DY 30: Networks IV (with SOE)

Time: Friday 10:00–12:00 Location: MA 001

DY 30.1 Fri 10:00 MA 001

k-shells on weighted networks — •Antonios Garas[1], Frank Schweitzer[1], and Shlomo Havlin[2] — [1]Chair of Systems Design ETH Zurich, Kreuzplatz 5, CH-8032 Zurich — [2]Minerva Center and Department of Physics, Bar-Ilan University, 52900 Ramat Gan, Israel

We discuss the decomposition of networks using k-shells in order to rank the nodes according to their centrality. We introduce a generalized method that considers the link weights in the calculation of k-shells. Our method is directly applicable to weighted networks, without the need of any arbitrary threshold on the weight values, and we show that it is able to partition a network in a more refined way, in comparison with the unweighted case. Using the classic SIR model, we show that nodes with higher spreading potential are located into shells closer to the core, and subsequently, we we discuss applications in different systems ranging from economic networks to on-line communities.

DY 30.2 Fri 10:15 MA 001

All scale-free networks are sparse — •Charo Del Genio[1], Thilo Gross[1], and Kevin Bassler[2,3] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Deutschland — [2]University of Houston, Houston, TX, USA — [3]Texas Center for Superconductivity, Houston, TX, USA

We study the realizability of scale free-networks with a given degree sequence, showing that the fraction of realizable sequences undergoes two first-order transitions at the values 0 and 2 of the power-law exponent. We substantiate this finding by analytical reasoning and by a numerical method, proposed here, based on extreme value arguments, which can be applied to any given degree distribution. Our results reveal a fundamental reason why large scale-free networks without constraints on minimum and maximum degree must be sparse.

DY 30.3 Fri 10:30 MA 001

Information storage, loop motifs and clustered structure in complex networks — •Joseph T. Lizier, Fatihcan M. Atay, and Jürgen Jost — Max Planck Institute for Mathematics in the Sciences, Inselstrasse 22, 04103 Leipzig, Germany

Information storage is a key operation in distributed computation, and an important analytic tool for understanding dynamics on, and information processing capabilities of, complex networks. We use a standard discrete-time linear Gaussian model to analyze information storage capability of individual nodes in complex networks, given network structure and link weights. In particular, we investigate the role of two and three-node motifs in contributing to information storage, and express information storage analytically in terms of the contributions of these motifs. We show analytically that directed feedback loops and feedforward loop motifs are the dominant contributors to information storage capability. Crucially, where the network contains positive edge weights on average, the information storage capability is positively correlated to the counts of these motifs. We also show the direct relationship between clustering coefficient(s) and information storage which results from these expressions. These results explain the dynamical importance of clustered structure, and offer an explanation for the prevalence of these motifs in biological and artificial networks.

DY 30.4 Fri 10:45 MA 001

Statistical description of subgraph fluctuations in random graphs — •Christoph Fretter[1], Matthias Müller-Hannemann[2], and Marc-Thorsten Hütt[1] — [1]School of Engineering and Science, Jacobs University, Bremen, Germany — [2]Institut für Informatik, Martin-Luther Universität Halle-Wittenberg, Germany

The pattern of over- and under-representations of three-node subgraphs has become a standard method of characterizing complex networks and evaluating, how this intermediate level of organization contributes to network function. We explored this relationship in previous publications [1,2]. Understanding statistical properties of subgraph counts in random graphs, their fluctuations and their interdependencies with other topological attributes is an important prerequisite for such investigations. Here we introduce a formalism for predicting subgraph fluctuations induced by perturbations of uni-directional and bi-directional edge densities. On this basis we predict the over- and under-representation of subgraphs arising from a density mismatch between a network and the corresponding pool of randomized graphs serving as null model. Such mismatches occur for example in modular and hierarchical graphs.

[1] Krumov L., Fretter, C., Müller-Hannemann, M., Weihe, K. and Hütt, M.-Th., Motifs in co-authorship networks and their relation to the impact of scientific publications. Eur. Phys. J. B, (2011) in press.
[2] Marr, C., Theis, F.J., Liebovitch, L.S. and Hütt, M.-Th., Patterns of subnet usage in the transcriptional regulatory network of Escherichia coli. PLoS Computational Biology 6, e1000836 (2010).

DY 30.5 Fri 11:00 MA 001

Impact of boundaries on fully connected random geometric networks — Justin Coon[1], Carl Dettmann[2], and •Orestis Georgiou[3] — [1]Toshiba Telecommunications Research Laboratory, Bristol, UK — [2]School of Mathematics, University of Bristol, Bristol, UK — [3]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Many complex networks exhibit a percolation transition involving a macroscopic connected component, with universal features largely independent of the microscopic model and the macroscopic domain geometry. In contrast, it turns out that the transition to full connectivity is strongly influenced by the details of the boundary and exhibit an alternative form of universality. The statistical physics approach taken produces a generalized formula for the probability of fully connectivity. This result is largely model independent and facilitates system design to promote or avoid full connectivity for diverse geometries in arbitrary dimension. I will also discuss applications of this formula to wireless communication networks.

DY 30.6 Fri 11:15 MA 001

Self-organized critical adaptive networks — •Matthias Rybarsch and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen, Otto-Hahn-Allee, 28359 Bremen

Dynamical systems of spins on a network can exhibit self-regulated evolution towards a critical state and are used as toy models for self-tuning in biological neural networks [1]. If, however, the model is changed from spin type to a network composed of Boolean state nodes which are more plausible in the biological context [2], this rewiring algorithm will no longer evolve the system to criticality and cannot be directly transferred in a simple way. Also, the function of such self-organized networks is often limited to a certain network topology like a regular lattice in case of ref. [1]. Here, we discuss a correlation-dependent mechanism for self-organized connectivity evolution which adresses these difficulties and evolves a biologically motivated, yet minimalistic network model to an average connectivity close to criticality in terms of damage spreading, both on lattice or random network topology.

[1] S. Bornholdt and T. Roehl: Self-organized critical neural networks, Phys. Rev. E 67, 066118 (2003)
[2] M. Rybarsch and S. Bornholdt: On the dangers of Boolean networks: Activity dependent criticality and threshold networks not faithful to biology, arXiv:1012.3287 (2010)

DY 30.7 Fri 11:30 MA 001

Continuous Percolation by Discontinuities — •Jan Nagler — MPI DS, Göttingen

The extent to which a complex network is connected crucially impacts its dynamics and function. Percolation, the transition to extensive connectedness on gradual addition of links, is often used to describe and model many different types of structure in the real world. How single links may *explosively* change macroscopic connectivity in networks where links add competitively according to certain rules has been debated extensively in the past three years. In the very recent article [Science **333**, 322 (2011)], O. Riordan and L. Warnke state that (i) *any rule based on picking a fixed number of random vertices gives a continuous transition*, and (ii) that *explosive percolation is continuous*. It is equally true that certain percolation processes based on picking a fixed number of random vertices are discontinuous. Here we resolve this apparent paradox. We identify and analyze this by studying an extremal case of a process that is continuous in the sense of Riordan and Warnke but still exhibits infinitely many discontinuous jumps in an arbitrary vicinity of the transition point. We demonstrate analytically that continuity at the transition and discontinuity of the percolation process are compatible for certain competitive percolation systems.

DY 30.8 Fri 11:45 MA 001

The role of nonlocal coupling in the transition from coherent to incoherent states — •Bruno Riemenschneider[1], Iryna Omelchenko[1,2], Philipp Hövel[1,2], Yuri Maistrenko[3,4], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin — [2]Bernstein Center for Computational Neuroscience, Humboldt-Universität zu Berlin — [3]Institute of Mathematics, National Academy of Sciences of Ukraine — [4]National Center for Medical and Biotechnical Research, National Academy of Sciences of Ukraine

We investigate the spatio-temporal dynamics of coupled chaotic systems with nonlocal interactions, where each element is coupled to a fixed number of nearest neighbours. Characteristic examples of such networks appear in neuroscience, chemical oscillators, electrochemical systems, and Josephson junctions. Depending upon the coupling parameters, i.e., strength and range, we find variations in temporal behaviour, as well as characteristic spatial patterns. These include wave-like solutions and a transition from spatial coherence to incoherence. Partially coherent, chimera-like states represent the characteristic spatio-temporal patterns at the transition, which leads to spatial chaos. The systems have been analyzed by both numerical simulations and theoretical derivations. To demonstrate the universality of our findings, we consider time-discrete as well as time-continuous models, i.e., logistic maps, Rössler and Lorenz systems, respectively. For each system we choose parameters that lead to chaotic behaviour in the uncoupled case.