SYND 1: Symposium Control of Network Dynamics (SYND)

Time: Thursday 9:30–12:00 Location: H 0105

Invited Talk SYND 1.1 Thu 9:30 H 0105

Controlling Complex Networks with Compensatory Perturbations — •Adilson E. Motter — Department of Physics & Astronomy and NICO, Northwestern University, USA

A fundamental property of networks is that the perturbation of one node can affect other nodes, in a process that may cause the entire or a substantial part of the system to change behavior and possibly collapse. Recent research in metabolic and ecological networks has demonstrated that network damage caused by external perturbations can often be mitigated or reversed by the application of compensatory perturbations. Compensatory perturbations are constrained to be physically admissible and amenable to implementation on the network. However, the systematic identification of compensatory perturbations that conform to these constraints remains an open problem. Here, I will present a method to construct compensatory perturbations that can control the fate of general networks under such constraints. Our approach accounts for the full nonlinear behavior of real complex networks and can bring the system to a desired target state even when this state is not directly accessible. Applications to genetic networks show that compensatory perturbations are effective even when limited to a small fraction of all nodes and that they are far more effective when these are the highest-degree nodes in the network. The versatility of our methodology is illustrated through applications to associative-memory, power-grid, and food-web networks. The approach is conceptually simple and computationally efficient, making it suitable for the rescue, control, and reprogramming of large complex networks in various domains.

Invited Talk SYND 1.2 Thu 10:00 H 0105

Toward control, prediction, and optimization of biological and engineering complex networks — •Kazuyuki Aihara — Institute of Industrial Science, University of Tokyo, Tokyo, Japan

In this talk, I will review our recent works on control, prediction, and optimization of biological and engineering complex networks. The topics include bifurcation and control of information representation in a complex neural network in the prefrontal cortex, stability analysis of biomolecular networks as well as a possibility of control and optimization in engineering complex networks such as power grids.

Invited Talk SYND 1.3 Thu 10:30 H 0105

Design of robust functional networks as complex combinatorial optimization problem — •Alexander S. Mikhailov — Abteilung Physikalische Chemie, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin

Robustness against local damage and distributed noise is a fundamental property of biological systems. Their level of robustness by far exceeds what is typical for modern industrial and transportation networks. As manufacturing and transportation systems become more complex and should be often built from individual units subject to failure and variations, requirements of robustness and resilience start to play a decisive role in technological applications too. Ideally, a functional system should acquire high robustness capacity without a significant increase of its size and of the frequency of regulatory interactions. Thus, various - and often conflicting - constraints need to be satisfied in system‘s design, leading to situations characterized by frustration. The natural solution provided by biological organisms to such problems is that they are treated through the process of evolution. The question is whether evolutionary optimization methods can also be applied to design artificial functional systems with high robustness. In this talk, we show that artificial network-based systems with high levels of functional robustness, comparable to those of actual biological organisms, can indeed be obtained through the optimization of network architecture based on simulated annealing. As two examples, synthetic oscillatory genetic networks and flow distribution networks, representing prototypes of industrial or logistic networks, are chosen.

Invited Talk SYND 1.4 Thu 11:00 H 0105

Braess Paradox, (In-)Stability and Optimal Design: Nonlinear Dynamics of Modern Power Grids — •Marc Timme[1,2], Dirk Witthaut[1], Martin Rohden[1], and Andreas Sorge[1,2] — [1]Network Dynamics Group, MPI for Dynamics and Self-Organization, Goettingen — [2]Faculty of Physics, University of Goettingen

Distributed, renewable energy sources will dominate the dynamics of future electric power grids. Upgrading grids for decentralized sources poses an enormous challenge for its design and stable operation and constitutes a multi-billion Euro business.

Bridging the gap between abstract statistical physics and detailed engineering device modeling, we are aiming to understand nonlinear power grid dynamics at an intermediate level using simple but dynamic coarse-scale oscillator models. Substantial results so far include: 1) The addition of new transmission lines may *destabilize* power grid operation (via Braess paradox that we identified in oscillator networks). 2) More and smaller, but distributed power sources may *stabilize* grid operation. Our results indicate that coarse-scale modeling of power grids by oscillator networks seems feasible for the study of their self-organized synchronization dynamics.

References:

Dirk Witthaut and Marc Timme, Braess Paradox in Oscillator Networks and Power Outage, under review (2012)

Martin Rohden, Andreas Sorge, Marc Timme, and Dirk Witthaut, Self-Organized Synchronization of Decentralized Power Grids, in prep. (2012)

Invited Talk SYND 1.5 Thu 11:30 H 0105

Delay-Coupled Laser Networks: Complex Behavior, Synchronization and Applications — •Ingo Fischer — IFISC (Instituto de Física Interdisciplinar y Sistemas Complejos), Campus UIB, 07122 Palma de Mallorca, Spain

Semiconductor lasers are known to be very sensitive to external feedback, as well as to input from other lasers. This sensitivity, due to the nonlinear interaction of lasing field and semiconductor medium and the unavoidable delays in feedback and coupling, often results in emerging complex behavior. At the same time the nonlinear interactions lead to synchronization phenomena. For a long time such behavior has been considered undesired and difficult to treat experimentally and theoretically. Recently, tools to treat these systems have been developed, coupled lasers are serving as testbed systems for delay-coupled networks and suggestions for applications have been proposed. In this presentation we provide examples of the advances and discuss the perspectives of such systems.