

Curriculum Vitae: Prof. Dr. Dr. h.c. mult. Hans Georg Bock



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Date and Place of Birth: May 9, 1948, Bottrop/Germany, German Citizen
Current Position: Senior Professor (C4) of Scientific Computing

Professional and Scientific Career

Since 2018 Professor Emeritus, resp., Senior Professor
2005 - 2017 Executive Director of IWR
1993 - 2005 Vice Executive Director of Interdisciplinary Center for Scientific Computing (IWR)
Since 1991 Full Professor (C4) at the IWR, University of Heidelberg
1988 - 1991 Full Professor (C3) for Applied Mathematics, University of Augsburg
1987 - 1988 Visiting Professor for Numerical Mathematics, University of Heidelberg
1986 Ph.D. in Applied Mathematics, University of Bonn

Initiation and Coordination of Large Collaborative Research Projects

Since 2017 Co-Initiator and Vice Chairman "Scientific Computing Sustainable Software Collaboratory (SCSC)", Heidelberg, funded by Carl-Zeiss-Foundation
2015 – 2023 Coordinator, Co-Initiator and PI "Scientific Computing for the Improved Diagnosis and Therapy of Sepsis (SCIDATOS)", Heidelberg-Mannheim, funded by Klaus-Tschira-Foundation
2007 - 2011 Initiator and Founding Director, Heidelberg Graduate School of Mathematical and Computational Methods for the Sciences – HGS MathComp (GSC 220), Vice Director 2011 – 2018
2001- 2010 Co-Chairman (with M. Niezgodka), International Research Training Program "Complex Processes: Modeling, Simulation and Optimization", Heidelberg-Warsaw (RTG 710), DFG funded
Since 1999 Head, Steinbeis Technology Transfer Center "Simulation and Optimization"
1994 - 2000 Co-Initiator (with M. Grötschel, W. Römisch) and PI, National Collaborative Research Program "Real-Time Optimization of Large Scale Systems", DFG funded
1993 - 2001 Chairman, Research Training Program "Modeling and Scientific Computing in Mathematics and the Sciences", Heidelberg (RTG 13), DFG funded

1991 - 2004 Co-Initiator and Project Leader, Collaborative Research Center "Reactive Flow, Diffusion and Transport" (SFB 359), Heidelberg, DFG funded

Services for the Scientific Community

Since 2018 Member, International Science Council, RUDN University, Moscow, Russia
Since 2011 Co-Founder and Chairman, national strategic "Committee for Mathematical Modeling, Simulation and Optimization (KoMSO)", German node within the European Mathematics in Industry network EU-MATHS-IN, since 2021 Vice Chairman
2008 - 2017 Chairman, Program Panel "Mathematics for Innovations in Industry" of the German Federal Ministry for Education and Research (BMBF)
2006 - 2012 Member of the Strategy Committee for the University of Heidelberg's proposal "Institutional Strategy: Realizing the Potential of a Comprehensive University" that won Heidelberg the status of University of Excellence in the German Excellence Initiative
2002 - 2010 CDC-EMS "Committee for Developing Countries" of the European Mathematical Society
1995 - 2006 Co-Chairman, "Association for Mathematics in Industry and Research"

Memberships in Scientific Advisory Boards. e.g., of University Projects (TU Dortmund: Research Network "Modeling and Simulation", Warsaw University: MAMBA Center of Excellence "Multi-Scale Bio-Molecular Modeling, Bioinformatics and Applications", International Science Forum Heidelberg) or of Companies (TecMath GmbH, InnovationLab GmbH)

Offers, Honors and Awards

2019 Elected as Foreign Member of the Russian Academy of Science
2018 Appointed Senior Professor of the University of Heidelberg
2012 Honorary Doctorate of the Russian Academy of Science
2011 ERC Advanced Investigator Grant "Optimizing Control – from a Vision to Industrial Reality", with S. Engell (Dortmund)
2011 Honorary Fellow, European Society of Computational Methods in Sciences and Engineering (ESCMSE)
2009 Elected as Member of the Heidelberg Academy of Sciences and Humanities
2008 Medal of Honor, Gottlieb Daimler and Karl Benz Foundation
2004 Microsoft Research Award
2003 Medal of Merit, Ministry for Education and Training, Vietnam
2000 Honorary Doctorate of the Vietnamese Academy of Science and Technology
1986 GEFFRUB-Award and Heinrich Hörlein Memorial Award
1984 Felix Hausdorff Memorial Award

Offers for chairs at the Universities of Cologne (1998) and Stuttgart (1995), a Fiebigger-professorship, TU Munich (1988), none of which were taken up

Research Fields

Computational Methods for Optimization and Optimal Control of Nonlinear Large-Scale Systems and Processes, especially

- Simultaneous, or One-Shot Methods for ODE, DAE and PDE Constrained Optimization and Optimal Control Problems, Direct Multiple Shooting and Collocation

- Initial Value, Boundary Value und Optimization Problems for Discontinuous and Switched Dynamical Systems
- Optimization under Uncertainty, Real-Time Methods for Constrained Optimal Feedback Control Subject to ODE, DAE and PDE, especially Real-Time and Multi-Level Iterations for Nonlinear Model Predictive Control
- Numerical Methods for State and Parameter Estimation including Real-Time and Multi-Level Iterations for Moving Horizon Estimation
- Optimum Experimental Design for ODE, DAE and PDE
- Indirect and Direct Solution Methods for Nonlinear Mixed-Integer Optimal Control Problems

Applications in Industry and Various Domains in Science, Humanities and Engineering such as

- Flight Dynamics and Aerospace Engineering, Automotive Engineering
- Robotics and Mechanical Engineering
- Electrical and Power Engineering
- Chemistry, Chemical and Process Engineering
- Systems Biology, Biotechnology, Medical Applications, e.g., Orthopedics, Immunology
- Computational Methods for the Cultural Heritage

Editorial Work

Co-editor of Springer book series: "Mathematics in Industry" (with F. de Hoog, A. Friedman, A. Gupta, A. Nachbin, A. Ozawa, W.R. Pulleyblank, T. Rusten, F. Santosa, J.K. Seo, A.-K. Tornberg), "Contributions in Mathematical and Computational Sciences" (with W. Jäger, H. Knüpfer, O. Venjakob), and "Advances in Numerical Mathematics" (with W. Hackbusch, M. Luskin, R. Rannacher). Co-editor of scientific journals: "Optimization and Engineering", "Vietnam Journal of Mathematics", and "Journal of Mathematics in Industry" (all Springer).

Promotion of the Next Generation of Scientists

Over 100 Diploma or Master graduate students, 55 completed PhDs as principal supervisor.

20 of the former doctoral students and postdocs now hold positions as professors at universities in Germany and abroad.

Selected Publications (out of 130 since 2005)

- H. G. Bock, D. H. Cebulla, C. Kirches, A. Potschka: Mixed-integer optimal control for multimodal chromatography, *Computers & Chemical Engineering* 153, 107435 (2021)
- J. Gutekunst, R. Scholz, A. Nurkanović, A. Mesanovic, H. G. Bock, E. Kostina: Fast moving horizon estimation using multi-level iterations for microgrid control, *at-Automatisierungstechnik* 68 (12), pp. 1059-1076 (2020)
- Coulibaly, A. Bettendorf, E. Kostina, A. S. Figueiredo, S. Y Velasquez, H. G. Bock, M. Thiel, H. A. Lindner, M. V. Barbarossa: Interleukin-15 signaling in HIF-1 α regulation in natural killer cells, insights through mathematical models, *Frontiers in Immunology* 10:2401 (2019).
- H. G. Bock, C. Kirches, A. Meyer, A. Potschka: Numerical solution of optimal control problems with explicit and implicit switches, *Optimization Methods and Software* 33:3, pp. 450-474 (2018)
- H. C. La, A. Potschka, J. P. Schlöder, H. G. Bock: Dual control and online optimal experimental design, *SIAM Journal on Scientific Computing* 39 (4), B640-B657 (2017)
- Schäfer, H. G. Bock, J. Sanday, H. Leitte: Virtually reassembling Angkor-style Khmer temples, *Digital Applications in Archaeology and Cultural Heritage* 2 (1), 2-11 (2015)
- H. J. Ferreau, C. Kirches, A. Potschka, H. G. Bock, M. M. Diehl: qpOASES: A parametric active-set algorithm for quadratic programming, *Mathematical Programming Computation* 6 (4), pp. 327– 363 (2014).

- S. Sager, H. G. Bock, M. M. Diehl: The integer approximation error in mixed-integer optimal control. *Mathematical Programming*, 133 (1-2), pp. 1-23 (2012).
- Kirches, L. Wirsching, H. G. Bock, J. P. Schlöder: Efficient direct multiple shooting for nonlinear model predictive control on long horizons. *Journal of Process Control*, 22 (3), pp. 540-551 (2012).
- P. Kühn, M. M. Diehl, T. Kraus, J. P. Schlöder, H. G. Bock: A real-time algorithm for moving horizon state and parameter estimation. *Computers & Chemical Engineering* 35 (1), pp. 71-83 (2011).
- Kirches, S. Sager, H. G. Bock, J. P. Schlöder: Time-Optimal Control of Automobile Test Drives with Gear Shifts. *Optimal Control Applications and Methods* 31 (2), pp. 137- 153 (2010).
- S. Bandara, J. P. Schlöder, R. Eils, H. G. Bock, T. Meyer: Optimal Experimental Design for Parameter Estimation of a Cell Signalling Model. *PLoS Computational Biology* 5 (11): e1000558 (2009).
- H. J. Ferreau, H. G. Bock, M. M. Diehl: An online active set strategy to overcome the limitations of explicit MPC. *Int. Journal of Robust and Nonlinear Control*, 18 (8), pp. 816-830 (2008).
- H. G. Bock, M. M. Diehl, E. A. Kostina, J. P. Schlöder: Constrained Optimal Feedback Control of Systems Governed by Large Differential Algebraic Equations. *Real-Time PDE-Constrained Optimization*, pp. 3-24, SIAM (2007).
- J. Simon, H. G. Bock, L. Doederlein, A. S. McIntosh, D. Metaxiotis, S. I. Wolf: The Heidelberg Foot Measurement Method: Development, Description and Assessment. *Gait & Posture* 23, pp. 411-424 (2006).
- M. M. Diehl, H. G. Bock, J. P. Schlöder: A real-time iteration scheme for nonlinear optimization in optimal feedback control. *SIAM J. on Control and Optimization* 43 (5), pp.1714-1736 (2005).

Organization and Co-Organization of Workshops and Conferences (Selection out of over 30 since 2005):

- Triennial "International Conference High Performance Scientific Computing - Modeling, Simulation and Optimization of Complex Processes", Hanoi, Vietnam, 2000, 2003, 2006, 2009, 2012, 2015, 2018
- "Model-Based Optimizing Control – From a Vision to Industrial Reality“, Heidelberg, IWR, June 9-10, 2016
- "Parameter and State Estimation: Methods - Software - Applications", Heidelberg, IWR, November 10-11, 2015
- EU-SEA Workshop "Advanced Computing for Control and Performance Optimization", Chonburi, Thailand, March 9 – 10, 2015
- "Bi-level Optimal Control - Combining Theoretical and Numerical Approaches“, Heidelberg, IWR, October 20-22, 2014
- "Workshop Industrial Optimization“, Heidelberg, IWR, February 17-20, 2014
- "Scientific Computing and the Cultural Heritage", Heidelberg, Academy of Science and Humanities, 2007, 2009, 2011, 2013
- "Chinese-German Workshop on Computational and Applied Mathematics", Heidelberg, Sept 28 – Oct 2, 2009
- International Workshop "Model Based Parameter Estimation: Theory and Applications“, Heidelberg, July 15 - 17, 2009
- "Model Based Optimal Experimental Design for Nonlinear Processes“, Heidelberg, Nov 6 – 7, 2008
- "Czech-French-German Conference on Optimization", Heidelberg, Sept 17 – 21, 2007
- "Myanmar-Germany Workshop on Computational Science", Yangon, Myanmar, Nov 6 – 10, 2006
- "Conference on Optimization under Uncertainties", Heidelberg, Sept 28 – 30, 2005

Including **KoMSO Challenge Workshops**

KoMSO Challenge Workshops are a special networking format between scientists from industry and academia that focuses on pressing open questions in current topical areas. The aim is to produce a white paper that may serve as a starting point for joint research collaborations.

- “Digital Twins. Industrial and Mathematical Challenges”, Heidelberg, Academy of Sciences and Humanities, May 7 - 8, 2019
- “Mathematical Modeling, Simulation and Optimization in the Pharmaceutical Industry”, Heidelberg, IWR, June 14 - 15, 2018
- “Challenges for Mathematical Modeling, Simulation and Optimization for Advanced Process Control of Batch Processes”, Heidelberg, IWR, February 9 - 10, 2017
- “Mathematical MSO for Air Traffic Management”, Raunheim, Lufthansa Systems, July 14 - 15, 2016
- “Mathematical Modeling, Simulation and Optimization for Energy Conservation“, Heidelberg, Academy of Sciences and Humanities, October 8 - 9, 2015
- “Online & Offline Optimal Control of Chemical and Biotechnological Processes”, Ludwigshafen, BASF SE, January 23-24, 2014
- “Mathematical Modeling, Simulation and Optimization of Future Energy Grids“, Heidelberg, IWH, May 7 - 8, 2013
- “Mathematics for Health Care“, Heidelberg, IWH, December 7 - 8, 2011

A Selection of Major Third-Party Funded Research Projects since 2010

Funded by European Research Council

- ERC Advanced Investigator Grant: Model-Based Optimizing Control – From a Vision to Industrial Reality – MOBOCON (2012 – 2017) with S. Engell

Funded by Federal Ministry for Education and Research (BMBF)

- MOrNet - Modelling, Optimization and Control of Networks of Heterogeneous Power Systems with Volatile Renewable Energy Generation (2018 - 2021), with V. Hagenmeyer, C. Kirches, E. Kostina, A. Potschka, S. Stiller. Industry Partners: IAV GmbH, Siemens AG, TLK Energy GmbH, TransnetBW GmbH
- MoPhaPro – Model-Based Optimization of Pharmacological Processes (2016 – 2020), with C. Kirches, E. Kostina, A. Potschka, J. P. Schlöder. Industry Partners: Bayer SE, Octapharma Pharmaceuticals GmbH
- IMNet – Mathematics for Innovations in Industry and Services - Accompanying Network Activities (2014–2018)
- GOSSIP - Nonlinear Mixed-Integer Optimization and Optimal Control of Strongly Coupled Industrial Processes (2013–2016), with C. Kirches, E. Kostina, A. Potschka, S. Sager and J.P. Schlöder. Industry Partners: BASF SE, Daimler AG, TLK Thermo GmbH
- PARAPLUE – Parameter estimation and optimum experimental design for nonlinear non-stationary industrial processes under uncertainties and real-time constraints (2010-2013), with S. Körkel, E. Kostina and J.P. Schlöder. Industry Partners: BASF SE, InnovationLab GmbH, Battenberg Robotic GmbH

Fully Funded by Industrial Partner BASF SE

- IWR Junior Research Group “Numerical Methods for Optimum Experimental Design in Partial Differential Equations” (2008-2015) – in Interaction with Various Departments at BASF

Further Contract R&D Projects with Industrial Partners in the Framework of the Steinbeis Technology Transfer Center “Simulation and Optimization”, e.g., ABB AG, BASF SE, Bayer AG, Daimler AG, ESA, ESOC, Robert Bosch GmbH, TLK Energy GmbH

Funded by Klaus-Tschira-Foundation

- “Scientific Computing for the Improved Diagnosis and Therapy of Sepsis (SCIDATOS)”, (2015 – 2023) with M. Gertz, W. Jäger, E. Kostina, H. Lindner, V. Lindner, A. Marciniak-Czochra, S. Riezler, M. Thiel

Funded by Deutsche Forschungsgemeinschaft (DFG)

- Theory and Methods of Control and Optimization of Dynamical Systems for Engineering Applications – A German Russian Collaboration Project (since 2021) with E. Kostina, V. Bolotnik (Russian Academy of Science)
- Numerical Methods for Diagnosis and Therapy Design of Cerebral Palsy by Bi-Level Optimal Control of Constrained Biomechanical Multi-Body Systems (2016 – 2021) with E. Kostina (within Priority Programme 1962)
- Numerical algorithms for hierarchical optimization for estimating parameters in state and control constrained optimal control problems (2013 – 2018) with J. P. Schlöder
- Improving Limited Angle x-ray computed Tomography by Optical data integration – ILATO (2012 – 2016) with A. Flisch, S. Krömker, U.J. Sennhauser
- Numerical Algorithms for Moving Horizon Estimation and Nonlinear Model Predictive Control under Uncertainties (2012-2014), with J. P. Schlöder.
- Structure exploitation for Scenario-Tree NMPC and MHE (2011 – 2016) with J.P. Schlöder
- Optimization with PDE: Optimal Control of Periodic Adsorption Processes (2006 - 2015), with S. Engell and S. Sager (within Priority Programme 1253)

A Selection of Invited Plenary and Keynote Lectures since 2010

- Inverse Optimal Control Problems and Applications to Modeling Human Locomotion. *12th International Conference on Large-Scale Scientific Computation*, Sozopol, Bulgaria, June 10-14, 2019
- Digital Twin and the Inverse Problem. *Digital Twins: Industrial and Mathematical Challenges*, Academy of Science and Humanities, Heidelberg, May 7-8, 2019
- Nonlinear Mixed-Integer Optimal Control – from the Maximum Principle Approach to Online Computation of Closed-Loop Optimal Controls in Real Time, *14th Viennese Conference on Optimal Control and Dynamic Games*, Wien, Austria, July 3-6, 2018
- Mathematical Modeling, Simulation and Optimization – A Key Technology for the 21st Century, *DIFF 2018 - International Conference on Differential Equations and Dynamical Systems*, Suzdal, Russia, July 6-11, 2018
- Mixed-Integer Optimal Control - Theory, Numerical Solution and Nonlinear Model Predictive Control, *28th European Conference on Operational Research EURO2016*, Poznan, Poland, July 3-6, 2016
- Scientific Computing for the Cultural Heritage of Angkor, *Computer-Based Methods for Research in the Humanities*, Hebrew University Jerusalem, Israel, May 7 - 8, 2012
- Optimizing Control – Intelligent Technologies for Automotive Engineering, *International Conference on Intelligent Technologies and Engineering Systems*, Changhua, Taiwan, December 12-14, 2012
- Scientific Computing, Technology Transfer, and the Preservation of the Cultural Heritage - A Case Study on the Road to Computational Humanities, *6th Academic Research and Development Summit*, Tainan, Taiwan, December 20, 2010

- Nonlinear Optimum Experimental Design - Mathematical Basic Research of High Economic Impact, *European Conference on Mathematics for Industry ECMI2010*, Wuppertal, July 26-30, 2010
- "... we need this to remain competitive ..." - New Mathematical Methods for Challenges in Industrial Technology, *China-Germany Conference on Mathematics and Industry*, Beijing, China, March 15-18, 2010