SOE 20: Networks: From Topology to Dynamics IV (with BP, DY)

Time: Thursday 15:00–17:15 Location: GÖR 226

SOE 20.1 Thu 15:00 GÖR 226

Predicting nodes' influence in Boolean networks — •Fakhteh Ghanbarnejad and Konstantin Klemm — Bioinformatics Group, Institute for Computer Science, Leipzig University, Germany

Boolean networks serve as discrete models of regulatory dynamics in biological cells. In recent years, the Boolean modelling approach has been successfully applied to real systems. A key question in this context is the relevance of a single node for system behaviour. We quantify the dynamical influence of a node as the statistical dependence between the node's initial state and the attractor reached asymptotically. We find that the eigenvector centrality of the network is a good predictor of dynamical influence. It outperforms several other centrality measures, including out-degree, betweenness centrality and k-shell index. Quality of prediction is further improved when eigenvector centrality is based on the weighted matrix of activities rather than pure adjacencies.

SOE 20.2 Thu 15:15 GÖR 226

Activity dependent criticality and threshold networks closer to biology — •Matthias Rybarsch and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen, Otto-Hahn-Allee, 28359 Bremen

Spin models of neural networks and genetic networks are simple and elegant and benefit from the statistical mechanics toolkit developed for spin glasses and magnetic systems. However, the conventional choice of variables in spin systems may cause problems in some models of biological systems when parameter choices and normalizations are unrealistic. We here consider a prototypical network model, that is biologically plausible in the local mechanisms represented in the model with each node locally defined and no non-local fine tuning required. As a result this model yields biologically plausible ensemble statistics for randomly wired networks. We explore the critical properties of such random networks and find a more realistic behavior as compared to random Boolean networks or classical spin versions of threshold networks. Finally we observe that the present model allows a simpler implementation of recent models of budding yeast and fission yeast networks.

15 min. break

SOE 20.3 Thu 15:45 GÖR 226

Topological traps and coordination failures on real networks — •Carlos P. Roca[1,2], Sergi Lozano[1], Alex Arenas[3,4], and Angel Sánchez[2,4,5] — [1]Chair of Sociology, in particular of Modeling and Simulation, ETH Zurich, Switzerland — [2]Grupo Interdisciplinar de Sistemas Complejos (GISC), Departamento de Matemáticas, Universidad Carlos III de Madrid, Leganés, Spain — [3]Departament d'Enginyeria Informàtica i Matemàtiques, Universitat Rovira i Virgili, Tarragona, Spain — [4]Instituto de Biocomputación y Física de Sistemas Complejos (BIFI), Universidad de Zaragoza, Spain — [5]Instituto de Ciencias Matemáticas CSIC-UAM-UC3M-UCM, Madrid, Spain

Coordination is a crucial phenomenon in many social and economic systems. We study evolutionary games in real social networks, with a focus on coordination games [1]. We find that populations fail to coordinate in an important number of cases, a feature not observed in most artificial model networks. We show that this result arises from the relevance of correlations beyond the first neighborhood, in particular from topological traps formed by links between nodes of different degrees, in regions with few or no redundant paths. This specificity of real networks has not been modeled so far with synthetic networks, hence we show the need to include these mesoscopic structures to address issues such as the emergence of cooperation in real societies. We claim that topological traps are a very generic phenomenon. which may arise in very many different networks and fields, such as opinion models, spread of diseases or ecological networks.

[1] Roca, Lozano, Arenas and Sánchez, PLoS ONE, in press.

SOE 20.4 Thu 16:00 GÖR 226

Synchronization and stability of power grids with renewable energy sources — •Martin Rohden[1], Andreas Sorge[1], Dirk Witthaut[1], and Marc Timme[1,2] — [1]MPI fuer Dynamik und Selbstorganisation, Göttingen, Deutschland — [2]Bernstein Center for Computational Neuroscience, Göttingen, Deutschland

The integration of renewable energy sources poses severe challenges for power grids of the future because these sources are substantially smaller, more fluctuating and more distributed than fossil-based power plants. We present a detailed numerical study of synchronization speed and stability of complex power grids, based on a recent model [1] derived from basic equations for electric circuits which describes the real dynamics of a power grid. This approach bridges the gap between very detailed but practically intractable power grid models and too abstract ones on the other hand. A stable working alternating-current power grid has to have a fixed frequency and needs to be robust against power fluctuations. We present simulations for different topologies of power grid networks regarding stability against power failures and overall synchronization speed. Furthermore we analyze the integration of renewable power sources into the grid and show the consequences for its stability and synchronization speed.

[1]: G. Filatrella et. al., Eur. Phys. J. B **61**, 485 (2008)

SOE 20.5 Thu 16:15 GÖR 226

Adaptive time-delayed feedback control of unstable fixed points and cluster states in networks — •Judith Lehnert[1], Anton Selivanov[2], Peter Guzenko[3], Philipp Hövel[1], Thomas Dahms[1], Alexander Fradkov[2,3], and Eckehard Schöll[1] — [1]Institut f. Theo. Physik, Technische Universität Berlin — [2]Saint Petersburg State University, Russia — [3]Institute for Problems of Mechanical Engineering, Russian Academy of Sciences

Time-delayed feedback as originally proposed by Pyragas is a simple and efficient scheme for the control of unstable periodic orbits and unstable fixed points. It is non-invasive since it employs the difference of an output signal $s(t)$ and its delayed counterpart $s(t-\tau)$, multiplied by the feedback gain K. In the (K,τ)-plane this gives rise to domains of successful control where the largest Lyapunov exponent becomes negative. Here, we show that it is possible to obtain an optimal value of the feedback gain by applying adaptive control, namely the speed gradient method. Furthermore, we study the role of different initial conditions and show the robustness of our method with respect to noise. We apply our method to stabilize unstable fixed points as well as to reach different M-cluster states in networks. By the latter we refer to a state where the nodes of a network are zero-lag synchronized within M clusters with a constant phase difference between these clusters.

SOE 20.6 Thu 16:30 GÖR 226

The symmetry of group and cluster synchronization — •Thomas Dahms, Judith Lehnert, and Eckehard Schöll — Institut f. Theor. Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We investigate stability of synchronized states in networks where synchronization takes place in cluster states. Using a master stability approach, we find that the master stability function shows a rotational symmetry depending on the number of groups. Topologies that allow for solutions on group or cluster synchronization manifolds show a very similar symmetry in their eigenvalue spectrum, allowing to reduce the extent of the parameter on which the master stability function has to be evaluated. We illustrate our results by calculating stability in the example of delay-coupled semiconductor lasers.

SOE 20.7 Thu 16:45 GÖR 226

Stability and Resonance in Networks of Delay-Coupled Delay Oscillators — •Johannes Höfener[1], Gautam Sethia[1,2], and Thilo Gross[1] — [1]Biological Physics Section, Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, Dresden 01187, Germany — [2]Institute for Plasma Research, Bhat, Gandhinagar 382 428, India

Dynamical networks with time-delays (delay networks) have many applications in diverse range of fields from physics and biology. Their analysis is challenging, because even a single delay differential equation constitutes an infinite-dimensional dynamical system. In this talk we describe a method to efficiently analyse the stability of delay networks and investigate the stability of large networks of delay-coupled delay oscillators. When the local dynamical stability of these networks is plotted as a function of the two delays a pattern of tongues is revealed. Exploiting a link between structure and dynamics, we show that in ensembles of large networks this pattern can be well approximated analytically.

SOE 20.8 Thu 17:00 GÖR 226

Coherence-incoherence transition in nonlocally coupled — •Iryna Omelchenko[1], Yuri Maistrenko[1], Philipp Hoevel[2], and Eckehard Schoell[2] — [1]Institute of Mathematics, National Academy of Sciences of Ukraine, Tereshchenkivska str. 3, 01601 Kyiv, Ukraine — [2]Institut fuer Theoretische Physik, Technische Universitaet Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

In networks of coupled oscillators we investigate the effects of nonlocal interactions on the dynamics and pattern formation. Novel types of bifurcations at the transition from coherence to incoherence are analyzed. They represent a critical pattern transformation which gives rise to breakdown of the spatially coherent state and transition to spatial chaos. The transition starts with the appearance of narrow layers of incoherence which then grow and occupy, eventually, the whole system. We follow the bifurcation scenarios for non-locally coupled logistic maps (both chaotic and periodic), and non-locally coupled Roessler systems, and conclude that the transition from spatial coherence to incoherence is typically accompanied by the appearance of hybrid, partially coherent states where coherent phase-locked regions coexist with incoherent spatially chaotic regions. In non-locally coupled Roessler systems chimera states appear at the coherence-incoherence transition.