Gerhard-Wilhelm Weber

Gerhard-Wilhelm Weber works at IAM of METU, Ankara, Turkey, in Department of Financial Mathematics and Department of Scientific Computing; he Assistant to the Director. Furthermore, he is Guest Professor at the Faculty of Economics, Management and Law of University of Siegen, Germany, and Collaborator at Center for Research on Optimization and Control (CEOC), University of Aveiro, Portugal. He received his Diploma and Doctorate in Mathematics and Economics at RWTH Aachen, and his Habilitation at TU Darmstadt. He held professorships by proxy at Institute of Mathematics, University of Cologne, and at Faculty of Mathematics, TU Chemnitz, Germany, then he worked at Cologne Bioinformatics Center; since 2003 he is at METU, Ankara. He chaired EUROPT where he is Past Chair now, he is Past Chair of EURO Working Group on OR in Computational Biology, Bioinformatics and Medicine, Vice Chair of EURO Working Group on OR for Development, Honoray Chair of EURO WG on Complex Societal Problems, and he represents German OR Society in Turkey. Prof. Weber got a number of awards, and he has been member in different research projects.

His research interests are lying in the areas of Continuous Optimization, Financial Mathematics, Operations Research, Optimal Control, selected topics from Discrete Optimization, Dynamical Systems, Statistical Learning and Computational Statistics, Inverse Problems, Topology, Complexity Theory, Computational Biology and Bioinformatics, Environmental Protection, the sector of Development and Societal Complexity.

Prof. Weber has published numerous articles, guest-edited 12 special issues, he has been in editorial boards of journals, wrote many referee and other reports. He co-organized about 50 scientific events (among of them also large ones of the EURO and INFORMS series) and is member in about 20 scientific organizations. Prof. Weber gave presentations all over the world, at scientific events and in seminars.

He taught courses in German and in English language, among of them, for example, Analysis, Discrete Mathematics, Mathematics for (various kind of) Engineers, Mathematics for Human and Social Scientists, Optimization in Financial Mathematics, Portfolio Optimization, Inverse Problems, Data Mining, Statistical Learning and Simulation, Mathematical Modelling, Numerical Optimization, Advanced Optimization, Topological Methods in Optimization, etc.. Prof. Weber organized various seminar series and supervised a number of students.

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NSOS – Nonlinear Systems Optimization and Statistics

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Some New Advances and Challenges in Modern Continuous Optimization with Semi-Infinite and Conic Quadratic Programming – Theory, Methods and Applications

Gerhard-Wilhelm Weber

Institute of Applied Mathematics
Middle East Technical University
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October 10, 2008
10h00-11h00 & **11h30-12h30**
ANF, EE II
Campus de Gualtar, 4710-057 Braga

Some New Advances and Challenges in Modern Continuous Optimization with Semi-Infinite and Conic Quadratic Programming – Theory, Methods and Applications

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Part 1: Gene-Environment Networks under Uncertainty

A research area of central importance in computational biology is devoted to modelling, prediction and dynamics of gene-expression patterns. We survey and improve recent advances in the understanding of the mathematical foundations of so-called gene-environment networks. For a representation of past, present and most likely future states of these regulatory networks also the presence of measurement errors and various kinds of uncertainty have to be acknowledged. Given the noise-prone data from DNA microarray experiments, we extract nonlinear differential equations which contain parameters that have to be determined. For this identification we apply some modern kinds of generalized Chebychev approximation and generalized semi-infinite programming (GSIP) and we include errors and uncertainty by interval arithmetics as well as ellipsoidal calculus. After this is provided, time-discrete dynamical systems are studied. Here, a combinatorial algorithm constructing and following polyhedral sequences allows us to detect the region of parametric stability. We investigate the structure and stability of the topological landscape comprising these networks with advanced methods of continuous optimization and present various regression models. In addition, we explain how computational statistics and spline regression with regularization and conic programming could become employed into our analysis.
Based on the aforementioned explanations, Part 1 becomes concluded by a short introduction into GSIP (and also SIP) problems with a special emphasis on their global structure and its stability behaviour under perturbation, numerical approaches, and by related topics from optimal control.

Part 2: Computational Statistics and Financial Mathematics with Model-Based Learning by Optimization

Statistical learning and data mining encompass the theories of classification and regression. Concentrating on machine learning and spline regression, we discuss how modern continuous optimization contributes here, and it turns out to become an real alternative to the more model-free methods of statistics.
A subfield of artificial intelligence, machine learning, is concerned with the development of algorithms that allow computers to “learn”. It is the process of training a system with a large number of data, extracting rules and finding patterns in order to make predictions on new data points. Common machine learning problems include supervised learning, unsupervised learning, semi-supervised learning, reinforcement learning, etc.. There are different kinds of applications in this field, especially, in computational biology, finance and the information sector. We focus on support vector machines (SVMs) which is one of the most powerful methods currently in machine learning. To achieve linear separability of the data, the problem becomes embedded into a feature space by the use of kernel functions. The finding and selection of these functions is a hard problem. While in literature, convex combinations of kernels were regarded and optimized by SIP, we turn to the greater wealth of integrals over kernels, replacing convex combinations by probability measures. This gives rise to infinite programming (IP) problems which we analyze by reduction ansatz and parametrizations, i.e., in the context of less abstract problem classes. We give careful discussions, propose regularization techniques for stabilization, and introduce into numerical methods such as discretization and exchange method.
In regression theory, we look for continuous approximations of (mostly) discrete data. We concentrate on spline regression with (Tikhonov) regularization and nonlinear regression. The ansatzes (model forms) underlying spline regression are additive and generalized additive models, which are characterized by some separation of variables, and MARS (multivariate additive regression spline) which is of a more multiplicative nature. We deduce the regularized problems, turn it to conic quadratic programming (CQP) problem where interior point methods are applicable. In case of MARS we see (using program package MOSEK) that our approach can indeed become an alternative to the one in statistics offered by Jerome Friedman and implemented in the package Salford MARS. Finally, by turning to parameter estimation in the financial fields of stochastic differential equations and credit risk management, we combine linear and nonlinear regression and apply CQP per step.
Throughout both parts of the presentation we detect research challenges. We conclude by discussing structural frontiers and chances, and by inviting to future collaboration!