SOE 18: Networks: From Topology to Dynamics III (with BP, DY)

Time: Thursday 10:15–13:00 Location: H44

SOE 18.1 Thu 10:15 H44

Detection of Mesoscopic Role-Structure in Complex Networks — •Joerg Reichardt[1], Roberto Alamino[2], and David Saad[2] — [1]UC Davis, CA — [2]Aston University, Birmingham

Not all nodes are created equal in complex networks. Rather, they play diverse roles in the functioning of a network and their role is reflected in the network's link structure. Hence, structural analysis can be used to infer the latent roles and functions of nodes purely based on connectivity data. Currently, network structure is studied at three different levels. At the macro level, global network properties such as degree distributions, path-lengths, diameters or clustering coefficients are investigated. At the micro level, properties of individual nodes and edges such as centrality indices or rank functions such as page-rank are studied. The study of the meso-scale, which aims at studying joint properties of groups of nodes, so far has mainly been focussed on the detection of cohesive subgroups of nodes, so-called communities.

The talk will show that, though important, communities are only one special case of a much wider class of mesoscopic structures called "stochastic block structures". This name comes from the fact that latent classes of roles and their resultant patterns of connectivity in a network account for salient block structure in the adjacency matrix of a network when the rows and columns are ordered according to these latent roles.

We present an effective and accurate algorithm that performs this task employing a purely Bayesian approach, show that it outperforms competing approaches and present applications to real world data sets that open new frontiers of research in the study of both structure, function and evolution of complex networks from a mesoscopic perspective.

SOE 18.2 Thu 10:30 H44

Structuring k-partite networks by decomposition into overlapping communities — •Florian Blöchl[1,3], Mara L. Hartsperger[1,3], Volker Stümpflen[1], and Fabian J. Theis[1,2] — [1]Institute for Bioinformatics and Systems Biology, Helmholtz Zentrum München — [2]Department of Mathematics, TU München — [3]Equal contributors

With increasing availability of large-scale networks we face the challenge to interpret these data in a comprehensive fashion. A common solution is a decomposition into modular building blocks, so–called communities. Prominent examples are functional modules in protein interactions. However, the integration of heterogeneous resources results in networks with nodes of multiple colors. Although existing algorithms address this issue, they identify separated, disjoint clusters by assigning each node to exactly one cluster. This is far from reality, where e.g. proteins are commonly part of many complexes or pathways.

We present a novel algorithm for detecting overlapping communities in k-partite graphs. It determines for each node a fuzzy degree-of-membership to each community. Moreover, we additionally estimate a weighted backbone graph connecting the extracted communities. The method is fast and efficient, mimicking the multiplicative update rules employed in algorithms for non-negative matrix factorization.

Results on a disease-gene-protein complex graph show significantly higher homogeneity within the complex and disease clusters than expected by chance. However, the algorithm is readily applicable to other domains with similar problems.

SOE 18.3 Thu 10:45 H44

Large-deviation properties of random graphs — •Alexander K. Hartmann — Institut of Physics, University of Oldenburg

The large-deviation properties of different types of random graphs are studied using numerical simulations. In particular the number of components and the graph diameter are considered. The distributions of these quantities are obtained down to very small probabilities like 10^{-700} using finite-temperature Monte Carlo and Wang Landau simulations. Different graphs ensembles as Erdös-Renyi, small-world and scale-free graphs are studied as a function of suitable control parameters. The parameter-dependend changes of the distributions are recorded, indicating the presence of non-standard transitions.

In particular, the distributions of the diameter are often given by Gumbel distributions, except right at a percolation transition, or are very close to Gumbel distributions.

SOE 18.4 Thu 11:00 H44

Coupled Order Parameter Systems on Scale-free Networks — •Christian von Ferber[1,2], Reinhard Folk[3], Vasyl Palchykov[4], and Yurij Holovatch[3,4] — [1]Applied Mathematics Research Centre, Coventry University, UK — [2]Physikalisches Institut, Universität Freiburg — [3]Institut für Theoretische Physik, Universität Linz, AT — [4]Institute for Condensed Matter Physics, Lviv, UA

We analyse a system of two scalar order parameters on a complex scale-free network in the spirit of Landau theory. To add a microscopic background to the phenomenological approach we also study a particular spin Hamiltonian that leads to coupled scalar order behavior using the mean field approximation. This set up may describe a model of opinion formation where e.g. opinions on a party a candidate are coupled. Our results show that the system is characterised by either of two types of ordering: either one of the two order parameters is zero or both are non-zero but have the same value. While the critical exponents do not differ from those of a model with a single order parameter on a scale free network there are notable differences for the amplitude ratios and susceptibilities. Another peculiarity of the model is that the transverse susceptibility is divergent at all $T < T_c$ when $O(n)$ symmetry is present. This behavior is related to the appearance of Goldstone modes.

SOE 18.5 Thu 11:15 H44

Discontinuous Phase Transitions in Random Network Percolation — •Jan Nagler[1,2], Anna Levina[1,3], and Marc Timme[1,2,3] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen — [2]Institute for Nonlinear Dynamics, Faculty of Physics, University of Göttingen — [3]Bernstein Center for Computational Neuroscience (BCCN) Göttingen

The transition to extensive connectedness upon gradual addition of links, known as the percolation phase transition, provides a key prerequisite for understanding networked systems [1]. Until recently, random percolation processes were thought to exhibit continuous transitions in general, but now there is numerical evidence for discontinuities changes of the order parameter in certain percolation processes [2]. Here we present the concepts of weakly and strongly discontinuous percolation transitions and explain the microscopic mechanisms underlying them. We study both numerically and analytically under which conditions the order parameter may change discontinuously and classify the type of transition in dependence on the dynamics of cluster joining [3].

[1] G. Grimmett, Percolation (Springer Verlag, Heidelberg,1999).
[2] D. Achlioptas, R. M. D'Souza, J. Spencer, Explosive Percolation in Random Networks, Science 323: 1453 (2009); R. M. Ziff, PRL 103, 045701 (2009); F. Radicchi and S. Fortunato, PRL 103, 168701 (2009); Y. Cho et al., PRL 103, 135702 (2009).
[3] J. Nagler, A. Levina, and M. Timme, unpublished (2009).

15 min. break

SOE 18.6 Thu 11:45 H44

Evidence for power-law anti-correlations in complex networks — •Diego Rybski[1], Hernán D. Rozenfeld[2], and Jürgen P. Kropp[1] — [1]Potsdam Institute for Climate Impact Research, 14412 Potsdam, Germany — [2]Levich Institute, City College of New York, New York, NY 10031, USA

We propose a degree analysis to quantify spatial correlations in complex networks. The approach considers the degrees along shortest paths in the networks and quantifies the correlations. In this work, the Barabasi-Albert (BA) model, a fractal network model, and examples of real-world networks are studied. While for the BA model the correlations show exponential decay, in the case of the fractal networks the correlations show a power-law behavior indicating long-range correlations. The results suggest that the analysis provides complementary information to the fractal dimension as measured with box covering.

SOE 18.7 Thu 12:00 H44

What scales in multiscale human mobility networks? — •Rafael Brune[1,2], Christian Thiemann[1,2], and Dirk Brockmann[1] — [1]Northwestern University, Evanston, USA — [2]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen,

Deutschland

Although significant research effort is currently devoted to the understanding of complex human mobility and transportation networks, their statistical features are still poorly understood. Specifically, to what extent geographical scales impose structure on these networks is largely unknown. Statistical properties of these networks have been obtained either for large scale networks or on small scale systems, indicating significant differences between the two. We will present a systematic investigation of various single scale mobility networks extracted from a comprehensive multiscale proxy network, covering sequential length scales of a few to a few thousand kilometers. We will report that certain properties such as mobility flux distribution are universal and independent of length scale, whereas others vary systematically with scale. Furthermore we investigate the relation of a series of network characteristics as a function of scale and analyze how the different length scales interact in the embedding multiscale network.

SOE 18.8 Thu 12:15 H44

The tomography of human mobility – what do shortest-path trees reveal? — •Christian Thiemann[1,2], Daniel Grady[1], and Dirk Brockmann[1] — [1]Eng. Sci. & Appl. Math, Northwestern University, Evanston, IL, USA — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Similar to illustrating the anatomy of organs using pictures of tissue slices taken at various depths, we construct shortest-path trees of different nodes to create tomograms of large-scale human mobility networks. This tomography allows us to measure global properties of the system conditioned on a reference location in the network to gain a fuller characterization of a node. It also suggests a canonical coordinate system for representing complex networks and dynamical processes thereon in a simplified way, revealing a new symmetry in the human mobility networks we investigated. Furthermore, introducing the notion of tree similarity, we devised a new technique for clustering nodes with similar topological footprint, yielding a unique and efficient method for community identification and topological backbone extraction. We applied these methods to a multi-scale human mobility network obtained from the dollar-bill-tracking site wheresgoerge.com and to the U.S. and world-wide air transportation network.

SOE 18.9 Thu 12:30 H44

Fusion in complex networks — •Carlus Deneke, Angelo Valleriani, and Reinhard Lipowsky — Max-Planck-Institut für Kolloid- und Grenzflächenforschung, Department of Theory and Bio-Systems, Potsdam, Germany

In real world networks, part of the information about the nodes and edges is often missing or unaccessible and single nodes might in reality consist of several nodes or subgraphs. Since these hidden structures may have a strong impact on the dynamical processes, it is important to investigate how the network properties change at different levels of resolution.

In this contribution, we investigate scale-free networks, in which randomly chosen couples of neighboring nodes are iteratively integrated or fused into single nodes. We introduce different fusion mechanisms and compare their effects on simple network properties such as the degree distribution and the degree correlations. By means of numerical simulations and analytical calculations, we show that the network properties change steadily under the iterated fusion steps.

We finally discuss possible connections to real world networks.

SOE 18.10 Thu 12:45 H44

Properties of transport networks need to be invariant under coarse graining — •Fabian J. Theis[1,2], Florian Blöchl[1], and Dirk Brockmann[3] — [1]Helmholtz Zentrum München, Germany — [2]Department of Mathematics, TU Munich, Germany — [3]Engineering Sciences and Applied Mathematics, Northwestern University, USA

Transport networks can rarely be observed directly, especially not across many scales. Instead, the flow between two locations can now only be estimated from proxy data. This results in the need for spatial averaging, so we commonly only observe a histogram of the actual distributions. We denote this process as coarse graining.

In this contribution we analyze which network properties are invariant under coarse graining, following the rationale that we can only infer such properties of the true underlying transport network from the proxy data. We show that shortest-path distances, which cannot take self-loops into account, are a poor distance measure in such networks. Instead we illustrate that a distance based on random walks, namely mean fast hitting time (MFHT), is much more adequate for such type of networks. Moreover, we show that community measures are coarse-graining invariant.

Taken together, we can develop a coarse graining method that leaves MFHT fully invariant: we first cluster the nodes into communities via hierarchical clustering of the mean commute time matrix. We then reconstruct a weighted graph connecting our communities, solving a distance realization problem, which we recently addressed in (Wittmann et al., TCS 2009). We illustrate the method on toy and real networks.