SOE 19: Networks: From Topology to Dynamics IV (with BP, DY)

Time: Thursday 14:00–16:00 Location: H44

SOE 19.1 Thu 14:00 H44

A sequence-based framework for simulating the evolution of gene regulatory networks — •Thimo Rohlf — Programme d'Epigenomique, Genopole Campus 1 - Genavenir 6, 5 rue Henri Desbruères, F-91030 Évry cedex, France — Max-Planck-Institute for Mathematics in the Sciences, Inselstr. 22, D-04103 Leipzig, Germany

An increasing amount of experimental data on global properties of genome organization across various species and phyla is becoming available, suggesting general principles as, e.g., scaling relationships or spatial regularities of gene distribution on DNA. A second level of information is accessible with gene regulatory networks, that control the space-time pattern of gene expression; here, similar (statistical) patterns of conserved regularities are observed. What can Statistical Physics contribute to tackle the question, which of these properties arose from combinatorial and architectural constraints, and which may have been shaped primarily by evolution? I will introduce and discuss a sequence-based artificial genome model that allows an integrative approach to model the emergence of genomic information at the levels of DNA sequence, regulatory networks and phenotype evolution. In particular, the following questions will be addressed: (1) Which types of network properties could be explained from combinatorial/statistical properties of genomes (random genome model), (2) how do they change in evolving genomes, in particular when (3) selective pressure is present, e.g. stabilizing selection for certain patterns of gene activity (phenotypes).

SOE 19.2 Thu 14:15 H44

Evolution based on centrality: Bistability between hierarchical and destructured networks — •Claudio J. Tessone[1], Matteo Marsili[2], and Michael König[1] — [1]Chair of Systems Design, D-MTEC ETH Zürich — [2]International Centre for Theoretical Physics Abdus Salam

We study a model of network evolution in which agents attempt to become the most central ones in a network. Considering purely strategic interactions, when agents try to maximise their centrality in the network, the best strategy for them is to create links with the most central agent among those they are not still connected to. Conversely, for link removal, the most efficient strategy is to remove a link to the least central node, among the neighbours. This condition leads to a self-reinforcing mechanism signalled by the emergence of highly centralised networks. These networks have the property of nestedness: for any two agents i and j, if the degree of agent i is lower than that of j, the neighbourhood of i is contained within the neighbourhood of j. Moreover, this mechanism simplifies the computational effort needed by the agents to identify their best strategy.

Interestingly, such structures only can appear if all the agents have been developing it. If disturbances, –such as decay of edges, introduced by finite of link life-time– are in place, we show that ergodicity in the system disappears. Under these conditions two equilibrium states can coexist for a given set of parameters: one where such hierarchical structure emerges; another where a completely random network prevails.

SOE 19.3 Thu 14:30 H44

Network evolution driven by spectral profile — •Sebastian Weber[1] and Markus Porto[2] — [1]Freiburg Institute For Advanced Studies (FRIAS), University of Freiburg, Germany — [2]Institut für Festkörperphysik, Technische Universität Darmstadt, Germany

A large class of real world networks evolve over time, constantly changing and adapting their topology with respect to criteria imposed on the dynamics they mediate. The properties of the dynamics is ultimately determined by its spectral profile, which is the eigenvalue spectrum of the associated operator. This operator inevitably involves the network's adjacency matrix, establishing the connection between topology and dynamics. Using the graph Laplacian or Kirchhoff matrix and its spectral profile as an example, the former being central in a wide class of physical processes (random walks, harmonic interaction networks, etc.) on networks, we show that a network evolution scheme recently developed by us is able to successfully evolve networks to display a given spectral profile's essential features [1].

[1] S. Weber and M. Porto, submitted.

15 min. break

SOE 19.4 Thu 15:00 H44

Adaptive network approach to the collective motion of self-propelled agents — •Anne-Ly Do[1], Cristian Huepe[2], Gerd Zschaler[1], and Thilo Gross[1] — [1]MPI for the Physics of Complex Systems, Dresden — [2]unaffiliated National Science Foundation grantee

Swarming is a showcase example of emergent behavior in complex many-particle systems. Previous modeling approaches rely on continuum theories or on individual based simulations and are difficult to study analytically as emergent-level equations are either complicated or not available at all. Here we propose an analytically tractable approach that bases on an adaptive network formulation. The nodes of this network represent individual animals while the links represent mutual awareness and therefore potential interaction between the linked individuals. Over time links are constantly created and broken as the movement of agents reshapes the network of contacts. Simultaneously the direction of movement can change as a result of the interactions with neighbors in the contact network. By means of moment closure approximation we derive an emergent-level description of the system and study it with the tools of nonlinear dynamics. We show that the system exhibits a phase transition from an unpolarized state, where no order motion occurs, to a state of collective motion, thus reproducing the results of recent swarming experiments.

SOE 19.5 Thu 15:15 H44

The backbone of the climate network — •Jonathan Friedemann Donges[1,2], Yong Zou[1], Norbert Marwan[1], and Jürgen Kurths[1,2] — [1]Potsdam Institute for Climate Impact Research, P.O. Box 601203, 14412 Potsdam, Germany — [2]Department of Physics, Humboldt University Berlin, Newtonstr. 15, 12489 Berlin, Germany

We propose a method to reconstruct and analyze a complex network from data generated by a spatio-temporal dynamical system, relying on the nonlinear mutual information of time series analysis and betweenness centrality of complex network theory. We show, that this approach reveals a rich internal structure in complex climate networks constructed from reanalysis and model surface air temperature data. Our novel method uncovers peculiar wave-like structures of high energy flow, that we relate to global surface ocean currents. This points to a major role of the oceanic surface circulation in coupling and stabilizing the global temperature field in the long term mean (140 years for the model run and 60 years for reanalysis data). We find that these results cannot be obtained using classical linear methods of multivariate data analysis, and have ensured their robustness by intensive significance testing.

SOE 19.6 Thu 15:30 H44

Personalized recommendation in Collaborative Tagging Systems — •Zi-Ke ZHANG — chemin du musee, CH1700, Fribourg, Switzerland

Personalized recommender systems are confronting great challenges of accuracy, diversification and novelty, especially when the data set is sparse and lacks accessorial information, such as user profiles, item attributes and explicit ratings. Collaborative tags contain rich information about personalized preferences and item contents. We are trying to find an efficient yet simple way to make use of tags to provide better recommendations.

SOE 19.7 Thu 15:45 H44

What network analysis can tell us about car-scrap bonus: the linchpins of modern economy — •Florian Blöchl[1], Fabian J. Theis[1,2], and Eric O'N. Fisher[3] — [1]Institute for Bioinformatics and Systems Biology, Helmholtz Centre Munich — [2]Department of Mathematics, TU Munich — [3]California Polytechnic State University

An input-output matrix collects good flows between different economic sectors, structural units of the economy like "Agriculture" or "Pharmaceuticals". This matrix can be viewed as a directed weighted network. We analyze input-output graphs for a wide set of countries collected by the OECD. These networks contain only 40 nodes, but are almost fully connected and have quite strong self-loops.

We apply two measures of node centrality, both relying on different properties of random walks on the graphs: random walk centrality and a new measure we called count-betweenness. The latter is similar to Newman's random walk betweenness, but allows for directed graphs and incorporates self-loops. Both measures give similar and reasonable results. For instance, we find that in Luxembourg the most central sector is "Finance and Insurance", in Brazil "Food Products", and in Germany "Motor Vehicles". Thus, car-scrap bonus really aimed at the linchpin of Germany's economy.

The sectors' rankings are quite different, however some sectors are important in most countries while others are never. We therefore additionally structure the data by hierarchically clustering countries. Thereby we achieve clusters that well coincide with geographical proximity or developmental status.