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Control Theory: Mathematical Perspectives on Complex Networked Systems

Organised by
Frank Allgöwer, Stuttgart
Vincent Blondel, Louvain-la-Neuve
Uwe Helmke, Würzburg

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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. Its range of applicability and its techniques evolve rapidly with new developments in communication systems and electronic data processing. Thus, in recent years networked control systems emerged as a new fundamental topic, which combines complex communication structures with classical control methods and requires new mathematical methods. A substantial number of contributions to this workshop was devoted to the control of networks of systems. This was complemented by a series of lectures on other current topics like 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, 37N35, 90Bxx.

Introduction by the Organisers

Control theory is now a classical field in mathematics which is permanently evolving due to new developments in the engineering sciences. The advent of new communication means like wireless signal transmission, or the internet has led to the development of *networked control systems*, which combine a possibly large number of classical control systems in a digital network. Control variables, measured variables and other signals are transmitted between the subsystems via communication channels. Properties of these channels like capacity and bandwidth, the protocol, or transmission delays and losses thus affect the possibility to control the system. On the other hand, wireless connections between distantly located parts

of a system offer new strategies for control and monitoring. New mathematical questions which arise in this context are, for instance, related to the amount of information needed to control a system, the role of the toplogy of the connecting graph, the differences between event-driven and synchronized communication or centralized and decentralized control, as well as the statistical properties of the channel.

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 partial differential equations, operator theory, real and complex analysis, probability theory, numerical analysis, discrete mathematics, stochastics as well as algebraic and differential geometry.

The workshop *Control Theory: Mathematical Perspectives on Complex Networked Systems* brought together about 45 internationally active researchers from Austria, Belgium, France, Germany, Israel, Italy, The Netherlands, Sweden, Switzerland, the United Kingdom and the United States, with both a mathematical and systems engineering background. In order to address the new challenges posed by the new communication structures, a special focus of this workshop has been on networked control systems. This was complemented by challenging systems engineering topics. In all these talks, the interaction of mathematical methods from nonlinear dynamics and control with those from discrete mathematics (especially graph and information theory) played a crucial role. The program comprised 24 talks on the theory and applications of control theory. The lengths of the talks were different, between 30 and 45 minutes, where always enough time (at least about 10 minutes) was granted for the discussion. The lectures were organized into rather coherent sessions on the topics:

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

In addition to these lectures and the very active discussions throughout the workshop there was an informal open problem session on Tuesday evening, in which 10 participants presented open mathematical problems in control. Furthermore, as a new format, we implemented poster sessions on Wednesday and Thursday evening to have a more informal forum to discuss recent results. These sessions were accompanied by 'poster-teaser-sessions', where each presenter of a poster had about ten minutes to introduce the audience to the topic of the poster and to answer first questions. In particular the younger participants used this chance to present their work very actively. The extended abstracts of all lectures and posters are collected in this report.

The traditional Wednesday afternoon walk to St. Roman was replaced by a walk to Wolfach, where the participants enjoyed the exciting new MIMA-museum.

Workshop: Control Theory: Mathematical Perspectives on Complex Networked Systems

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