Control Theory: On the Way to New Application Fields

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Abstract. Control theory is an interdisciplinary field that is located at the crossroads of pure and applied mathematics with systems engineering and the sciences. Recently, deep interactions are emerging with new application areas, such as systems biology, quantum control and information technology. In order to address the new challenges posed by the new application disciplines, a special focus of this workshop has been on the interaction between control theory and mathematical systems biology. To complement these more biology oriented focus, a series of lectures in this workshop was devoted to the control of networks of systems, fundamentals of nonlinear control systems, model reduction and identification, algorithmic aspects in control, as well as open problems in control.

Mathematics Subject Classification (2000): 93xx.

Introduction by the Organisers

Control theory is an interdisciplinary field that is located at the crossroads of pure and applied mathematics with systems engineering and the sciences. Traditionally, the interaction with systems engineering and signal processing has been particularly strong. More recently, deep interactions are emerging with new application areas, such as systems biology, quantum control and information technology. The field therefore covers a wide variety of topics, ranging from fundamental mathematical aspects and new control paradigms in the sciences to real world engineering applications of industrial relevance. In particular, it has deep connections to different branches of pure and applied mathematics, including e.g. ordinary and
The Oberwolfach workshop “Control Theory: On the Way to New Application Disciplines” brought together about 45 internationally active researchers from Austria, Australia, France, Germany, Israel, Italy, The Netherlands, Sweden, and the United States, with both a mathematical and systems engineering background. In order to address the new challenges posed by the new application disciplines, a special focus of this workshop has been on the interaction between control theory and mathematical systems biology. This was enhanced by two special sessions with 8 lectures on systems biology and complemented by an open discussion on systems biology, to explore future perspectives in the interaction to control theory. Topics of these lectures included persistency in chemical networks, modelling and robustness issues of biochemical reaction networks, monotone systems, the dynamics of gene regulatory networks and mathematical models for metabolism of bacteria. To complement these more biology oriented talks by challenging systems engineering topics, a series of lectures was devoted to the control of networks of systems, another hot topic that currently very actively explored by the systems engineering community. In all these talks, the interaction of mathematical methods from nonlinear dynamics and control with those from discrete mathematics (esp. graph and information theory) played a crucial role. Although many fundamental mathematical questions in systems biology are apparently still unanswered or even unasked, it became evident through the discussions that the appropriate combination of such mathematical tools will be instrumental for further success in this area.

The program comprised over 30 stimulating talks on the theory and applications of control theory. Each talk had a length of thirty five minutes with at least 5 minutes discussion time. The lectures were organized into rather coherent sessions on the topics:

- Systems Biology
- Fundamentals of Nonlinear Control Systems
- Model reduction and Identification
- Networks and Control
- Algorithmic Aspects in Control
- Fundamental Control Problems

In addition to these lectures and the very active discussions throughout the workshop there was a 45 Minutes open discussion on systems biology and an Thursday evening informal open problem session, in which 10 participants presented open mathematical problems in control. Another highlight of the conference was the after dinner surprise lecture on Monday evening by Prof. R. E. Kalman (Zürich) on the classical problem of electrical network synthesis. He gave a beautiful talk on the history of the subject, spanning the period from the classical work Cauer, Forster, Brune and Bott-Duffin till the still unsolved aspects of the problem.
Weather conditions prevented the otherwise traditional Wednesday afternoon walk to St. Roman. Thus, in addition to the excellent scientific program, most participants enjoyed instead the excursion to Wolfach, to attend the very famous Nasenparade.