method for Solution of Advection Equation by Unstable Schemes .......................................................... 559
  Igor V. Popov

Algorithm of Competing Processes for the Richardson Iteration Method with the Chebyshev Parameters ........................................... 568
  Mikhail V. Popov, Yuriy A. Poveschenko, Igor V. Popov, Vladimir A. Gasilov, and Alexander V. Koldoba

Unstable Flow Modes of the Non-isothermal Liquid Film ................... 576
  Ludmila A. Prokadina

Discrete Modeling of Oscillatory Processes in a Blocky Medium ............ 583
  Vladimir M. Sadovskii and Evgenii P. Chentsov

An Overlapping Domain Decomposition Method for the Helmholtz Exterior Problem ............................................................... 591
  Alexander Savchenko and Artem Petukhov

A Semi-Lagrangian Numerical Method for the Three-Dimensional Advection Problem with an Isoparametric Transformation of Subdomains ... 599
  Vladimir Shaydurov, Alexander Vyatkin, and Elena Kuchunova

Some Quadrature-Based Versions of the Generalized Newton Method for Solving Unconstrained Optimization Problems .................. 608
  Marek J. Śmietalski

One Parallel Method for Solving the Multidimensional Transfer Equation with Aftereffect ......................................................... 617
  Svyatoslav I. Solodushkin, Arsen A. Sagoyan, and Irina F. Yumanova

Numerical Simulation of Heat Transfer of the Pile Foundations with Permafrost ................................................................. 625
  Sergei P. Stepanov, Ivan K. Sirditov, Petr N. Vabischevich, Maria V. Vasilyeva, Vasily I. Vasilyev, and Anastasiya N. Tceeva

The Inverse Problem of the Simultaneous Determination of the Right-Hand Side and the Lowest Coefficients in Parabolic Equations ............ 633
  LingDe Su, P.N. Vabischevich, and V.I. Vasil’ev

The GPU Solvers for High-Frequency Induction Logging ..................... 640
  Irina Surodina
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematical Modeling of Fan-Structure Shear Ruptures Generated in Hard Rocks</td>
<td>648</td>
</tr>
<tr>
<td><em>Boris G. Tarasov and Vladimir M. Sadovskii</em></td>
<td></td>
</tr>
<tr>
<td>On the Numerical Analysis of Fan-Shaped Waves</td>
<td>657</td>
</tr>
<tr>
<td><em>Boris G. Tarasov, Vladimir M. Sadovskii, and Oxana V. Sadovskaya</em></td>
<td></td>
</tr>
<tr>
<td>High Performance Computations for Study the Stability of a Numerical Procedure for Crossbar Switch Node</td>
<td>665</td>
</tr>
<tr>
<td><em>Tasho D. Tashev, Vladimir V. Monov, and Radostina P. Tasheva</em></td>
<td></td>
</tr>
<tr>
<td>Solving a Singularly Perturbed Elliptic Problem by a Multigrid Algorithm with Richardson Extrapolation</td>
<td>674</td>
</tr>
<tr>
<td><em>Svetlana Tikhovskaya</em></td>
<td></td>
</tr>
<tr>
<td>Conservative Finite-Difference Scheme for Computer Simulation of Field Optical Bistability</td>
<td>682</td>
</tr>
<tr>
<td><em>Vyacheslav A. Trofimov, Maria M. Loginova, and Vladimir A. Egorenkov</em></td>
<td></td>
</tr>
<tr>
<td>Numerical Modeling of Micropolar Thin Elastic Plates</td>
<td>690</td>
</tr>
<tr>
<td><em>Maria Varygina</em></td>
<td></td>
</tr>
<tr>
<td>Iterative Solution of the Retrospective Inverse Problem for a Parabolic Equation Using the Conjugate Gradient Method</td>
<td>698</td>
</tr>
<tr>
<td><em>V.I. Vasil'ev and A.M. Kardashevsky</em></td>
<td></td>
</tr>
<tr>
<td>Discrete Approximations for Multidimensional Singular Integral Operators</td>
<td>706</td>
</tr>
<tr>
<td><em>Alexander Vasilyev and Vladimir Vasilyev</em></td>
<td></td>
</tr>
<tr>
<td>A Generalized Multiscale Finite Element Method for Thermoelasticity Problems</td>
<td>713</td>
</tr>
<tr>
<td><em>Maria Vasilyeva and Denis Stalnov</em></td>
<td></td>
</tr>
<tr>
<td>Asymptotic-Numerical Method for the Location and Dynamics of Internal Layers in Singular Perturbed Parabolic Problems</td>
<td>721</td>
</tr>
<tr>
<td><em>Vladimir Volkov, Dmitry Lukyanenko, and Nikolay Nefedov</em></td>
<td></td>
</tr>
<tr>
<td>Influence of Snow Cover on the Seismic Waves Propagation</td>
<td>730</td>
</tr>
<tr>
<td><em>Gyulnara Voskoboynikova, Kholmatzhon Imomnazarov, Aleksander Mikhailov, and Jian-Gang Tang</em></td>
<td></td>
</tr>
<tr>
<td>Hybrid Model of Particle Acceleration on a Shock Wave Front</td>
<td>737</td>
</tr>
<tr>
<td><em>Lyudmila Vshivkova and Galina Dudnikova</em></td>
<td></td>
</tr>
</tbody>
</table>
XIV Contents

Solution of the Stochastic Differential Equations Equivalent to the Non-stationary Parker Transport Equation by the Strong Order Numerical Methods ........................................... 744
   Anna Wawrzynczak and Renata Modzelewska

Numerical Method for Solving an Inverse Boundary Problem with Unknown Initial Conditions for Parabolic PDE Using Discrete Regularization ................................................... 752
   Natalia M. Yaporova

Two-Dimensional Interpolation of Functions with Large Gradients in Boundary Layers ................................................................. 760
   Alexander Zadorin

A Volunteer-Computing-Based Grid Architecture Incorporating Idle Resources of Computational Clusters ........................................... 769
   Oleg Zaikin, Maxim Manzyuk, Stepan Kochemazov, Igor Bychkov, and Alexander Semenov

Effects of the Neuron Permutation Problem on Training Artificial Neural Networks with Genetic Algorithms .................................... 777
   Iliyan Zanin斯基

Author Index .................................................. 783

faragois@cs.elte.hu